Regional Support Centre
1 Todd Campus
West of Scotland Science Park
Glasgow
G20 0XA

New Build Projects and IT Networks

Practical things to consider
A Network Managers Viewpoint (version 4.2; April 2008)

1. Introduction

So you've been presented with the plans of a college new build or a major refurbishment, for which you are expected to provide the network infrastructure, capable of delivering all your learning and administration needs for the foreseeable future!

The following points and observations are from real life experiences in large- scale new-build sites, where networks have had to be built from scratch, or where large extensions have had to be grafted onto an existing infrastructure.

This document is aimed at senior technicians or heads of IT, to help inform and identify pitfalls and issues to think about; leading up to, and throughout the installation of the IT network infrastructure of a new-build project.

2. The Team; who's who and what they do

2.1 The Architect

The architect is more likely to be a company rather than any one single person; a company which will have designed the building, produced the models and drawings, the specification of the materials and so on. Basically they created the building from the list of specifications and requirements given to them by the college.

It is unlikely you will ever meet the architect or any of his/her representatives but you can be sure they have little understanding of IT requirements nor of network data comms issues. So it's important to be vigilant and assertive, to implement changes at an early as stage as possible when you spot any problems with infrastructure specifications.

2.2 Clerk of Works

http://www.icwgb.org/
"Clerk of works, also known as Site Inspectors, Site Supervisors or Build Quality Officers, monitor the work of companies that carry out contracts for their employer or client. Their main responsibility is to make sure that work is carried out to the client's standards, specification and schedule."
(Institute of Clerk of Works, 2006)

The Clerk of Works is an independent contracted experienced professional from the construction industry. They are appointed by the college, albeit on a temporary contract for the life of the project. They are the ones who ensure that contractors on site are not cutting corners, and that the quality of workmanship is of a standard that is acceptable. He/she will be depending on your input, so if you're not happy about something, keep

him/her informed so that they can enforce any contractor to "make right" a job if required. The Clerk of Works is a very powerful force during the new build construction phase, and it's very important you get to know the person. If for some reason your college has not appointed a Clerk of Works there is a very real danger that site contractors could leave the site leaving shoddy workmanship, cut corners, and generally not a particularly well-executed installation. Above all, they are independent of the main contractors and are paid by the college to look after college interests.

2.3 Health & Safety Officer

http://www.hse.gov.uk/scotland/index.htm

It cannot be emphasised enough how important health & safety is, not just in regard to college employees and students, but also the contractors who are building your new college. It is vital that your college secures the services of a Health & Safety officer - someone recommended by the Health & Safety Executive to keep an eye on the new build project.

The usual nominated college health & safety officer will not suffice; this is a specialist job and requires experience of construction sites of a similar scale. This is for the protection of the college – including its staff & students, as well as those working on or near the construction site. They need not be full time but they should inspect the site, attend project meetings, and advise on H&S policy, procedures and documentation with regard to the new build project.

2.4 Project Manager

The Project Manager is someone who, similarly, is independent of the main contractor, and has been brought in especially for the life of the new-build project. His/her responsibility is to communicate to the project team and contractors on the progress of the project, manage documentation, and monitor the milestones of the project schedule, ensuring that those who need to be informed are kept abreast of events as they unfold. Experience of the construction industry is vital. Even if they do not have specialist IT knowledge, they should have a though understanding of construction issues, and project management methodology.

2.5 Project Owner

The Project Owner is usually the college Vice Principal, or a member of the Senior Management Team (SMT); basically someone with senior management responsibility who has ultimate responsibility of budget and project management controls. This is someone with a wide vision on the strategic ambitions of the college, who you will ultimately have to keep informed on progress. They must not be confused with the Project Manager. They do not have day-to-day responsibility for the running of the project, but it's more a supervisory role rather than a "hands-on" manager. They will be responsible for informing the College Board and SMT on progress and any issues that may arise.

2.6 Technical Manager

This is the person who supervises the technicalities and installation of the IT infrastructure as it's being installed. The Technical Manager is usually the one who specified the technical IT requirements, the network cabling, switches routers etc. - and anything else IT-related within the scope of the new build project. **Basically it's you!** The Technical Manager is usually a network manager, senior technician, or someone who works for the college and has a firm grasp of the college's IT technical requirements and network configurations. They will also have been instrumental in the scoping and procurement phase of the IT solution.

The Technical Manager will liaise with the Clerk of Works, Project Manager and the relevant contractors, ensuring that the installation is going as specified, and that any mistakes are picked up early enough to be rectified without holding up the whole project. The Technical Manager should conduct daily inspections on work done as the project unfolds, and will develop a good relationship with the installation crew. By comparing schematics, the Technical Manager will ensure that all drawings are of the same version, and that any last minute changes are well understood by all. Often the contractors who install the cabling are not from the same company as those configuring and installing the active components.

3. The Issues

3.1 Health & Safety

When you have 20 people in a cabling crew, tripping over themselves to install miles of UTP in your new building, it is vital that everyone on site is well aware of health & safety issues, and that each person involved takes responsibility for the workplace and everyone in it.

Everyone should wear a hard hat and high visibility clothing, including eye protection if specified. Remember there will be plumbers, electricians, plasterers & joiners etc. - all working around one other; this constitutes a naturally hazardous environment, therefore the installation company must conduct Risk Assessments for each area and installations where risks are identified and minimised.

In addition, method statements must be produced, which describe in detail how the installations run (there will be many) will be done, what tools will be used, how many installation crew will be used, and if those involved had had appropriate training to do the job or operate machinery and tools. Even a stepladder requires a technician to be trained before being used. Absolutely nothing can be taken for granted and everything must be documented!

From experience, some cable installation companies (or rather the foreman on site) may try to avoid filling in forms or conducting risk assessments, or

they may try to photocopy previous ones and pass them off as current. Ask to see the documentation before they are allowed to progress to the next run of installations. Make sure that the level of required documentation is specified long before the installation company has been selected, as they may try and use it as an excuse for any delays.

Risk Assessments and method statements should be produced for any installation of racks, switches or any equipment, as all these activities also carry some risk, and common sense cannot be taken for granted. All activities must be documented, and identified risks minimised as far as feasible. All documentation should be copied and passed to the project Health & Safety officer who can advise on all these issues.

3.2 Network Design and Topology

Once you have had an opportunity to see the building floor plans and layout, you should see the staff rooms, classrooms, open access areas etc. The architect should have produced drawings that show where each network socket and mains power supply is to be located.

What is usually forgotten is where the wiring closets are to be located; this is where the first battle starts - the fight for space!

There is huge pressure to maximise the building space as available space for student/staff use. But the reality is that a certain amount will be dead space for one reason or another, and cannot be used. Remember, there is also a need for storage space, toilets etc., and for network wiring closets and server rooms. Even in this day of IT literacy, it's often the last thing architects think about, and so it's up to the college network manager to design a network UTP schematic that will fit the requirements of the building.

This is not hard to do, and JISC Regional Support Centres can help you with this. You may need to push for the odd cupboard to allow you to install a rack for cable distribution; if you don't, it's unlikely you will get space at a later date, as the demand for more network sockets grows at an exponential rate.

And don't let the promises of WiFi fool anyone; it's a complimentary technology not a replacement to copper. As of 2007, WiFi cannot come close to the reliability and performance that can be achieved with UTP copper, and should never be considered as a replacement. It has it's uses, but not for fixed location, high density installations of high performance workstations or servers.

It could be worth thinking about mobile telephony over WiFi, as well as portable Internet or VLE access on campus. Student wireless access in Cafeterias, Library, lecture theatres, learning spaces, residences & other gathering places is a welcome feature of modern networks.

This is the time when you need to think about an IP address schema. Do you currently support protocols other than IP and will your new switches support them? Perhaps you may want to introduce application switching, or Layer 5 switching. A request for information can be useful here. Speak to companies you have used in the past and some you have not. They will push their favourite vendor, but you will get a good idea of what's possible. Even the smallest college will require a sub-netted & routed infrastructure for segregation; a classless flat layer-2 network will not suffice for today's applications and demands.

What will your security policy be; will you require a firewall? Perhaps network address translation is needed - then what will your DHCP configuration scopes look like and what VLANS will be assigned to where etc.? There are many possibilities to consider, but you need not worry if you're unfamiliar with all the latest technologies, and what they could do for you. Just chatting to a few vendors will be useful, and with support from your JISC RSC you should be able at develop a migration path without too much stress.

What about those VLANs and the possibilities of telephony services over your network? These will also need to be able to handle video and whatever future demands may be. You will need to think about how you will switch from your legacy building or network to your new build - will it be a step change or a phased approach? Just what are the issues with each approach? Will your MAN, service provider or JANET allow a parallel connection while you move everyone over? Will you have you fibre connection ready and what about you're on campus MAN's point of presence switch? Who will change its configuration when the time comes? Your firewall and security policy all comes under the spotlight. Will you need to inform JANET (UK) of any DNS entry changes before you move?

3.3 Procurement Management

You may find that once you have a fair idea of the structure of your new network, you may have to go through a procurement exercise that might include a European Tender procedure, or at least a process of selection against some criteria.

Depending on your requirements you could go to the Office of Government Commerce, and direct from catalogues many IT & comms products and services, without going to tender, as this has already been done for public sector IT procurement. This can save a lot of time and effort.

http://www.ogcbuyingsolutions.gov.uk/procurement/procurement.asp

An invitation to tender should have a high level of technical detail, to ensure you receive what you require and that it's informative enough for vendors to be able to respond in a meaningful way.

Procurement management is a huge subject in itself but the basic steps are:

a. Request for Information - approach known companies and ask for their assistance in developing ideas in developing a new network with new technologies.
b. Find out roughly what these ideas will cost and include any maintenance costs over a period of time. Say a cost of ownership over five years, when you would be thinking about replacing the technology again anyway. Then use that knowledge to develop a budget proposal for the new build project team or SMT
c. Develop an invitation to tender, including the scope of the network project, detail technical specifications and any installation support; document everything you think you'll need to get you up and running.
d. Ensure you know what the selection criteria are: for example you could use, Cost, Technical suitability cost of ownership over time, future proofing, maintenance.
e. Publish tender in the European Journal if required. In Scotland you could seek the assistance of the Authorities Buying Consortium (ABC) which can be an invaluable resource. http://www.abc-scotland.org.uk/ Other UK regions may well have local procurement support services available that would be worth looking out for.
f. Select the most favourable tender bid in accordance to your selection criteria.

3.4 Active Components (Switches and routing technology)

Your new network will depend on some sort of routing engine and switches. You may have a favourite brand or vendor you are used to working with. But don't be afraid to broaden your view and see what other vendors have developed in recent times. Obviously Cisco systems are up there as market leaders but they are by no means the only answer. Nortel Networks are have a product range that easily rivals anything that Cisco can produce, as far as performance & reliability is concerned, and in many ways is easier to configure and manage. Both vendors have telephony solutions but only Nortel have as long a history of telephony. Foundry, Juniper & Extreme Networks all make high performance switches, which are more than capable of handling a campus network.

The point is not to focus too much on the vendor but rather think about the performance, functions, manageability and any other criteria that will allow you to deliver the services your users demand with available resources.

You may want to think about switch density, how many ports are available on each switch, therefore how much space is required in those racks. Will you be IP switching at the desktop switch or will your routing function be done at the core of your network, if so what resilience do you think is

necessary? Not all switches support power over Ethernet or 802.3pQ necessary for vlan propagation. Even if 802.3pQ is supported it's unlikely that it you will be able to mix switches from different vendors or even older versions of the same switch if you intend hanging onto legacy equipment.

How much heat is produced by these components, leading to how much air conditioning if any is required? In your specification it's wise to include the installation and configuration of all active components (switches, routers, WiFi access points & firewall) within the scope of the project by the vendor, to minimise the impact on your support team. Then you want to ensure that training and some sort of handover program is not overlooked to ensure your team knows how to make any configuration changes you require.

You will want to be confident that you know how to add more components at a later date and how to update any switch images that are issued by the manufacturer.

You will want to install a monitoring tool to measure the growth of traffic across the network, as applications are rolled out. The demand on bandwidth will grow, so you will want to know just how much impact that makes on the new switches and backbone links.

3.5 Vertical Fibre

Generally speaking, a building network design follows the convention of vertical fibre optics and horizontal copper. This means that your backbone trunks leading to your core protocol switches are usually fibre. They run vertically from your distributed wiring closets in corridors etc down the building risers to the main server or central communication room. This ensures that no matter what technology or bandwidth demands occur in the future, you only need upgrade the switches and not the whole installation.

The current convention is to use single mode or mono mode fibre of 9/125, that is 9-micron fibre in a 125-micron sheath. There are many types of connectors available, and you should use the ones that match your equipment and fibre patch panels; for example the common one these days is the LC or mini-LC connector that fits the mini GBIC interfaces, although FCPC are regarded as the most reliable and robust fibre connector for patching and are therefore most commonly used by service providers. There are many installations using Multi Mode 62.5/125 fibre, but the single mode is far better for high bandwidth uses that are greater than 1 Giga bit and certainly with the new 10 Giga bit standard.

It is sometimes taken for granted that vendors test all fibres after installation; this is wrong. If left alone, installation teams may run a continuity check on one and assume the rest are ok. You must insist on a full OTDR (Optical Time Domain Refectomitry) test to check for reflections etc on all installed fibres. This should result in your receiving a test result on each fibre with a graphic image of the –Db losses suffered on the fibres.

3.6 Horizontal UTP

Running from the corridor wiring closet to the desktop socket is the UTP (Unscreened Twisted Pair) cable, one for each port outlet.

There can be many hundreds on each floor and so you should have a standard numbering scheme in place but more on that later. There is debate on using Category 6a standard or Category 5e both work; both have merits but never mix'n'match - for example you must not use a Category 5e patch lead on a Category 6a cable run. It may work some of the time, but it causes reflections and therefore intermittent problems which can frustrate technicians and users alike. Category 6a Cable is more expensive, it's stiffer and has a wider minimum bend radius, and more stringent installation rules, but has the ability of carrying full gigabit bandwidth over it's full cable run.

However make sure the installation vendor is fully Category 6a certified, and that their team has Category 6a installation experience and test equipment.

Category 5e is less expensive, has a slimmer cross sectional area, is physically more flexible, a smaller minimum bend radius, and vendors should have had plenty of experience; but you must still make sure they are Category 5e certified as a pre-requisite of the job.

Popular UTP cable standards / performance

Cable Standard	Bandwidth	Datarate	Max distance
Cat 5e	100Mhz	100Mb/s	100 meters
Cat 5e	100Mhz	1 Gb/s	~50 meters
Cat 6	250Mhz	10 Gb/s	~50 meters
Cat 6a	500Mhz	10 Gb/s	100 meters

What is important to remember is that whatever cable you use it must be LSZH (Low Smoke Zero Halide) and this rule will soon apply to your patch leads. This is in case of fire, as it should help reduce the emission of toxic fumes proliferating throughout the building.

It is vital that your installation team understand installation standards and that you have those specifications listed in the tender document long before installation begins. All exposed UTP cables should be in some form of containment. Whether it is PVC trunking or steel conduit is not important, but cables should not be left to the open - not only is it unprofessional & unsightly, but can also be a danger if pulled by a mischievous user.

Cable runs in the plenum or above ceiling tiles in corridors or rooms, even if they are generally out of sight, should be regularly cable-tied to the fabric of the building. This should ideally be done on some cable tray at intervals no greater than 1 meter. Cable ties should not be too tight as to deform the cables in the harness, but just enough to hold them neatly in place.

As with fibre installations, every UTP cable should be TDR tested and all test results should be retuned to the college IT dept for future reference and as part of the acceptance criteria.

It is a good idea to label the cables during the installation with suitable printed shrink sheath labelling this will save time identifying the other end if a face plate label is removed. Some good examples of labelling technology can be seen at this URL.
http://www.sharpmarkusa.com/photos.html

3.7 Face Plates & Patch Panels

It is usual to keep to the same manufacturer's solutions for all UTP cable and terminations, such as Krone etc. But whatever you decide to use, make sure of the following guidelines:

The faceplate should have a spring-loaded shutter to protect the port and it's connectors, and the label should have a Perspex cover window that clips over a pre-printed number. On the reverse side there should be a small cable tie-clip to secure the cable as it lies towards the IDC connector itself.

The Patch Panel should be of the same manufacturer as the faceplates you are using, and have cable management brackets to allow the UTP cable to be tied and dressed according to installation guidelines. These guidelines will differ between Category 5e to Category 6a, which requires each cable to be tied in it's own individual slot before being fed into a cable loom.

The numbering scheme is really important and should be standard throughout the college, but if you have a scheme that has grown and evolved over many years and the numbering scheme was an invention that worked for a handful of cables, then it's time to change.

The standard method is not to re-label the patch panels nor ports in the racks, but to use the port numbers already printed on them - the reason being that in a warm enclosure such as a closed wiring closet, the labels will fade and fall off, making it difficult to identify what port goes where in the years to come.

Therefore the most common scheme goes like this: Cabinet number / Patch Panel Number / Port number.

The Cabinet number could have a prefix identifying the building and floor location i.e. **B22** meaning **B**oyd Building floor **2** cabinet **2.** So with a simple scheme, an entire campus with hundreds of racks can be individually identified; then the Patch Panel 1 – 99. Of course it's impossible to have 99 patch panels in a cabinet, but you get the idea.

The top panel is 1, the second is 2, the third etc. But remember to start at one and not zero - it just makes life easier. Then the port number - some panels have 24 ports, and some 48 and so on, but one thing is common - each port has been printed with a number from 1 to 24 or 1 to 48 with a permanent clear number, and so use it.
As an example, on a face plate in a room you could have printed behind the Perspex protective window **B22 / 03 / 19;** this would tell the technician to activate the port located in **B**oyd Building floor **2** cabinet **2** patch panel **3** port **19**. This method has proved to be scalable and easy to follow, and does not rely on sticky labels nor ink markers that are prone to fade inside the cabinet.

You must not allow the installation team to use printed sticky labels of the face plates either, as these quickly fade and peal. Students love to peel them off or draw on them, so make sure contractors use the number scheme you tell them to, and fit the right type of socket label behind the protective window.

3.8 Server Room

Server rooms & Communications centres have similar needs, such as uninterruptible power supplies and air conditioning. Remember to ensure a conditioning unit has power resilience. There have been many instances where power fails, shutting the cooling system; but as the servers are all powered on battery backup; the heat build-up is enough to seriously damage your servers; which is what you were trying to avoid in the first place.

False floors to enable under floor wiring and power distribution to be kept out of sight is really nice, although expensive, and not to easy to keep well managed. It's worth thinking about some new cable management systems, like hanging baskets, which are just overhead cable management for all your data cables that drop down to cabinets and racks. However, this technology may involve Health & Safety issues, as working overhead on ladders is required every time a new cable is installed.

Mains power can be distributed in closed power conduit with hard-wired conduit down to the rack linking to rack power rails for distribution inside closed cabinets.

Remember to leave yourself plenty of room around cabinets to allow access to the back of the rack to feed cables through.

Fire retardant Halon gas systems are no longer permitted, but you will still need to make sure that the room is fireproof to an acceptable level, in case a server or UPS goes on fire. This is specialist knowledge, as regulations regarding this are updated regularly and best practice changes accordingly; therefore a fire officer who specialises in machine rooms should be consulted.

3.9 Wiring Closets

Don't succumb to the pressure of cramming everything into one small room in the basement to save space, then trying, and have all the UTP cable emanate from there. This is not structured and not scaleable in the long run. You should have a UTP distribution point on each floor where possible. Remember that your network will have to carry high bandwidth low latency media, which requires modest copper cable runs to ensure reliability. This is especially true for Category 5e, where a 1 Giga bit link will only run to a maximum of 50m in ideal circumstances, practically more like 25m and certainly not the full 100m of a UTP run. Remember that with a structured wired system, you will have to support all telephones, workstations & servers which results in a lot of copper UTP being installed the resultant cable harness can be quite large.

If you have to compromise on space and concentrate all your switches in one closet in the basement, it is vital that you consider the weight of all that copper cable harness bearing down the building riser. If your cable harness is too big, and the space it has to fit through is too small, then the weight of the harness can crush the UTP cables underneath, distorting its electrical characteristics, which introduces intermittent and "difficult to find" network problems at a later date. Spreading the cable harness out into several smaller bunches helps to avoid this problem.

You may think that only server rooms require UPS's and air-conditioning - not so. Without any way to escape, heat can build-up over days; even with a few switches running in a small cupboard, this can lead to switches becoming unstable and then to eventual failure.

At the very least there should be assisted venting to the outside world via duct and fan.

Cable management becomes all the more important in small confined places. Make sure you use racks that have the vertical cable management on either side of the switches and calculate the vertical size of the racks to accommodate the 1U horizontal cable management that will become vital as patching gets busy. And again access to the rear and sides of a rack is important.

If Cat 6 infrastructure has been chosen, remember that Cat 6 patch cables must also be used. These are much stiffer than Cat 5e and require a greater minimum bend radius. This can be a problem in the confines of a small wall-mounted cabinet. You may require switches to be mounted further back in the cabinet which may not be always possible. It may also be worth considering products such as "PatchSee" www.patchsee.com which can be of great help tracing patch cables once a wiring closet is crammed full of patch leads.

3.10 Installation

When the cable installation teams come on site to implement the installation, it is vital that you visit the site regularly. This is undertaken with permission from the Site Manager and the Clerk of Works and the Health and Safety Officer. You may need to receive a health and safety briefing before being allowed on the building site, and you will certainly require protective clothing.
However, it is vital you gain access to conduct inspections of the cabling work as its being done. You must also liaise with the cable Installation team foreman to ensure they know exactly what is required. You must use all the diplomacy and management skills necessary to keep the foreman and installation team on your side, and willing to accommodate any small but necessary changes.

3.11 Acceptance criteria & testing

As part of the tendering and specification of the installation, it is important to include cable testing as part of the job. Each cable must be tested in accordance of the cable type. If the UTP is Category 5e then Category 5e tester should be used. If Category 6a cable is being installed then a full 500Mhz Category 6a tester should be used.

Many vendors don't, as yet, own a Category 6a tester due to the expense, therefore are unlikely to be in a position to offer this service. A hardcopy printout of each test result of each cable should be handed over to you at the end of the job; this is not unreasonable and should be included in the job specification.

Fibre optic cable should be treated in the same way. The job cannot be accepted nor handed over until all test results have been completed and handed over. Make sure the vendor is using the appropriate test equipment for the cable type and knows how to use it.

Once all the active equipment has been installed and configured you should have a testing procedure devised that will check that all protocols you require are being routed by the switches in the way that you would expect them to be. Some test servers could be set up, and a roaming laptop utilised to check if access is possible from different subnets and VLANs of the installation.

4. RSC Scotland South & West Experience

This document is just a summary of thoughts drawn from extensive hands on experience of new build and refurbishment projects primarily in networking and infrastructure. (i.e. £13m Health Building new build, (Glasgow Caledonian University, 1998), £5m Library & e-Learning centre extension (Glasgow Caledonian University, 1997), £0.5m network refit project (Glasgow Caledonian University, 2002), numerous building refurbishments totalling £40m resulting in replacement of localised networks 1992 – 2002, Commissioning of new refurb. network (Cardonald College Glasgow, 2006)

5. Contact details

Mark J. Clark e-Advisor: Technology & Infrastructure Management
Tel: 0141 585 0022, email m.clark@rsc-sw-scotland.ac.uk
Fax: 0141 585 0020, Web http://www.rsc-sw-scotland.ac.uk/