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Building Secure IT Server Room

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Abstract

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Despite Cloud and Datacenter technologies breakthrough need for local server rooms still exists. Often the only resource available for server room design is IT support or IT project manager with no or not enough knowledge about the task. Our research combines information and ideas available in sources like datacenter standards and best practices, server room facility providers' sites, Internet technical discussions and author's own experience and provides short but complete instruction, what should be done and taken in consideration to produce a secure server room. The results of research include description of interdependencies which exist in facility design area, so the research can be used in several special cases; however, practitioner's consideration is to be used in every specific project.

Keywords: Server Room, IT Infrastructure, IT Infrastructure Projects, Data Center

Contents

1. Introduction

Despite the winning trend of moving IT hardware to a distant location like datacenter or cloud, there still are cases when stack of servers and active network devices should be installed within easy reach of the local business (Armbrust et al. 2010, 54-58). Installing a large server configuration within working office space is not the best solution for this need. Doing so, one will easily exceed the acceptable level of noise and thermal load on the surrounding office. Moreover, access to the servers will be allowed to all people can walk into the office. The better way to address these issues is organizing a Server Room dedicated to running IT installations (Marks 2000, 99.) With dedicated room noise can be reduced at the perimeter of the facility, air conditioned within the room and implementing access control and keeping the accurate log of visitors are straightforward task (AllBusiness).

Regardless of a size of facility you are building, major data centre or small server room, result should correspond to the business criticality of the information held within the facility (Memon et al. 2009, 351). It is essential that the chosen design is right for particular requirements of ICT. Server room is the heart of IT operations, and therefore it must be well-thought-out before built.

In our research we provide a dynamic model of a Secure Server Room as a result of collecting and critically analyzing existing recommendations coming from small datacenter facilities providers, IT industry standards and ICT practitioners. From this critical analysis we create recommendations for the person having IT Server Room building project at hands. While creating recommendation we also largely used our own 15 years experience as IT Infrastructure solutions practitioner and consultant.

We provide a template (Appendix B) with guidance for making advanced Work Order to a Construction Company which is chosen to build the facility. This template can be also used as a check list for a complete Server Room building project. At the end we share some thoughts about validity of research deliverables basing on used research method and knowledge sources. We also ponder, what approach is recommended to practitioner while implementing results to the specific situation, where our model is used.

There are several books (e.g. Snevely 2002), web-pages and industry standards (e.g. ANSI/BICSI 002 2011) describing challenges and provide solutions to them regarding building secure facility for IT hardware like servers, network devices and interconnecting network. In addition, IT services of companies often list their special requirements for server rooms to be fulfilled by real estate solutions provided during the establishment of a new office. Plenty of information is available.

However, both these types of documents have their specialties which make them difficult to be used during the office project with limited time and resources. Indeed, as the book and standard mentioned earlier are hundreds of pages long, it would be hard to read them in a short time in the beginning of the project. Also, solutions presented in them are often overkill for a small office server room. IT services' demand documents are concentrating on the special requirements, e.g. LAN equipment positioning within the server room, and combining a comprehensive specification basing on them is impossible.

ANSI/BICSI Data Center Design and Implementation Best Practices defines a Computer Room as "an architectural space with the primary function to accommodate data processing equipment" (2011, 7). Building a server room can be a subject of a sub-project within bigger building, relocation or upgrade project. This study aims to collect findings and recommendations mostly from Internet resources and translate them to variety of technical specifications for a Server Room Model. In present, words "server room" do not describe research object exactly enough to define scope for our research. More so, used terminology defers among data sources. Some service providers speak only about "data centers"; others make distinction between "data centers" and "server rooms" basing on positioning (same building with users vs. distant building) or basing on size and dedication.

Server room as we want to define it is a special case of a data center. DiMinico (2006), basing on Telecommunications Infrastructure Standard for Data Centers ANSI/TIA-942, suggests a gradation of data centers called "Tiers", basing on availability which is represented by redundancy of operations combined with number of distribution paths:

Tier 1: basic non-redundant server room

Tier 2: server room with single distribution path and redundant components

Tier 3: data center with one distribution path active and multiple paths available

Tier 4: fault tolerant data center, multiple distribution paths active. (DiMinico 2006, 33.)

Lately companies began building server rooms with multi-zone approach setting different power density levels (zones) within the single server room. This approach may help cutting down capital expense. The basic idea is that different use of ICT requires different levels of processing power from servers and space for growth. Therefore designing floor-space with different density support makes sense. (Cappuccio 2009.) We outline multi-zone data centers out of this research interest and concentrate on generic “single zone” server room. In this research we concentrate on Data Center of Tier 1 and Tier 2 basing on typology above, and call it “server room”.

Reason for choosing such scope is practical. As many other globally operating companies, the Enterprise where author is working in at the time of doing this research, have a policy of moving IT data operations to big redundant data centers, which can be described as Tier 4 basing on TIA-942 typology. This business decision reduces significantly efforts in design and maintenance of data centers by eliminating from company’s assets local server rooms. At least in theory.

In practice the need for locally maintained server rooms have not disappear by decision of concentrating computing capacity in data centers. Large variety of Business demands in IT area just does not support 100% clear solutions fit for everyone. For instance, R&D teams use locally hardware they need an instant physical access to. Other case is, when Enterprise’s operational area expands to places in the world, where neither a Tier 4 data centers nor stable data connections are available. In such countries and regions secure place for IT hardware (e.g. File and Print Server) within the office space should be provided during the Office building project. Ad hoc server room specifications increase a risk of IT security breach for a single office, and also for the entire Enterprise IT because the IT Security is as strong as its weakest link.

I was involved in building several server rooms in several companies; some of the companies were globally working enterprises. Scope of server rooms’ types I needed to deliver was from “WLAN router in the metal box on the wall” solution to a Global Network Operations Center server room facility. One shared attribute in all these projects was that very little and fragmented instruction for the project manager was provided.

This research aims to help people who got tasks of designing and building server room to their responsibility in companies where building and maintaining datacenters is typically outsourced to the suppliers, and where knowledge management system does not contain up to date instructions for local standalone server room facility building. Use of this research empower IT Infrastructure Project Manager to be able presenting advanced design for server room facility to Business and explain why certain feature is needed and what is potential risk or cost of not providing it. Therefore it helps improving IT security and Business efficiency.

2. Method

Research in general aims is to enlarge peoples' understanding of surrounding environment and provide knowledge about it (Kothari 2009, 1). Knowledge by definition is well-justified true believe (Sayre 1997, 123-133). Scientific research produces knowledge which is true or as close to a truth as it is currently possible. This high quality demand is fulfilled by using research methodology at one hand, and by reviewing new finding by scientific community in order to verify own results critically, at other.

Research type widely represented in Information Technologies is Design Research, which delivers solutions to real life problems and not so much theoretical knowledge. This is partly because of IT being such a new and rapidly evolving area of human life, and though which baseline knowledge is in stage of building, and partly due to pragmatic needs of people and society for getting working tools to govern the surrounding world. (Vaishnavi, Kuechler 2007, 2-3.) The late objective is often presented as the reason not to read Design Research to area of "real science". We are not to discuss the matter in this work, but only want to point out that using scientific research methodology is very rewarding in any rational area of human activities, and so in Design Research. Indeed, this methodology has been developed through human history as a way of producing most reliable knowledge.

March and Smith (1995) describe Model is a set of "propositions or statements expressing relationships among constructs". It "can be viewed simply as a description, that is, as a representation of how things are. The concern of models is utility, not truth". Design Research is an instrument which produces pragmatic solution to real life problems and tasks. Because the epistemology of Design Research is Pragmatism and Instrumentalism (Vaishnavi, Kuechler 2008, 18), one need to pay attention to two main demands while using it and on other hand implementing its results: expected results should be defined before beginning the research (McBurney, White, 2009, 44), and implementer of achieved design should always use critical evaluation comparing two environments – where design results are achieved and where they to be used.

Statements above are true for our research too. While starting it we had a clear picture in mind, what we expect as the result – a model of Server Room design which is dynamic enough to include some useful options. Provided by research model needs a critical evaluation while being used for building real facility, because even with large number of options added, it by no means contains whole specter of real world situations affecting the final result of design.

The intent of this Design Research is to produce a Model, which increases productivity of a business organization whilst implemented. On practical level, we aim to help an IT person to carry out successfully a task of designing a secure Server Room. We collected advice from number of different sources to the general level instruction, which can be used for several different designs. We compare knowledge gained from the different external sources and also to our own understanding of the matter, and provide a recommendation to practitioner as a result. Implementer of this Model will need to find her own solution basing on one hand, on a knowledge she can get from this research, and demands and constrains from business, on other. Approach of this research is therefore Induction. Practically, writer himself has built several Server Rooms for different companies, and would appreciate having 40-pages or so long Server Room Design Manual at hands while working on these projects, especially in the beginning of his IT vocation.

3. Building Secure Server Room

In this part of our research we name most important issues, which should be paid attention to while planning and implementing a secure stand alone server room. We bring most recent results from data center facility industry standards and solution provider materials to combine them into a model fit for purpose described earlier.

High quality design and implementation of a server room facility is a significant condition for the proficient functioning of ICT systems. Insufficient quality can lead to reduced work results of the company's employees. (StuffReview.) In building projects space allocation process often generates conflicts between the different interests within the company and sometimes between different companies sharing the building. Therefore, it is important to examine the company's space requirements growth trends so that these can be explained to stakeholders and validated by them and best possible solution can be found. Once allocation is done, it will in many cases persist for the entire lifespan of the building, and it may be impossible to acquire more or alternative space for IT afterwards.

Server room needs to be optimally situated in the building. Physical size of the space needed is only one affecting factor here. While choosing the position of the server room you must pay attention to aspects related to equipment transport paths, security, noise level, high power electrical fields, fire resistance, heating and cooling implementation related constrains, conduit paths, floor load tolerance and general building structures' position. Whilst designing server room it is important for the IT project manager to actively provide her input to a higher level decision making teams regarding all factors affecting future performance of the server room facility. (Nygaard 2010, 4.) Too much flexibility in one or many of the factors will for sure reduce the productivity of ICT in the future, and may turn your life as a facility user a personal nightmare. For example, not having space for fire resistant safe cabinet in combination with SOX rules (see for example DataBank 2009) may force you saving backup cartridges at your home. Small favor to other stakeholders like allowing a water pipe crossing the server room is a ticking time bomb, which will turn in full scale disaster not "if" but "when", and being sewage pipe adds an unforgettable flavor to it.

1.1 Location

Server room construction planning begins from choosing the proper location which suits installation and functionality constrains of ICT infrastructure elements. Some of the most important decisions here are made before the first server rack is ordered and the first piece of network cable is laid. Your first task in finding the best spot for the server room inside existing building is to determine your server room size. These requirements should be based on existing and expected future needs. (SearchStorage Channel.com.)

Server room should be designed with enough options for a growth during its life time. Free or easy to obtain space should be left in the server room or adjacent areas. As spoken earlier, stakeholders of the building project should collectively agree and approve space needs of every business area including needs for the future expansion of ICT. The allocated space should be located in a suitable, easily accessible and secure part of the building. (Releford, 2000.)

Nygaard introduces that server room and its conduit paths should be in place for the whole lifetime of a building complex. The company will have to live with design approved by stakeholders of a building project for a long time. He claims that generic cabling systems will have a lifetime over 10 years before getting technologically outdated. (Nygaard 2010, 6.) We do not agree that in all cases such a long use time should be considered. Indeed, life time of a building complex could be as long as 100 and more years! We believe that this is clearly not a place for IT department's decision making. IT should present to a business dependency between facility expected service time related to the cost and implementation time. In the new world of business parks and globalization, business representative may introduce a much shorter time for server room life than 10 or more years. In this case client’s estimate should be used instead of a common recommendation because it can significantly reduce costs of some parts of a server room facility and deliver operational IT infrastructure earlier. However, accepting an “interim solution” without approved schedule for a final one would be a common risk here. This is because in (IT) infrastructure nothing is more permanent than once called “temporary”.

Equipment installed in server rooms may be quite heavy. Be aware of a floor loading demands. For example, a 42 RU tall rack fully loaded with blade servers can weigh nearly 950 kg (for example, Conry-Murray 2007). Some high buildings cannot support server room equipment like blade server cabinets without pricey structural reinforcements (Higbie 2005). Minimum distributed floor loading tolerance is 7,2 kPA/150lbf/ft2, recommended minimum is 12 kPA/250 lbf/ft2 (DiMinico 2006, 19.), that in metric system is approximately 700 kg/m2 for a minimum, and as recommended minimum 1200 kg/m2.

Internet discussions between IT professionals provide pages of detailed advices regarding positioning of the facility. Server room is best to be placed in a basement or on a lower ground floor preferably in a central area of the building. If you decide to place the room below groundwater line, flooding possibility should be addressed. Raised floor is often mentioned as a way of ensuring the equipment against the flood (for example SecurityForumX.com 2003). To combat smaller sources of water like water pipes breakages on the same of upper floors, water sensors can be used. Rooms with function of accommodating heavyweight hardware (e.g. blade racks) should be positioned at basement level, instead of upper floors because the latter would include costly reinforcement of load-bearing structure of the building. See calculations in later parts of this research.

Floors, walls and roofs must be of adequately sound construction to prevent unauthorized access to the server room. We review this aspect more thoroughly in later sections. The facility should be positioned adjacent to the building’s core conduits. This will reduce the cost and implementation time for acquiring data and power connectivity. If free air cooling solution is planned as a part of air conditioning, the room should be placed adjacent to outside building’s walls preferably from the shadow side of the building. This will provide an easy connection to external cool air. Even if air conditioning devices will be used for cooling, installation is easier to implement when outside air or some other large area like garage is available for a heat rejection.

Planning the routing of the electrical cables in a server room can be very sophisticated task, though adjustment to all other restraints is required. ANSI/BICSI Data Center Design and Implementation Best Practices (2011) document – the new Datacenter Standard – is a great source of detailed information and knowledge for the Server Room planner. When developing the building plan for the power systems you need to keep in mind following recommendations: minimize the distance of electrical feeders between different distribution equipment since unnecessary distance requires greater feeder sizes and therefore extra costs. You should also reserve sufficient space for the conduit runs. Try choosing conduit paths can be built with least bends of network cables. (ANSI/BICSI 2011, 21.)

Author’s own experience tells that while building a server room facility you may want to consult your company’s insurance provider for determining best location for your server room, if different buildings or concurrent areas within building are available. On one of my previous workplaces we had a mind opening conversation with risk management specialist, when he indicated that we are planning to build a business-critical facility “100 meters from the seashore, above gas station and in the building one can see a Swedish atomic power plant from the window”. Risk consultant from insurance company can also point some interesting solutions can’t come to non-professional mind. For instance, locating your server room to the same side of the railroad with the fire station can reduce your risk, therefore, insurance payments.

1.2 Space Requirements and Separate Rooms Solutions

Like it is stated earlier, sever room must accommodate all of your equipment and have space for growth. Solution must allow enough space for cabling and maintenance access to the side and back of server racks and other installed equipment. In front of the racks there should be space for technician to be able to fully extend servers from the rack and to stand in front of it also using a ladder. (SearchStorageChannel.com.) Numerically recommendation for space around server and communication racks can be specified as following: clearance at front 1,500 mm; clearance at back 1,000 mm.

Sometimes you have a chance to use two spaces to accommodate the server room equipment. In such case you might find the following recommendations useful. We discuss the need of separate rooms later in this research, where we end up not recommending having separate rooms in use of IT. ANSI/BICSI Data Center Design and Implementation Best Practices (2011) discusses in details separate room for the power supply. The room size required by the power systems will be relative to the needed capacity and required level of reliability and redundancy. In redundant installations dedicated room should be granted for each system to allow physical disjointing. Below is a listing of electrical equipment, components and systems that can be incorporated in server room plan with recommendation regarding inside or outside.

Objects typically installed in dedicated electrical space outside the core server room area:

- automatic transfer switches - ATS
- switchgears of service entrance
- unit substation transformers
- load banks
- tie breakers
- generator with paralleling switchgears
- uninterruptible power supplies - UPS
- UPS batteries
- distribution boards.

Objects typically installed within the server room area:

- power strips
- remote power panels - RPPs
- power distribution units – PDU. (ANSI/BICSI 2011, 21-22.)

Also Power Distribution Unit may possibly be located in a separate area which is adjacent to the server room. Advantage of such decision is that electricity maintenance activities can be performed outside the secure space of server room. (ANSI/BICSI 2011, 21-22.)

The size of a server room must be big enough to accommodate needed equipment and enable IT personnel to rearrange it due to changing business demands and technology. This includes changes in electrical power and air conditioning setup. The server room should have additional storage space for new hardware waiting for installation to the racks and replacement parts such as fans, power units, cards, disks and spare backup tape cartridges and empty cases. Spare PC's, monitors and other equipment used by end users often have no other secure space to be stored than within the server room. It is a common practice in some enterprises to purchase all PC's and monitors needed for one year upfront, which makes a pile of boxes easily bigger than one full 42 RU tall rack. Inadequately calculating these needs for space could make you to moving production servers to a new area, which generates a significant disturbance in service provision for the client. (Chevance & Wilson.)

Location and size of the server room are most difficult factors to change after the room is ready. While building the facility for a new client in a role of, say, external project manager or IT infrastructure consultant, it is crucial to grasp, what business is planning to do with the site you are building the server room for. As an IT specialist you need to discuss with the client different possible scenarios and point that cost of spare space for potential expansion is several times smaller than the cost of stopping all IT operations for time of moving to a new space. Client or Business representative needs to understand, that if there are plans to expand the business or intensify the IT use, server room solution should include demands for redundancy and scalability. And of course as good PM you are, you will document these conversations and add them to the Project Documentation.

1.3 Walls, Doors and Ceiling

Walls, doors and ceiling are usually designed and produced by building contractor who is aware of demands and commercial building construction regulations and policies. However, understanding basic principles upfront will help IT person responsible for server room project finding a mutual language with contractor and to assess a cost and duration of the building project in advance.

Server room might be a source of significant noise level. Cooling system and fans of operating equipment produce noise, and for this reason server room should be placed distantly from permanent office workplaces. Noise levels in server rooms may be as high as 70 dB or even more. Server room's ceiling should be fitted with sound-absorbing substance. Materials also should satisfy the demand for dust-proofing. If false ceiling is used, tiles should be well fixed so they do stay tight at their places and not fly around the room in case of gaseous fire extinguishing system is launched. (Nygaard 2010, 11,12.)

Server room should be separated from outside area by a fire-rated wall. Fire proof category of walls and door depends on local regulations. Nevertheless, successfully implemented soundproofing and fire prevention do not necessarily guarantee that a server room is satisfactorily robust to stop uninvited guests. For the purposes of intrusion prevention, walls of reinforced concrete or an addition of steel sheet to plywood/plasterboard should be contemplated. Windows should be avoided or alternatively they should be fitted with bullet-proof glass, since these may provide an easy path for intruders. Heating via roofs or outside walls by sun light should be avoided as it may call for additional cooling system capacity and therefore higher building and operational costs. More about physical security can be found in dedicated section further.

In server rooms walls, ceilings, floors and floors beneath raised floors should be finished with anti-dust agents and have even surfaces. Floor should have anti-static coverings and should be earthed to avoid the accumulation of static electricity charges. The resistance between earth and any point in the floor should be from 1 to 10 MOhm. (Nygaard 2010, 13.) Do not use carpet in server room because it is much harder to roll a rack or simply technician's chare over a soft carpet comparing to hard surface like vinyl tile. In Internet technical discussions soft carpets are also blamed for collecting dust and being difficult to keep clean and dry.

Minimal door size for the server room should be 1m wide and 2,13 m high (DiMinico 2006, 19). This size allows bringing in and out all kind of equipment which will be used in server room during its lifetime. If you are planning to use raised floor in your server room, which we will discuss in later part of this research, remember to plan space for the ramp inside or outside the room. Depending on height of the floor it can take one square meter of a floor space or even more. Placing the ramp inside or outside the server room will also determine shape and position of the door regarding the floor level. Therefore, you should decide it before completing specifications for building contractor.

Recommended minimum height for server room is 3,6 – 4,3 m and higher is better. In order to improve cooling efficiency, there should be enough space above the installed cabinets accumulating rising hot air and minimizing its blending with cold. Evidently, it also delivers space needed for organizing good lighting and overhead cable trays. The downside to a high ceiling is the increased amount of fire extinguishing gas needed by fire suppression system, if you plan to install one. The break even height is approximately 4 m. (McFarlane 2007.) Chalasani (2010, 12) describes TIA-942 Datacenter Standard demand for typical server room ceiling height as minimum of 3,5 feet (~260 cm) from finished floor to any obstacles like lighting fixtures, sprinklers or cameras.

There is an option to use a false ceiling in the service room. False ceiling (a.k.a. “drop ceiling”) performs the critical role of hiding, securing and protection of electrical cabling and as well of air-conditioning ducting. Similarly to TIA-942, the minimum false ceiling height should be 260 cm from the surface of an ordinary floor or raised floor if you plan to install it, to the underneath of any ceiling-mounted installations: sprinklers, cable holders, air ducts, light fittings, etc. (Nygaard 2010, 13.) False ceiling can also be used as a return air path to the air conditioner intake. Used in such way, it gives more flexibility in moving server racks while server room renovation. Indeed, it is much easier to move special tiles to the new place than to move pipes.

One more reason for using false ceiling often mentioned in Internet discussions among IT specialists is that it reduces the volume of the room and so increases air conditioning and fire extinguishing systems’ productivity. This is true only than there is too much of volume in the first place. However, in discussions there are always practically experienced people who do not recommend using this solution, because it is complex to design and maintain right, and is easy to build in a wrong way e.g. by using inappropriate materials or getting tiles attaching badly and so they fly all over the place every time gaseous fire suppression system is tested. It is obvious, that when a ceiling grid is installed, flexibility of the installation of lights, cable tray and duct work also get significantly reduced.

1.4 Floor

To provide scalability and sustainability, server room flooring solution should be carefully planned. The raised floor is a widely used feature of server room installations. The design principals of the server room raised floor have remained rather unchanged for decades. The junction of IT and telecommunications has approved again the usefulness of assembling computer rooms with raised floor solutions utilized. Originally, server room raised floor concept was developed and implemented to deliver the following utility:

- supports, tracks, conduits for cabling
- a copper grounding grid for of equipment
- cold air distribution system for air conditioning.

Figure 1. Raised Floor

Despite the evolvement and significant changes of requirements of server rooms happened after the introduction of raised floor concept, raised floor still continues being a key design component of every advanced server room facility. From air distribution point of view, raised floor is one of the most practical solutions since it provides the most predictable cold air distribution setup. So far, any proposed alternatives to server room raised floor solutions have had only modest results. Instead, troubles coming from the use of raised floor are minor and cost can be well predicted. (PTS Data Center Solutions.)

The role access floor is having in modern data and communication rooms, is very significant. Raised floor solutions allow simple segregation of communications cabling and electrical wiring. While business demands evolve, this design gives the room owner flexibility to reorganize communication networks and change the way server room is operated. Raised floor is in addition a very efficient method of simply keeping cables out of site. Installing applications under the raised floor also reduces the risk of their contamination from dirt and dust that easily accrue in server room environments. (Comms Room Services #1.)

Perforated tiles are used for a cold air delivery to the front of the servers. ANSI/BICSI Data Center Design and Implementation Best Practices (2011) paper pays great attention to floor designing details. Recommendation for the design phase is that the general layout of the raised floor is identified before defining the exact positioning of the perforated tiles. HVAC (Heating, Ventilation and Air Conditioning) designer needs to agree the estimated number with the technology consultant to ensure that the construction documentation requires the proper quantity and type of perforated floor tiles and cutouts. The accurate locations of such tiles can be specified before the flooring system installation. (ANSI/BICSI 2011, 29.)

Computational fluid dynamics (CFD) uses mathematical methods and algorithms to analyze and solve tasks that involve fluid or air flows. CFD model of the floor design could help to ensure that the cooling design fulfills the operational requirements generally and also to define the exact positioning of floor tiles, so server overheating can be avoided. (Electronic Environments.) Cutouts that are not properly closed are a problem which needs to be addressed. Half-filled cutouts can generate the situation when more than half of the cool air does not reach the perforated tiles. The positions of the perforated tiles and tile cutouts are finalized basing on the decided positions of equipment cabinets and racks. (ANSI/BICSI 2011, 29.)

As a small but important detail, the Standard recommends aligning equipment racks back and front sides with the floor tiles' rims. The nearby clear floor tile can then be detached with no need to move cabinets. Perforated tiles should not be assembled until needed, since cold air distribution system performance will be affected negatively by every unnecessary installed perforated tile. (ANSI/BICSI 002-2011, 29.) IBM describes the task of cutting and placing raised floor panels from the floor panels' integrity perspective. IBM recommends distributing the weight of the rack on several 600 mm floor tiles. Otherwise additional pedestals might be needed especially when cutouts for air and cables weaken the panel significantly if done all in the same pane. (IBM.)

Standard for Data Centers recommends raised floor for its better appearance than one of overhead cabling. Raised flooring allows better control of conditioned air distribution, higher power densities and better flexibility in location of air conditioning equipment. The Standard claims that stand-alone computer systems are usually designed for cabling works done from below, and so delivering cables through the raised floor is more convenient. (DiMinico 2006, 25.) Basing on our own experience, cables can be pulled from the top of the rack as easily as from the bottom. Raised floor however makes possible to separate aisles for power and network cables.

Raised floor height recommended by McFarlane (2007) is at least approx. 46 cm. If you can't have at least that, you will be forced significantly limiting electricity power you can put in per server cabinet. If your server room is rather small, you will have very irregular cool air flow because of a lower floor height. “Engineering is a business of tradeoffs, and you should have a careful evaluation, including CFD modeling, before deciding on floor and ceiling heights in a restricted space.” (McFarlane 2007.)

The Signal Reference Grid’s (Figure 2) purpose is establishing an equipotential ground plane for all electric devices installed in the Server room. Everything in connection to it “moves” in sync in the case of an electrical disturbance coming from any source. Electronics functionality is disturbed when there is a difference from one device to other in potential. An equipotential grid radically decreases potential differences, as a result reducing current flow and removes the harmful affect on logic circuits. It is important to note that electrical noise of any frequency can be only reduced more or less effectively, never completely removed. (Compaq.)

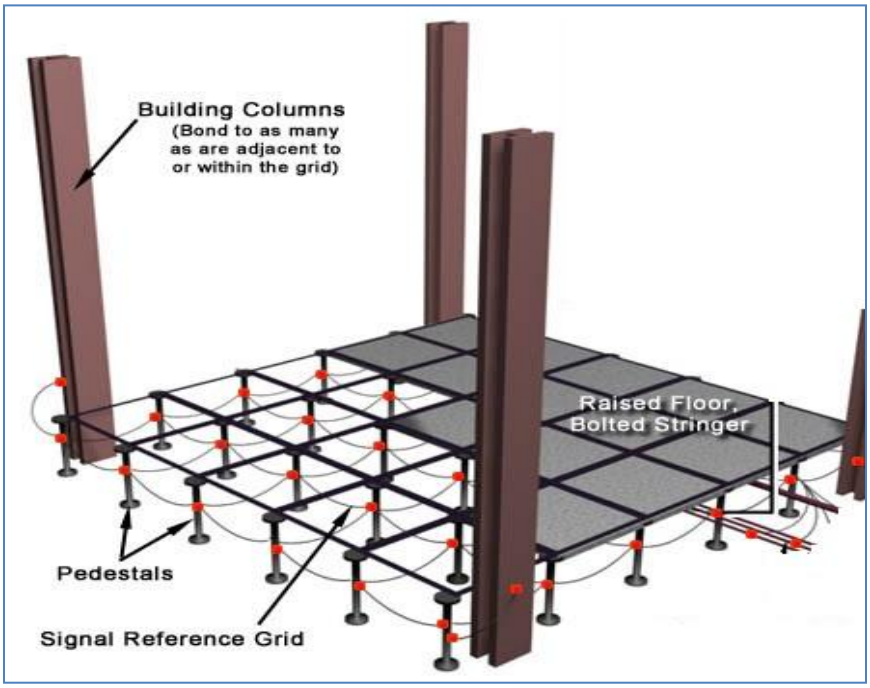

Figure 2. Signal Reference Grid (Compaq)

Neil Rasmussen (2006) however points, that the new network connectivity techniques as fiber, wireless and Ethernet are less or not at all as sensitive to the electric noise as SCSI, parallel ports and video cables. He claims, that network reference grid is not needed any more, since such old connection types are not used in modern server rooms. We still recommend using one, since for example KVM switch used by Operator’s console connects all managed devices to the same place using low immunity cabling.

The last but still significant thing to mention here is a cleaning. Technical facilities such as your server room are usually not in a scope of cleaning companies, serving the building. Access restrictions are not making the issue any easier. You need to discuss this matter with your company's facility manager and get monthly cleaning of the server room organized. One trick suggested by many practitioners in Internet discussions is setting the ventilation for the server room to overpressure. Even small overpressure keeps most of dust outside your server room by pushing air out, not sucking in.

1.5 Overhead Cable Trays

In server rooms it is a part of a standard design to put telephony and data cables from racks above cabinets and racks and power cables beneath the raised floor. This design provides good separation of two types of cables. Cable routing must be in balanced relation with the delivery of cooling air and installation of pipes for the room cooling equipment. It is important to avoid installing too much of equipment and cables beneath raised floor since doing so might disturb the circulation of cooling air. (Nygaard 2010, 13.)

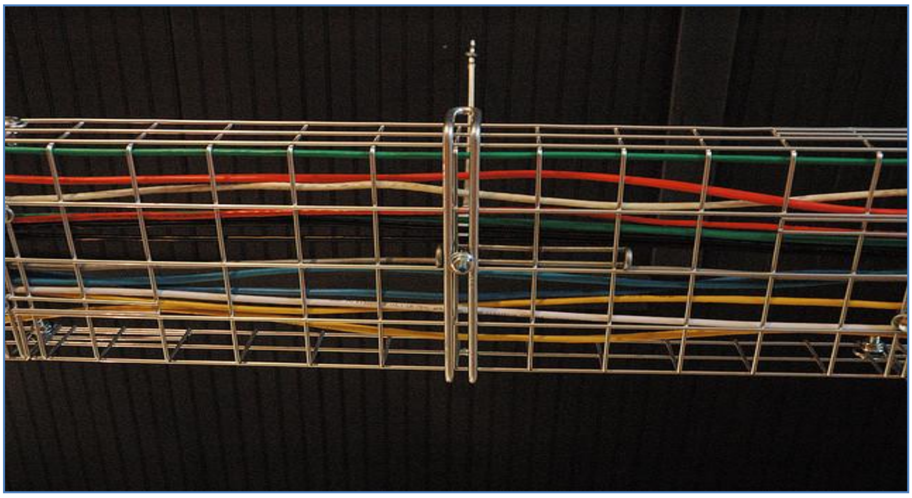

Figure 3. Overhead Cable Tray

Putting cables on the overhead cable trays (Figure 3) is much cheaper solution than building a raised floor. Cable trays can be mounted on the top of racks. Suspending trays from the ceiling delivers flexibility for supporting different size cabinets and for task of reorganizing racks. Installation of cable trays can designed using several layers approach. You need to coordinate trays' location with lighting, ducts, overhead conduits and overhead power distribution. Basing on TIA-942 Standard DiMinico suggests overhead cable tray to be split to a three layers reading from bottom to the top: signal, power and fiber. (DiMinico 2006, 27-28.) Using raised floor or overhead trays do not exclude one another.

1.6 Power Supply

Server room power systems are not to be taken lightly. Without robust solution for a power supply, it would be impossible to operate the whole scale of equipment that most organizations have. Many individual factors affect the decision regarding the type of power supplies you need. It is also important to calculate carefully the total quantity of power you require including future expansion, since only doing you will be able you to build a system that meets the needs of the client -- current and future. But providing enough power is just a first step in completing power system design. ICT systems demand conditioned power with redundancy, scalability and backup built into supporting power systems.

You must have a detailed electrical plan at hands before any electrical cable or any circuit breakers installed. If task seems to be too difficult to be worked out alone, you always can get assistance form electricity system subcontractor. There are two possible ways to decide how much power you want to have in your server room. One is to calculate **maximum** load ratings from all the hardware you will have installed from the beginning, make an intelligent guess regarding the hardware is likely to be added in the future with **maximum** load ratings of that, and adding these amounts together produce a figure. However, doing calculations this way you will highly overbuild the power system, because **nominal** operational load ratings for hardware are usually significantly lower that introduced as a maximum by manufacturers in device specifications. For instance, for regular server relation between maximum and normal operational power can be as high as double. Overbuilding leads to overspending. Another way is to develop a power supply plan using the **nominal** operating power figures specified by manufacturer instead. The drawback to designing your system this way is that it results in the inability of all equipment to start up simultaneously because the spike in power consumption happens during the first minutes of the device startup. (Lowe 2002.) You probably will need to add planned delays in systems automated start up anyway, because applications of a lower layer like networks and data storage should be available before database servers and finally application servers can successfully boot.

Power supply for a server room can be organized in a variety of ways. Basis for the design lays on an answer to a question: what level of reliability of IT services you need to provide to the business. Workgroup file and print server used during workdays demands for a redundant power supplies in servers and UPS. Server room with high demand for reliability like one hosts network infrastructure servers such as name servers or identity and access management databases needs a much robust setup including redundancy in power circuits backed up by UPS and a diesel power generator. (Lowe 2002.)

The quality of the electricity power for server room equipment is important to the equipment's long-term reliable operation. When you install new power systems, check the quality of the power coming into the building to make sure that it is within standards demanded by hardware manufactures or the applicable Authority Having Jurisdiction (AHJ). There are specially designed for this task power monitors on the market. If power quality is low, advanced UPS or power conditioning device will be needed to solve the problems. (Lowe 2002.)

Power strips attached to power hips are the best way of delivering power to the server racks regardless of are you using raised floor or not. Power strips are power outlets on the end of flexible power cables – power whips - which can be attached to the rack. (Figure 4).

Figure 4. Rack mounted power strip

You will need to provide each physical server with at least three power connections: to for redundant power supplies and one for a remote management card. Here as in network cabling you can use a color coding, so you will not connect both power supplies to the same circuit, which would on one hand overload it an on the other remove the redundancy from the power supply. You could use for example gray, black and white whips and power cords and add a color mark to each power strip in the rack cabinet. Power strips than can be connected to the different supply or phase dependently on what power supply configuration you decided to have in your server room. (Lowe 2002.)

ANSI/BICSI Data Center Design and Implementation Best Practices (2011) recommends following: adequate working space should be provided for access and maintenance around all electrical equipment. Specifications for this can be found in the manufacturers' instructions, applicable official standards or the relevant AHJ. Adequate access should be organized to the spaces containing electrical equipment for replacement or maintenance. Standard recommends, that electrical distribution system parts like switch gears, UPS and batteries must be placed in dedicated electrical facilities or otherwise located outside of the server room space. (ANSI/BICSI 002-2011, 21.) So far we have not seen enough bases for demand of building a special electricity room. If once in a while electrical systems should be maintained, access to main server room will be needed and supervision of IT person should be granted any way, with dedicated room or without it.

One more related to the power supply thing to ensure while building a server room in a new location is a contractual reliability. This means that you should be able to negotiate with the real estate facilitator about power maintenance breaks. If there is no mentioning about break length and time in the contract, they can be anything any time, and IT will be the first division of the company suffering from this.

1.7 Uninterruptable Power Supply

An Uninterruptible Power Supply (UPS) is a device that is assembled between the mains and the ICT device to avoid undesired features of the mains from unfavorably affecting the operation of the device. Such undesirable features to be mentioned are: outages, surges, bad harmonics, etc. UPS usually be capable of performing the following functions:

- carry on providing power to hardware during mains outage for certain time after a blackout has happened
- clean out noisy power supplies by cutting off moderately small surges.

In addition, some UPS alone or in combination with software provides the following functions:

- automatic systems shutdown if power outage excess the certain period of time
- display power consumption data
- restart equipment after a resolution of outage
- send alarms basing on certain triggers
- provide short circuit safety. (Christenson 2005.)

In addition to maintenance activities organization, other two factors to consider while planning putting electrical subsystem elements outside your server room or inside it are heat load and noise. The heat input to a server room from a single small unit of 1 kVA is insignificant. However, larger multiple units UPS system will increase heat load on the air cooling system more. For example, heat production of an on-line 5 kVA UPS device is 2900 BTU/hour. Audible noise of UPS is a significant concern only when it is placed in a work office area. Majority of systems have a noise level of 50-60 dBA measured at two meters distance. (Pacific Gas and Electric Company.)

You need to insure that the power supply supporting your server room is sufficient for growing needs of the business in the future. Saving on UPS during the server room building project might turn into a great replacement project later. Allocate enough electrical capacity for adequate lighting and several power outlets. Designing this right makes future enhancements and maintenance easier. (Chevance & Wilson.) Emergency lighting should get power supply from UPS or own battery enabling rescue and maintenance during power outage.

Ensure the reliability of the UPS for the future by making a maintenance contract for it. Other option is once to find out that batteries in your UPS are 1. not functional and 2. deformed in the way that you need a tool set of car mechanic including lifting jack to get them out of UPS. Companies providing UPS's will be happy to provide your company with such a contract and renew it automatically once the existing expired.

1.7.1 One or many UPS's?

There are rack mounted UPS's and stand alone UPS's. How many UPS devices should one consider to install in server room? Generally options are: one for each rack or one or two for all IT hardware. There are several incentives for choosing between presented solutions. Reasoning comes from price, redundancy, scalability and maintainability.

Grounds for securing every server cabinet with UPS could be justified by avoiding establishing a single point of failure. Outage of one UPS, shots down all systems which are using it as a source of power. However, in server room devices are often inter-dependable in application delivery. For example, functioning network is essential for all applications, and so is data storage. Basing on previous, installing UPS for each rack instead of standalone UPS solution creates several single points of failure instead of removing them. One more point to consider is, that monitoring and maintenance of one or two standalone UPS's is much less complicated then one UPS per rack. Considering solution price, making several small UPS's redundant means one small UPS purchase; making standalone UPS redundant means second big UPS purchase. Scalability is also easier provided with small UPS's. (UPSonNet.#1.)

When loads and setup allow, consider purchasing three single phase UPS systems, each fed from singular phase, instead of one three-phase UPS. With limitation discussed above such solution enables operations continuity if one of UPS's or one of input phases fails. Three single phase units may cost much less than one three-phase UPS unit. (UPSonNet.#1.)

The capacity of the UPS is a next important thing to define. Plan to maintain on backup power supply only devices which need be run during the outage. The UPS must support communication items, servers, in some cases personal desktops (laptops are equipped with batteries), and emergency lights in case they are not provided with own batteries. Connect desktops and screens to UPS only if you need to provide service to clients despite main power loss, for example network operators' workstations. Prevent connecting multi-functioning printers, non-emergency lights and so, even if the UPS capacity makes it possible. (UPSonNet #2.) We would add to the list the cooling system, as will be discussed some pages further.

There was a real life story in one of Internet discussion forums about UPS solution failure. One of them told a story about well-defined and -built system which was suddenly no good for a job, because office workers learned to use UPS powered power outlet for boiling tee water during power breaks.

To correctly define power availability, you need to understand connection between VA and Watt ratios, since both are used in documentation provided by suppliers. The Wattage figure stands for the quantity of real power required by the load. **Power Factor** which is the Watts to VA ratio is calculated basing on the nature of the load. Power Factor can in theory be any figure from zero to one, but it usually lies between 0.6 and 0.8. If you do not have the exact number, Power Factor of 0.7 should be fine for large systems. (UPSonNet #2.)

You should also take in account that the backup time is powerfully related to the volume of your load (Figure 5). Lower load extending the battery time because it draws less current from the batteries. Adding to the UPS capacity 20 - 30% extra, which is anyway a good practice, will enable you to grow protection time of your IT network for considerably longer time. As a rule of thumb, if you need UPS to keep 1000 W equipment up for 30 minutes, you need at least 1000/0,7*1,2*0,5 ~900 KVAh device.

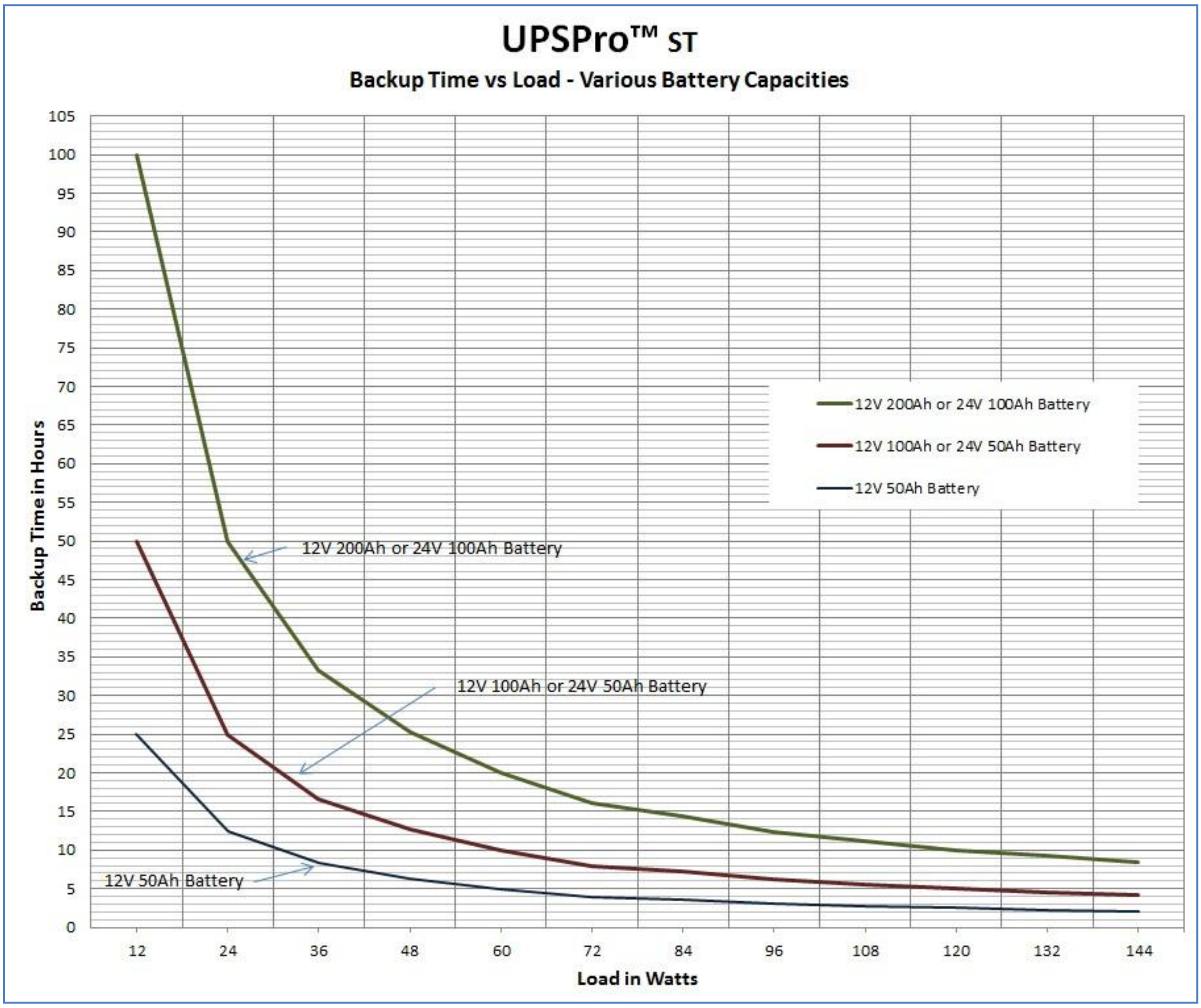

Figure 5. Backup time vs. Load (Tycon Power Systems)

Statistically, in developed countries the length of 9 from 10 of utility grid outages is shorter than 5 minutes. The number of outages is normally from 10 to 30 per year. If server room you are building is not located in a particularly electrically instable region, you may anticipate not more than 3 over 5 minutes long power grid failures a year. Unless business you build a server room for is providing uninterruptable real time service, you might be content with an UPS setup that keeps your equipment running normally for 5 minutes, and then turns off your servers, disk shelves and network devices in a controlled way. Most usually power outage will usually be shorter than 5 minutes, and shut down procedure won't be used. For that reason, 7 to 15 minutes back-up period should suffice for most small installations. If you need to stop applications one after another, like networks after servers, you need to double or triple this time, because shutting down all hardware together will definitely disturb a shut down procedure of some advanced applications. Purchasing UPS system, make sure it comes with software suitable for your network, servers and software. (UPSonNet #2.)

Power outages often come in sets of two, when after first outage technician was able to restore the power but it fails again after a short time, because the root cause of failure was not eliminated. After the first break power is shortly restored and UPS countdown is reset, but batteries were not refilled. It make sense thus to use shorter count down time before controlled shut down, than UPS capacity allows.

1.7.2 UPS Classes

Generally speaking, there are three types of UPS's: the least costly **Off-line UPS** is at the same time the simplest one; next in cost is **Line Interactive**, in which the major disadvantages of off-line devices are corrected and finally **Double Conversion On-Line UPS** which delivers the best power delivery insurance for the highest price.

An Off-line UPS, which is also known as Back-up or Stand-by provides the load from mains in continuous operation. Upon outage, the load connections are re-connected to the batteries providing juice to equipment through the inverter. Most of the high frequency harmonics and short-range spike surges are corrected using dedicated filters. On the other hand, longer turn fluctuations of a voltage can harm protected hardware when such UPS is used. Off-Line UPS's are generally provided with spike suppressors. Such suppressors should protect the hardware from voltage spikes coming from utility grid. Off-line UPS's are used generally as SOHO power backups, added to the personal computers and applications which are less critical. In these installations eliminating 85% to 90% of malfunctions caused by power problems is acceptable. (UPSonNet #2.)

Professional installations generally require better protection. It is offered by Line Interactive UPS, a.k.a. "Smart" or "Interactive". Like Off-line systems, Line Interactive UPS is also working on stand-by scheme, in normal operation feeding juice directly from mains, switching to batteries upon power loss. As an improvement to Off-Line UPS, this type is equipped with supplementary circuits' filter which corrects output voltage, maintaining it inside allowed acceptance band, thus supplying the critical load with conditioned power. Line Interactive UPS's capacity generally lays in the range of 0,5 kW to 5 kW. They are widely used to provide a power back-up solution for servers, network devices and other computer hardware in this power range. (UPSonNet #2.)

Line Interactive UPS units are used to provide short backup times. Usually their main task is to provide a controlled shutdown after some minutes after beginning of outage. Like the Off-Line unit, here is a risk to find the failure at the moment when power is switched to the battery. This is because of its stand-by behavior, when battery is not involved in operations and therefore is not continuously tested. Any concealed malfunction, for instance loose connection or faulty batteries might be found at the exact moment when device suppose to fulfill its critical mission. (UPSonNet #2.)

Neither Off-line nor Interactive UPS's are capable of correcting frequency. Because of this they should be avoid on sites outfitted with small back-up power generators. Such generators generally provide weak frequency control. The Line Interactive UPS is a good solution in IT installations where 90% to 95% of utility grid instabilities should be eliminated. It is also possible to back up with Line Interactive UPS less critical for business equipment, and at the same time servers and network equipment with On-Line UPS. (UPSonNet #2.)

On-Line UPS is also known as a True On-Line UPS or Double Conversion UPS. This is the supreme solution for all loads from 1-2 kW up to MW consumers. In these devices the load is continuously provided from the inverter, feeding equipment with conditioned voltage and stabilized sinusoidal waves. In occurrence of UPS malfunction or failure mains line in these systems keeps providing power to the load after the Transfer switch automatically makes the turn. Same will happen in case of UPS overload. The on-Line UPS provides an output voltage which is generally stabilized inside one percent tolerance band. If frequency malfunction is wider than tolerance band, free running crystal controlled clock in UPS starts dictating the output frequency. (UPSonNet #2.)

These advantages of Double Conversion On-Line UPS type turn it into the superb solution for business critical installations. It is the best choice despite of the increased equipment and electricity costs. On-line UPS provides the best electricity safeguard against any and all types of mains faults. Such system has no size limits. In practice, no limit exists on the increasing available back-up time. Back-up time may be increased by adding more batteries. On-Line systems usually allow increasing the power to satisfy the growing load. UPS units can also be connected in parallel redundant configuration to enhance reliability. Finally, Double Conversion On-Line UPS s is the best alternative to provide modularity, hot swapping, power factor correction, fault clearing, reliable work from generator, supervising, maintenance and communication. (UPSonNet #3.)

Testing UPS should be done with the switch, not by pulling the plug from the wall because while pulling the plug you also disconnect the ground reference, and this is not a good practice. Almost all UPS's use lead-acid batteries, which are similar to a car battery. Running such batteries to a "deep cycle" meaning very low level should be avoided since they decrease lead-acid batteries effectiveness. For sure, emptying the batteries during the power outage situations the ultimate reason you have purchased a UPS in the first place, but you should avoid running a UPS empty when it is not needed. (Christenson 2005.)

1.7.3 Could UPS cause explosion?

Often putting UPS to a separate room is decided basing on fact, that UPS batteries produce hydrogen while charging, and thus can cause an explosion. The outcome of hydrogen explosion in forgotten battery store room is shown in Figure 6 taken from H2Incidents web page. UPS batteries which produce hydrogen really can cause an explosion! However, let's also look at *Explosion Lessons Learned* section of the same site. Does it recommend keeping UPS's in separate firewalled and explosion safe room? No it doesn't. Hydrogen specialists only recommend taking care of proper ventilation. While discussing this topic with Corporate Security Manager of Enterprise important piece of advice was produced: "To avoid guessing and guaranty the business continuity, always consult safety requirements provided by UPS (or any other hardware for that matter) manufacturer for proper installation! Manufactory knows its devices and is accountable for safe use of them."

Figure 6. Explosion in UPS Battery Room. (H2Incidents.)

Department of Defense of United States of America produced paper named Military Handbook, Electronic Facilities Engineering (1989), which contains an answer to the question about possibility of UPS explosion, and more important, how to avoid it. Hydrogen level produced by for example legacy device Emerson 750 KVA UPS can be kept below safety concentration by ventilation rate of 32 CFM. Current ASHRAE standard (Standard 62n) states that appropriate ventilation guideline is to provide 17 CFM (9.2 L/s) per person in an office building. (Kohloss 2003, 16.) Thus "normal office area ventilation" assembled in a server room will keep level of hydrogen safe.

And as last but not least, there is a new type of batteries on the market that are not passing any gases outside the container at all. For such sealed **VRLA** (Valve-Regulated Lead-Acid) **batteries**, the whole discussion above is completely irrelevant because hydrogen is not passed to the server room space at all.

1.7.4 Power generators

Generators (Figure 7) are used to guarantee your server room continual functionality during a long power outage. A flawless transition from mains to standby generator provided power is crucial, because it enables your critical ICT applications run without interruption as long as needed for mains power to be restored. The purpose of a power backup generator is to provide power for a sufficient period of time. Here we assume that the generator is refueled from time to time in the event of a long term outage. If company demands high availability for IT systems, one thing to remember is that you should have refueling and maintenance contracts to ensure generator's functionality. (Lowe 2002.)

Figure 7. Standby Gas Powered Generator

Decision of locating the generators either indoors or outdoors should be based on client requirements and facilities constrains. Locating generators outdoors on indoors does not usually have a big difference in cost. Other constricts to be considered should include:

For both solutions

- constraints regarding heaviness, vibration, physical structure and fire rating demand for surrounding area;
- diesel tank size and position;
- local officials' and building related rules and regulations.

For positioning indoors

- cost of floor space;
- additional costs for fitting generator indoors such as louvers, noise reduction etc.

For positioning outdoors

- greater risk of exposure to weather and physical damage. (BICSI 002-2010, 34-35.)

Same standard updated in 2011 recommends having generators installed indoors. As a reason to this recommendation writers claim that indoor generators can be monitored and maintained easier, especially in times of bad weather conditions disrupting mains, when generators' operation may be needed. If indoor installation is not a suitable solution, outdoor installation setup should contain a shelter for generator. Generator exhaust systems should not lead gases into facility's ventilation air intakes but preferably on the downwind side looking from ventilation air intakes. (ANSI/BICSI 002-2011, 22-23.)

Nowadays both – indoor and outdoor installation – are equally possible for backup generators. Before choosing your option, it is good to know different considerations regarding each solution. It is obvious, that installed indoors, generator is easily accessible and secured. It can be installed close to the server room facility minimizing a need for cabling and facility owner resistance. On the other hand this solution is more expensive and troublesome, since issues like maintenance access, fuel deliveries, engine exhaust and silencers, cooling air intake and discharge, acoustic noise limitations, vibration demand more planning effort than in external installation solutions.

In some cases it is too difficult to install the generator inside due to one or several constrains listed earlier. In such cases external installation should be chosen. This is a cost effective and environmental friendly solution. Installation outside the building demands for a weatherproof enclosure with sound reduction. Area for such installation should reside ideally immediately outside the building. Constrains here are demand for acoustic noise level and exhaust emissions. Noise levels are typically up to 80 dB. Less than 65 dB can be achieved using combined noise reduction techniques, but the cost and physical size of such solutions often excesses the limits very quickly. (Comms Room Services #2.)

Again, IT security is as strong as its weakest link, and such a link can be found in very surprising places. For example, we know cases when electricity productions and thus IT service provision continuity were jeopardized because generator's fuel tank was emptied by thieves between regular maintenance checks. Here too, we recommend using external contractor to keep generator checked and refueled for the certain performance.

Size of generator you need in addition to the supported load depends on the **duty cycle** in which the generator will be expected to operate. The duty cycle means simply how often the generator is expected to be in operation. Three types of backup power generators' duty cycles are Base Load (Continuous), Prime and Standby. Standby generator type is commonly used to back up essential loads in environments, where mains power is generally stable but power loss to critical services are highly undesirable. Natural Gas, Liquid Propane or Diesel allow a quick cold start and thus support the standby function best. (Comms Room Services #2.)

The load is derived from the power requirements of the assets and equipment to be supplied. Since you are probably not planning to start your server room from the power generator, you do not need to account maximum power usage figures of the ICT equipment. Operational normal can be used here. The difference between total and essential load can be significant as well. Typical essential load include items which you must have on during the power outage: emergency lighting, UPS, server room air-conditioning and power for operator's workstation. (Comms Room Services #2.)

Start options for generators are Manual, Remote and Automatic. It is clear, that only automated option is suitable for server room backup power supply change to the generator. In case of human intervention there should be instructions, training and shift list, all established to ensure, that operator is present, knows being operator and knows how to operate the switch. Automatic start or AMF (Auto start upon Mains Failure) module is a combination of an automatic start module with an Automatic Transfer Switch, which are together able to start the generator and start providing power to the server room basing on set of logical pre-conditions. Switching back to mains once outage is over can be done automatically or manually. (Comms Room Services #2.)

1.8 Cabling

In providing Information Availability i.e. making information available when it is needed, physical network plays a key stone role. We already have addressed cabling structure in earlier parts of this research, namely in raised floor and false ceiling dedicated sections. In this part we describe fundamental principles and latest findings regarding cabling design. We also will provide some advice for organizing network and power cables while setting up servers.

Cabling standards are evolving all the time aiming better fulfillment of ever growing networking requirements coming from new information and communication systems and technologies. Your server room network solution needs to be ready for support bandwidth hungry applications such as data replication, videoconference and multimedia. At the time this research is produced, Gigabit Ethernet standard have to be used to match data availability demand in typical business environment. (Higbie 2005.)

Cabling must be run allowing growth. You need to cable for current needs keeping in mind what you anticipate as a business demand in the future. In practical terms for network this means that you need to provide a cabling enough for speeds that you will use during the next 10 years. 10 gigabit systems will certainly come into use in such time.

We already questioned the idea that Server Room is built to last for at least 10 years earlier. While deciding whether going on faster and more expensive standards or not, remember that in a standalone server room network cabling for its most part will be easily upgradable later. Indeed, connecting server(-s) to switch(-es) means putting a network cables from one rack to the next/second next standing, and in usual case of several network interfaces per server, upgrading a link for cabling part means just cutting a couple of plastic zip ties. In such case decision of network capacity lies on application and networking specialists and business representatives and affecting physical server room design work very little.

Story is of course slightly different, if you need to connect servers and back bone switches to the communication devices standing in separate communications room. Doing so makes future upgrade much more difficult, and here you probably need to address higher than current demand and consider using next from Gigabit Ethernet network speed standard i.e. 10, 40 or 100 Gigabit Ethernet. However, at current prices (see for example Haber 2011 and Lawson 2011) going to 100 Gigabit networking without demand at hands just to avoid re-installation of cables between rooms does not make much sense, because market prices per port for 10, 40 and 100 Gigabit are $600, $1.000 and $150.000 respectively. Once again, here decision of network capacity to be installed lies in application and networking capacity planning.

Assembling cables, wires and cords cleanly and neatly organized, provides effortless tracing of cables and makes replacing of bad cables simple. Good cable management also provides space for a good air flow in the back of the servers, which is important enough even alone. Cable management is a science, and if it is implemented and managed in your server room properly this will reduce networking incident resolution time in the future dramatically. Decide early if your cabling will run overhead or under the raised floor, and if both ways, which type of cables will be run over and under.

Define specific zones for network cable runs and keep electrical lines away from them. Be sure to keep copper cables on separate runs from fiber because the fiber can be crushed by the weight of copper cable clusters. Implement enough room in cabling design to the proper bend radius of different types of cables. Using color coding greatly simplifies cable management; properly labeling each cable will save significant time opening floor tiles trying to locate a bad cable. (Klinder 2005.)

“Never use another man’s rifle!” is a quote from the movie which comes to my mind while discussing an option of using network cables left by previous tenant. You do not know who terminated, put these cables in place, who used them and how. Ergo, you can’t be sure they will not blow up in your face. Author has read about network installation where Cat 5 cables were “marked” by making certain number of knots on both ends of the cable.

If you are re-using existing server room, be sure to have all legacy cables removed before starting installing new ones. It is beneficiary to have all abandoned cables out of your way before you start installing new ones. Spare abandoned cables will disturb air flow, can add fuel for a possible fire and could cause lots of confusion in maintenance phase. (Higbie 2005.)

Using cable color code (Figure 8) can add much clarity and remove lots of anxiety from networking maintenance works. If you use three physical Network Interfaces in each server, make them going to three different switches: Red, Blue and Green. All Ethenrnet0 connections go to Red switch using red cables; all Ethernet1 connections go to the Blue switch using blue cables and Ethernet2 going to Green switch using green cables. Uplink cables connecting to outside world like to the DMZ or ADSL router should be off color, like gray, so that they stand out in every group of cables. (Simons 2008, 2009.)

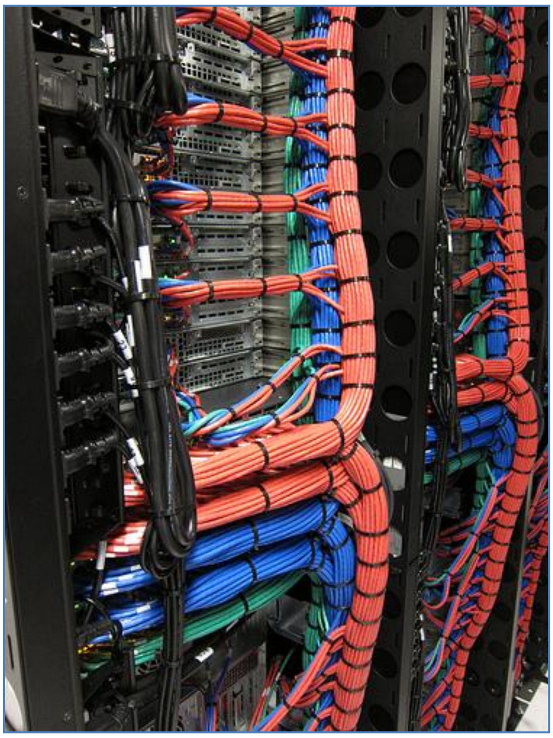

Figure 8. Using Colors (Softlayer.com)

Your racks will have redundant power supply. Using color coding for power cables makes sure that you don't overload single circuit accidentally and don't connect both/all power supplies to the same circuit creating the single point of failure. Keep copper network cables as far as possible from power cables. Power cables, especially clumps of them, cause electromagnetic interference on unshielded CAT-* cables, and this creates massive packet loss. Racks usually have a built-in cable management to supply servers they contain. Usually there are cable channels running vertically along the back corners of the cabinet with entry points placed systematically along the way. It would be perfect having network cables on one side of the racks and power cords on the other. (Simons 2008, 2009.)

It is surer to buy cables than to make them yourself. Only disadvantage in buying bulk is that you do not get cables with exact needed length. However, self made ends may not last as long as molded ones, and this finding is very uncomfortable to make some day at three o'clock in the morning. To obtain right amount of cables of needed length you plan a rack build, choose where equipment will be relatively to the switches and then buy cables of length based on that distance. Use Velcro zip ties to bundle the cables to the groups and also to make larger bundles from smaller groups. Plastic zip ties should not be used on anything that could need to be replaces, even if they are re-open type. (Simons 2009.)

Generally, there are three ways of delivering connectivity to a rack server:

- Connect to a network core switch every data port;
- Provide a separate switch per rack or per row basing on bandwidth demand. This approach is often called Zone Switching
- Provide patch panels at both the core switch and the rack and establish cross-connections between them. (PTS Data Center Solutions.)

“Vertical cabling" and "horizontal cabling” are widely used terms and they come from network architecture design basics. Vertical cables are also called “backbones” and they are laid between distribution facilities like between central hub and server room. Horizontal cables are laid between distribution facility and endpoints. The important part in lying cabling between areas is, that this cabling is more permanent comparing to rack patching. Because of this difference, Velcro is not good any more, and here you should use zip ties. Because of the permanent nature of installation, you will not need to take the cables out of bundles too often. (Simmons 2008.) Some firms offer ready to install pre-terminated cabling system delivery. This approach can reduce installation time and testing times significantly.

1.9 Cooling

Adequate cooling is crucial to ensure trustworthy operation of ICT equipment which produces significant loads of heat whilst operating. Malfunction of the air conditioning can break the equipment and jeopardize business continuity of your client. Early notification of cooling system malfunction and extra air conditioning capacity are both very recommendable. And as earlier, you will save yourself and them coming after you from lots of trouble by making an automatically renewable contract for cooling device maintenance.

Air conditioning is acquiring a high share of the power consumption (approximately same volume as all other hardware installed together) within the server room, selecting the right air conditioning solution can have a significant impact on financial and environmental running costs. In modern server room, business critical ICT installations create a number of new problems related to a cooling design. These are fresh constrains which could not have been anticipated when the data center cooling design principles were developed over 30 years ago.

Adaptability and scalability requirements for server room cooling systems remain a big challenge for many firms. This includes problems with cooling of already installed high density blade server systems and impossibility of predicting their usage growth. Server room cooling task is complex because of the fact, that ICT systems typically are refreshed every 1,5 to 2,5 years. Cooling system for the server room should be designed flexible and scalable, with features of redundancy. The server room cooling requirements should include pre-engineered, standardized, and modular solutions. (PTS Data Center Solutions.)

Once appropriate design goals are established in collaboration with business, there are a following steps recommended for server room cooling design best practices, listed by PTS Data Center Solutions – a data center consulting firm and turnkey solutions provider from USA.

- Determine the highest heat load. Start with the identification of the heat producing hardware to be deployed. Additionally, the lighting, heat lead from the adjacent areas and people working in server room will contribute to the total heat load. Instructions for defining heat load from other sources than equipment you can find later in this chapter.

- Estimate power consumption on a per Rack Location Unit (RLU) basis. A good basis for defining the consumption trend is that average RLU power density is growing every year. Usually racks with variety of power densities are deployed throughout server room overall area. The challenge is to supply these RLUs with varying densities with cooling using only the average RLU density as the existing basis. The fact, that same RLU's provide different heat load in different operation cycle stages is not making this task any easier.

- Determine the cooling requirements for each rack. For cooling to be sufficient you need to provide an **adequate quantity** of air with the **proper temperature**. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standard recommends temperature band of 20°-24° for the air delivered to the inlet of the IT infrastructure[1]. Despite the fact, that electronic devices perform more steadily at lower temperatures it is not recommendable to make

[1] ASHRAE Thermal Guidelines updated in 2011 (ASHARE 2011, 4) recommend enlarging temperature-humidity envelop significantly to temperature range of 18-27 and relative humidity of 20%-80% "driven by the desire for achieving higher data center operating efficiency and lower total cost of ownership (TCO)". However, as we will see later in this section, due to computing hardware behaviour the temperature corridor can't be so large.

cooling air too cold due to the threat of getting to the condensate point. Regarding air volume, good guideline is that 1 kW of electrical load requires 160 cubic feet of cooling air per minute.

- Execute Computational Fluid Dynamic (CFD) modeling. It can be performed for the both areas: above and below the raised floor. In a server room it provides information essential for making knowledgeable decisions about placement of air conditioning equipment, IT-equipment, perforated tiles, high and low density RLUs, etc.

- Create a Cooling Zone Strategy. As stated above, efficient server room cooling is as much about adding cold as it is about removing produced heat. In general, the three methods of the server room cooling along with their average heat removal potential can be seeing in the following table (see detailed description of methods at the end of steps list):

Room Cooling	~2 kW per Rack Location Unit
Row Cooling	~8 kW per Rack Location Unit
Cabinet Cooling	~20 kW per Rack Location Unit

- Define the Cooling Methodology. In addition to cooling zone requirements, what types of air conditioners will be used must be decided. There are four types of air conditioners: **air cooled; glycol cooled; chilled water cooled** and **condensed water cooled**. It is also important to define how heat within the system will be rejected. Next thing to determine is what type of cooling redundancy is required and available, meaning for example, that air flow system can be made redundant with water cooling solution.

- Create the Floor Plan. Here it is best to use 'hot aisle/cold aisle' - approach. After planning the hot/cold aisles it is critical to position the air conditioning units basing on cooling zone strategy solution. This may include approach based on room, row or rack cooling. Foundation for decision making includes the specific ICT infrastructure, power densities, amount of air required and other attributes addressed earlier.

- Install Cooling Performance Monitoring. The fact is that once effective cooling design is established only for a current load profile. Load profile will change rapidly due to changes in ICT hardware during the lifecycle of the server room. It is vital to develop and deploy an monitoring system which will control cooling performance in each row and cabinet, so you spot troublesome parts before it affects equipment performance. (PTS Data Center Solutions.)

1.9.1 Cooling methods (basing on PTS Data Solutions)

Room Oriented Cooling

Traditionally server room cooling design contains providing room oriented cooling as a cold air from units at one end of the room. This solution is desirable when power densities are low and there are only few hot spots in a server room. On the other hand, room oriented solutions are affected by room constraints including room shape, ceiling height, rack layout, obstructions above and below the floor, air conditioning unit location, power distribution and so on. In big server rooms this cooling solution remains the most economical approach.

Row Oriented Cooling

In row oriented architecture the air cooling units are coupled with a row and dedicated to a single row. Units may be installed among or overhead the IT racks, also under the floor. In comparison to the previously described room-oriented architecture, the airflow routes are shorter and more clearly defined. Additionally, airflows are more predictable, all of their designed capacity can be utilized, and so higher power density in the server room can be achieved.

On top of cooling performance the row oriented architecture has a number of other benefits. The reduction in the airflow route distance end to end reduces the required air conditioning units' fan power, increasing their efficiency. Here cooling capacity and redundancy to be concentrated to particular rows. Row based cooling allows server room to be built without a raised floor.

Rack Based Cooling

The rack based cooling approach places the air conditioner and humidifier adjacent to the ICT devices containing racks. Circling in a single rack, airflow paths are even shorter and exactly defined than in previously described solutions, and airflow is totally unaffected by room constraints. All of the provided capacity of the cooling unit can be employed, and the highest power density of 50 kW per rack can be achieved. As a row cooling architecture, the rack-oriented solution has other useful characteristics in addition to allowing dense rack installations. Shortening airflow routes reduces the required fan power which increases cooling unit efficiency.

A rack oriented cooling provides a possibility to provide desirable cooling capacity and redundancy levels on a per rack level. This makes a mixture of rack and blade server cabinets possible even in a single row. Rack based cooling solution allows a server room to be implemented without raised flooring. The biggest disadvantage with this design is that it includes a large number of air cooling devices and air pipes comparing to other designs. Typically it is more costly to deploy and maintain the rack specific hardware. (PTS Data Center Solutions.)

Cooling devices also should be connected to UPS of the machine room or have UPS by their own. IT hardware is designed operating intake air temperature up to 35 °C (e.g., IBM 2010; Intel 2006). In case of cooling devices malfunction air temperature could raise as fast as several degrees a minute. It is important to have an automated irreversible2 shutdown procedure implemented to avoid hardware overheating and breakage. Such control system can come with the UPS or it could be controlled by a separate device(-s) which cuts off the power input to UPS and though starts the controlled shut down cycle. In case of using a generic thermostat for such control one should use two pieces in parallel because otherwise implementing a single point of failure. Author had once a 20 server farm blackout due to 30 € device he was not able to bypass while it got broken.

David Moss from Dell implemented a research (Moss 2009) to determine, which operational data center temperature is most efficient in combined IT and cooling power consumption. His findings are best presented in following graph (Figure 9). Optimal temperature to have in Server room is 74-79 F, 24-27 °C. This finding is explained by Moss himself pointing, that cooing fans in servers accelerate increasing power consumption and therefore heat production by 5-10 times while temperature goes high.

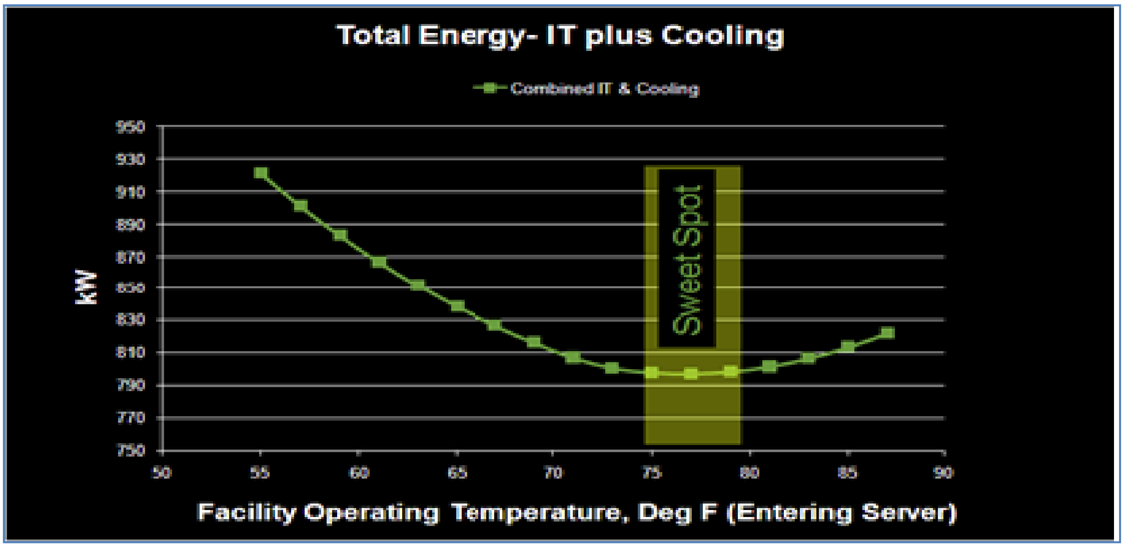

Figure 9. Energy consumption by server room temperature

[2] Irreversibility is important here, because if air conditioning in not working, it makes no sense automatically re-start server room with discharged UPS after temperature went down just below the critical.

1.9.2 Calculating the Size of an Air Conditioner

Here is a quick guide showing how to prepare requirements for the air conditioning system for server room basing on article posted to the home page of server room solution provider OpenExtra (2005). To estimate the power of air conditioning system will be enough for your server room just calculate heat coming from all sources together and purchase an air conditioning system that is capable of eliminating such volume. In reality it is much more complicated.

“Heat gain” or “heat load” both mean the amount of generated heat. For measuring heat either British Thermal Units (BTU) or Kilowatts (KW) are used as a metrics. 1 KW equals to 3 412 BTUs. Below is a list of most usual factors which add the heat to the server room. By taking those factors into calculation basing on your concrete situation you will get an accurate enough measure of the total heat load that you need to be ready to reject by your cooling facility.

Floor Area of Room

Building structures add some heat to the total. Calculation goes as following:

Room Area BTU = Length (m) x Width (m) x 337

Windows

Usually server rooms do not have windows for security reasons. However, if your server room has windows, calculate the heat produced like following:

Window BTU = Length (m) x Width (m) x 870 (for South window) or x 165 (for North window) x 1,5 (for windows without blinds)

People

Usually people do not work in server rooms continuously, but if in your server room situation is different, add as presented:

Total Occupant BTU = Number of occupants x 400

Hardware and other equipment

Obviously, the biggest amount heat in a server room is generated by the main habitants of the room: ICT hardware and other equipment. Like we stated earlier, power consumption mentioned in devices documentation is usually a maximum amount; the nominal operational power consumed is usually significantly lower. But unlike in Power Supply part, where we recommended playing on the safe side, here we recommend using nominal consumption. This is because the hardware startup phase takes some minutes, and therefore raises the temperature in the room by some extra degrees before settling on the nominal heat production level. These extra degrees will be easily rejected by the cooling system later.

Equipment BTU = Total wattage x 3,5

Lighting

Heat load from the lighting is straightforward to count:

Lighting BTU = Total wattage for all lighting x 4,25

About size of available units

Cooling capacity of small air conditioning units usually lies between 5 000 and 10 000 BTUs. Such small air conditioners may fit in window or specially made whole, rejecting the heat to the outside air. Large air conditioning units' capacity may be rated in tens of thousands BTUs. Sometimes a unit of "ton of cooling" is used. 1 ton = 12000 BTU (OpenExtra 2005.)

1.9.3 Free air cooling

Air from the outside space can also be used as a part of air cooling system in your server room. This does not mean that air from outside will be taken into the server room, but using two separate air flows exchanging temperatures in the heat exchanger. The temperature of outside air in the Central Europe or similar places makes cooling by outside air useful for over half of the operation time. Some solution providers promise that free air cooling can be used always than outside temperature is under 22 °C. This makes free air cooling a cheap substitute to conventional server room air conditioning by compression based devices.

Even if free air cooling cannot completely comply with the cooling load demand or outside temperature is part time of the year higher than needed for successful free air cooling, partial use can help achieving savings in cost and environmental load. (Comms Room Services #3.) American Society of Heating, Refrigeration and Air conditioning Engineers (ASHRAE) works with ICT hardware providers to validate their equipment to be able running in the new class A3 allowable range, that is, up to 40 °C at inlet for short periods of time. Server rooms with such hardware can use only free air cooling in over 90% locations in the world.

1.10 Lighting

Well designed lighting in the server room is very important. Main task for lighting in the server room is to provide a productive visual working environment for ICT specialists. At the same time demands cost efficiency and legal requirements should be met. Extra difficulty is brought by the fact, that in server room people are often working in awkward positions, such as at floor level or even under or behind the cabinets, when standard office solution is not necessary enough. Best solution could be the panel lighting across most of the sealing space or at least as many light sources installed in the way, that no place you might work on is in the shadow (SpiceWorks). Adjustable task lighting can be a very good solution especially for server installation work (Sustainable Computing).

Reacting to the need of energy consumption reduction many server rooms operate an automated lighting system using motion sensors. The cost savings achieved by this policy can be significant. Automated environment is also more secure, potentially deterring the opportunist thief especially if hooked up to CCTV system (Shameem 2013). Using efficient LED lighting with automated lighting controls can contribute greatly to energy savings. LED lighting is especially suitable for server room lighting due to its low heat output. Fluorescent tubes send heat down into the workspace, the limited amount of heat generated by LEDs is conducted up into the plenum cable without affecting temperatures in the rack areas. Installation of LED lighting is in some cases having a payback time of three years. (Elkins Technologies 2011.)

Emergency lighting is an essential part of safety installations. Emergency lighting is used when the supply to the normal operational lighting fails and should therefore be powered from an independent source of that supplying the normal lighting. In the server room such power source can be the UPS or emergency lamps' own batteries. Emergency lighting standards and regulations vary from country to another. Pay attention to emergency lighting implementation quality, because they play a role in situations when human life might be in danger.

1.11 Data cabinets

19-inch rack is a standardized frame or enclosure for mounting multiple equipment modules Like servers, network devices and UPS's. Each module has a front panel that is 19 inches (482.6 mm) wide. There are edges or ears on each side of a rack to allow hardware to be fastened to the rack frame. There are different types of data cabinets, from which you can choose most suitable for your needs and surroundings. **Network Cabinets** are less than 1000 mm deep. They are used for accommodating small servers, NAS Systems, switches and cables. Cabinets of this type can be used as an open rack, meaning with side walls and front and back doors removed (Figure 10).

Figure 10. Open Rack

Server Cabinets are more than 1000 mm deep. Such cabinets are usually housing large servers, Raid disk shelves, NAS Systems and Blade UPS's. Cabinets of this type can be used also as an open rack. **Wall Mount Cabinets** (Figure 11) are 3RU to 45RU high and 600mm or less deep. This type is often installed outside the server room and in some cases can be the only "server space" in the office. There are complimentary applications for security, noise reduction and ventilation available for this type of a cabinet. Wall Mount Cabinet can house small servers, patch panels and switches.

Figure 11. Wall Mount Cabinet

Under Desk or **Desk Top Cabinets** are 4RU to 22RU toll and less that 600mm deep. This type is suitable for the Small Office and usually installed outside the server room. They can be also configured as an open rack. (Rack World Systems.)

It is essential to check the physical size of your equipment before rack type selection. The type of equipment to be installed and constrains of the space i.e. security should be used in accession of use open racks vs. closed cabinets. Open racks provide better cooling air circulation but do not provide physical security for installed equipment and data. Server room operators usually remove at least front and back doors of cabinets because “they just are on the way”.

800 mm wide server racks bring an additional challenge for air cooling since warm air flows from the rare to the front mixing with cold air provided by air conditioning system for equipment intake. In 600 mm wide racks there is little room on the sides for air to bypass the servers and the problem is therefore minimized. (Nygaard 2010, 14.)

ANSI/BICSI Datacenter Design Best Practices (here and below: 2011) describes very specifically usage of rack cabinets in a server room. The amount of ICT hardware to be placed within a rack or cabinet depends on many factors that differ for each server room, hardware platform and company agreed good practices. Corporations often have their own standards for cabinets filling order. For example, it might be seeing as a good practice to leave some space between installed servers to be filled later with patch panels, network devices, or to make maintenance simpler. In other companies leaving space unused is seeing as a potential source of disorder and waste of valuable server room space.

There are several principles, which can be used while filling the cabinets with servers and network devices:

- by hardware platforms
- by connectivity (e.g. DMZ)
- by Company Divisions
- to achieve desired density.

Enough space should be designated for patch panels, network devices and power outlet strips for the moment in the future when cabinet is in use at its maximum capacity. Do not place patch panels and power strips directly behind active devices, otherwise you will block the maintenance access and air circulation. The amount of equipment installed to the cabinet may be limited by availability of power and cooling, rather than space. Hardware power densities continue rising, and it is advised to design the server room in a way that there is still spare cooling and power capacity available once all space is already used. Any unused rack space should be filled with blanking panels preventing hot air from the rear recirculation into the front of the racks.

If you install redundant equipment in different racks, consider placing these racks physically separated, far away from which other. This helps you ensuring facility infrastructure (power, cooling) diversity and thus eliminates some potential single points of failure. Same works for physical disaster.

Big number of servers within cabinets and high amount of power and network cables per server creates challenges for cable and cooling management within the server cabinets, especially 600 mm wide. Having cabinets 1200 mm deep provides adequate space for redundant power strips installation and organizing vertical cable management in the back of the cabinets. (ANSI/BICSI 002-2011, 26- 33.)

1.12 Physical Security

When it comes to information security, physical security is the foundation for your overall strategy. Server room security enhancements protect your expensive ICT equipment and your client's business continuity. Succeeding in physical security implementation will reduce downtime from accidents, interference or theft. Chosen physical security systems should deliver advanced protection for server rooms. Such security measures like access control systems or CCTV surveillance help achieving high level of physical security and therefore improving information security in general.

ANSI/BICSI Best Practices paper (2011) recommends following: server room secured video monitoring and access control system database should be provided. Front end user interface of these systems should reside in secure operations facility. For business parks, where several companies rent the space such facility can be centralized. Information from video monitoring, access control system and fire/smoke alarm monitoring systems should be collected, monitored and stored for the later use. (ANSI/BICSI 002-2011, 26.)

There are plenty of physical security increasing innovations available on the market. We list some of access control providing solutions for you to decide, which solution or combination of solutions is optimal for your server room. We also recommend including in security design team responsible person from Company Security Department.

To increase strength, durability and security of the server room walls consider installing steel mesh inside the lightweight walls. Built-in security shutters provide discreet protection, since they are invisible when not in use; used, they put on view effective physical obstacle over windows and doors for intruders looking for opportunity. See-through shutters increase visibility within the server room for night guards or people working out of office time. Customer designed security grills provide an extremely resilient physical impediment to entry. (Comms Room Services #4.)

"CCTV security systems are considered to be the most effective method of reducing crime" (British Chambers of Commerce Business Crime Survey). Undeniably installations of CCTV video security systems are nowadays widely met. Surveillance is an important tool for fighting crime and protecting public areas. In combination with intruder alarms and access control systems, it enables remote viewing of your server room from any place 24/7. Advanced cameras include intruder motion detection and can be managed remotely. (Comms Room Services #5.)

1.13 Fire suppression systems

Fire is a great danger to a server room facility. Fire detection and suppression systems are intended to provide early notification about the fire ignition within the room and minimize the amount of damage from it. Risk analysis of your server room includes evaluating of several important aspects and technologies: early fire detection, fire suppression efficiency, danger to people, potential damage to installed hardware and facility, potential damage to the building and environment. Each factor should be taken into account before deciding which combination of fire detection and fire suppression will provide the optimal protection in your case. (Comms Room Services #6.)

Smoke detection based on aspiration is essential solution in areas where sources of fire are hard to spot. Within fast circulating air very thin smoke is hard to detect, and this can cause delayed alarming increasing the damage caused by smoke and fire. Aspirating smoke detection efficiently resolves this challenge. Air samples are constantly taken in the detector's monitored area -- detector chamber -- and examined continuously by analyzer using light or laser. If smoke particles are detected, security procedures like alarm or fire extinguishing are activated immediately basing on fire fighting concept. Aspirating smoke detector is the best choice for protecting server room environment. (Siemens.)

Gaseous Fire Suppression systems (Figure 12) are widely used to protect data center facilities against fire. Practically all types of fire are extinguished in at most 60 seconds when the oxygen concentration is dropped below 15%, where over 6% is just enough for a human to keep breathing. Therefore gaseous extinguishing systems are able to provide a fast, reliable and clean insurance for a server room. In order to remove oxygen nowadays fire suppression systems use inert gases Nitrogen and Argon, sometimes with a small amount (under 10%) of CO_2 added. Designated names of these gases are IG-01, IG-55 and IG541, trade names *Argotec; Argonfire; Argonite; Inergen*. All these fire suppression systems are odorless and colorless. Since all three gases exist in the Earth atmosphere, using them makes the fire suppression system safe for the people and for the environment. *Halon* gas, which was used for the same purposes earlier, is now rarely met, because it can produce poisonous combinations in hot environments. It is also harmful for environment. (Concept Fire Suppression Ltd.; CommsRoom Serivces #5.)

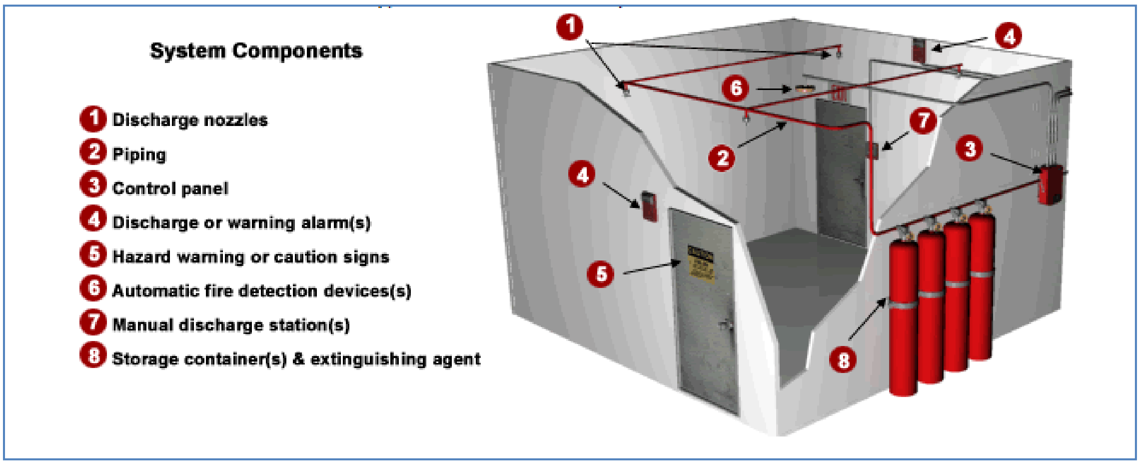

Figure 12. Gaseous Fire Suppression System (www.OSHA.gov)

Most gaseous fire suppression systems are effective only if server room they are used in is efficiently sealable. To prevent re-ignition secured facility can maintain gas concentration at the needed level for minimum of 10 minutes after discharge. Room integrity test in accordance with the local safety requirements should be carried out before taking the room in use. (CommsRoom Serivces #6.)

1.14 Environmental monitoring: Temperature, Water, Electricity

Many disasters that occur in server rooms are completely preventable. Monitoring the server room insights is mission critical to owner organization.

Environment monitoring is a powerful tool for protecting ICT hardware and data from disaster brought by environmental causes like water or heat. Good standalone environmental monitoring system's reliability should not depend on the availability of server room infrastructure or network which it is monitoring. System has to operate on its own power source and should be able to send out alert message via text message to email or mobile phones any moment of time. For this such systems usually have a built-in 24 hour back up battery pack and include communication equipment. Filtering the gathered events and sending only critical information as warnings enables fast response for critical situations in server room environment. (Comms Room Services #7.)

Below we list critical and non-critical environmental monitoring alerts, as recommended by Comms Room Serivces, a company from UK providing complete server room solutions:

Critical alerts

- Fire: 1st detector alert
- Fire: 2nd detector alert ("Gas released into the room")
- Water within the room
- Power outage
- UPS in use
- Generator in use
- Power restored
- Critical air-conditioning failure ("Call maintenance")
- Room temperature high
- Critical UPS failure ("Call maintenance")
- Generator Emergency Power Off has been depressed.

Non-critical alerts

- Minor air-conditioning signals e.g. sequential maintenance needed
- UPS minor fault
- Generator fault.

(Comms Room Services #7.)

4. Further research

As in every almost research, here we left some areas of secure server room building for the future research. Even though we tried to keep chronology of a building project in mind while moving from one topic to another, the clear **design process description** with steps following one another was not provided. Such a process including important decisions to be made will definitely help the practitioner. **Risk log** including typical risks of a server room building project is another welcomed addition.

On a technical side, emerging opportunity of **free air cooling** usage is a very interesting and requested. At the time this research was written, only a few hardware providers accepted free air cooling as a main way of keeping ICT devices in working condition. While number of such hardware brands grows, free air cooling should be investigated and described.

Sometimes the new server room project is a part of **server room move** from existing location to the new one. Adding a part containing advises regarding process, schedule, potential risks and good practices of server room move will bring the practical usability of this research much closer to the real challenges setup by the dynamic business in front of ICT professional.

5. Discussion: Research method and its influence on results generalization

This research was born basing on a single driver and two motives behind it. We were willing to create a relatively short overall instruction for building a secure, well designed facility to accommodate ICT hardware which serves local business. The instruction we aimed to produce should be able to be used by IT professional that got a task of designing and leading the project of building such facility. One motive behind the willingness to write such a research for professional review was to provide our colleagues at a time of writing – IT Infrastructure Project Managers in globally operating Enterprise - a helping hand, to enable them grasping general understanding required for successful designing and building of a server room. Another motive was to critically review, correct and systematize writer’s own “learning by doing” based knowledge about server rooms.

Looking at the Figure 13 done by Hevner et al (2004) illustrating Design Research basis and deliverables, we can see two demands: Relevance and Rigor. Relevance demand is based on idea that well done Design Research delivers knowledge needed by business to produce better results. From our point of view the concept of relevance also includes the demand that knowledge provided is applicable to the business in practice, meaning that it should give solutions that can be taken in use. Rigor from our understanding is a demand for reliability. Results provided by Design Research should not be in a conflict with existing foundations and theoretical knowledge, and they should be produced using approved by scientific society research methodology.

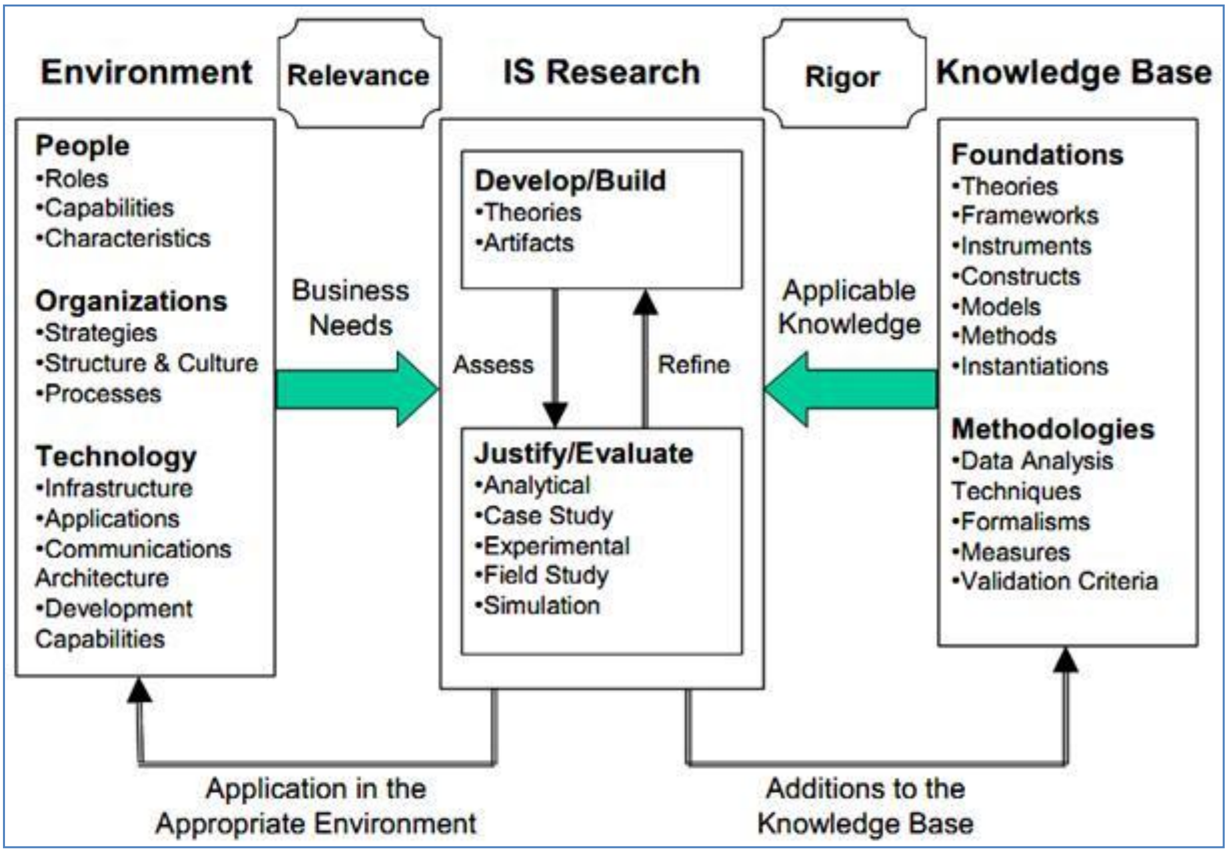

Figure 13. Design research (Hevner at all, 2004)

By Hevner et al (2004), quality assurance is provided through results assessment and refining during research. Since Design Research is producing organization specific knowledge, often it is impossible to reproduce the similar research to test the results. In such cases results assessment and refining should be done by implementing the findings and critically reviewing the results of the implementation, has it produces expected outcomes or not. If experimental approach is not applicable, there still is a possibility to use analytical review by other specialist in the area where the research is produced.

Material used to produce the results was very broad. We started with the idea that Standards would be the main source of wisdom because of their nature. However, we soon found out that they sometimes give different suggestions or their demand is clearly overkill for the small server room projects. And so our own experience combined with Internet techie discussions and server room providers brought at the end even bigger portion of knowledge.

Because of the nature of this research and especially the broadness of produced results we were not able to test all results in real life. However, we received several reviews from IT colleagues experienced in server room designing, building and operations. Basing on this input we were able to make assessment and refining of the produced knowledge. Since the matter of research lies in area of technical design, we used several sources more or less directly with no or very little critics. This way of producing results in our opinion is justified while providing the new technical information to a reader. For example, there are hardly several controversial opinions about types and specifications of UPS's.

Practically several, often controversial drivers exist in a field of utility design. This is happening because shared resources like space, electricity, air condition capacity and of course money in real world are always taken from somewhere else, existing by itself and not for a means of a single designer, and though provided design is always a result of negotiations and tradeoffs and therefore unique. If we decided to provide a solution to a special case, we would have to simplify all variety of real life situations to one special case which probably would never exist, and though our research would be useless. Instead, we produced a dynamic and general Model of a Server Room can be used in designing and building such a room by IT Professional. Implementation of our findings in specific conditions great attention should be paid to definition of new design fundamentals.

6. Appendix A

How to buy UPS system (Basing on article from UPSonNet)

Add capacity for future expansion.

Allow adding external batteries and use UPS units in parallel to make power increase possible

Choose UPS basing on your application needs. Expansive features often do not serve any need. Extra features can be added later once they are needed

Damage covered by provider is most often only a price of your hardware. Data losses or discontinuity of service are usually not covered by guarantee agreement

Insure that software coming with UPS can communicate with your servers OS in order to shut them down gracefully

Insure that UPS have surge protection on input and on communication lines

UPS should include the ability to test own batteries and alert whenever they are bad. Perform scheduled manual test or buy one from provider

Terms used by providers are often misleading. Do not hesitate to ask questions to open not-exact language

Backup time has only meaning in combination with load. Decreased load grows backup time exponentially

Choose hot swap batteries. If you plan to make maintenance yourself, make sure that replacement of the batteries is doable by UPS operator and does not always demand for qualified technician

Insure that after sales service is provided by reliable firm which can operate in your area

Read through Guarantee terms. How long, where maintenance happens and how long does it take to get engineer in place. It is possible to get several years guarantee, 7 days per week, on-site.

Purchase form well-known firm with good reputation and long history in UPS business. If provider is new, ask for references (UPSonNet #2.)

7. Appendix B

ServerRoomSpecificationsTemplate.xlsx

Template 1. Server Room Specifications

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