

So you're going to move your datacenter?

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Good morning, welcome to our fellow Penn State 2016 attendees. Thank you for choosing "so you're going to move your datacenter?" You're here to learn from two of your macadmin peers who have recently uprooted and relocated their core servers and data networks, and want to know what they learned, what went right and wrong and the surprises they encountered so you can be better prepared when your turn comes. Sean and I will be providing case studies and lessons learned from our separate experiences on 2 different scales, in 2 very different environments.

Introductions



@SWY



@ SWY on Slack, Twitter, Github, ect. Work at an 90 person creative agency headquartered in Madison, WI, where I'm the senior member of a 2 person IT team. The 2 of us there handle all internal-facing IT, from end user machine lifecycles, Windows and LAMP servers, storage, security, WiFi, purchasing, licensing- and many other duties as assigned.

I am presenting today along with...

Introductions



@seankaiser



Hi, I'm Sean Kaiser, and I'm the system administrator, well officially I'm the systems integration specialist, for Northmont Schools in the Dayton, Ohio area. A group of 9 of us moved the technology equipment from our old high school into the new one over winter break this past year. I was in charge of moving the district's data center.

I'm going to talk a bit about a long term construction project that, at least for this presentation, ends with moving into our new data center.



When I say “move a datacenter”- what do I mean? A little perspective where I spend my day:

<click for arrow>

this is my workplace, in downtown Madison, WI.

This entire building is NOT a datacenter- it’s an integrated marketing and advertising agency, inside a former church.



In order to talk about a infrastructure relocation project, we first need to lay out where infrastructure started.

This is what the upper 2 floors of my workplace looked like up through the beginning of this year. If you look closely enough, you can find a server rack in this picture.

<click for arrow>

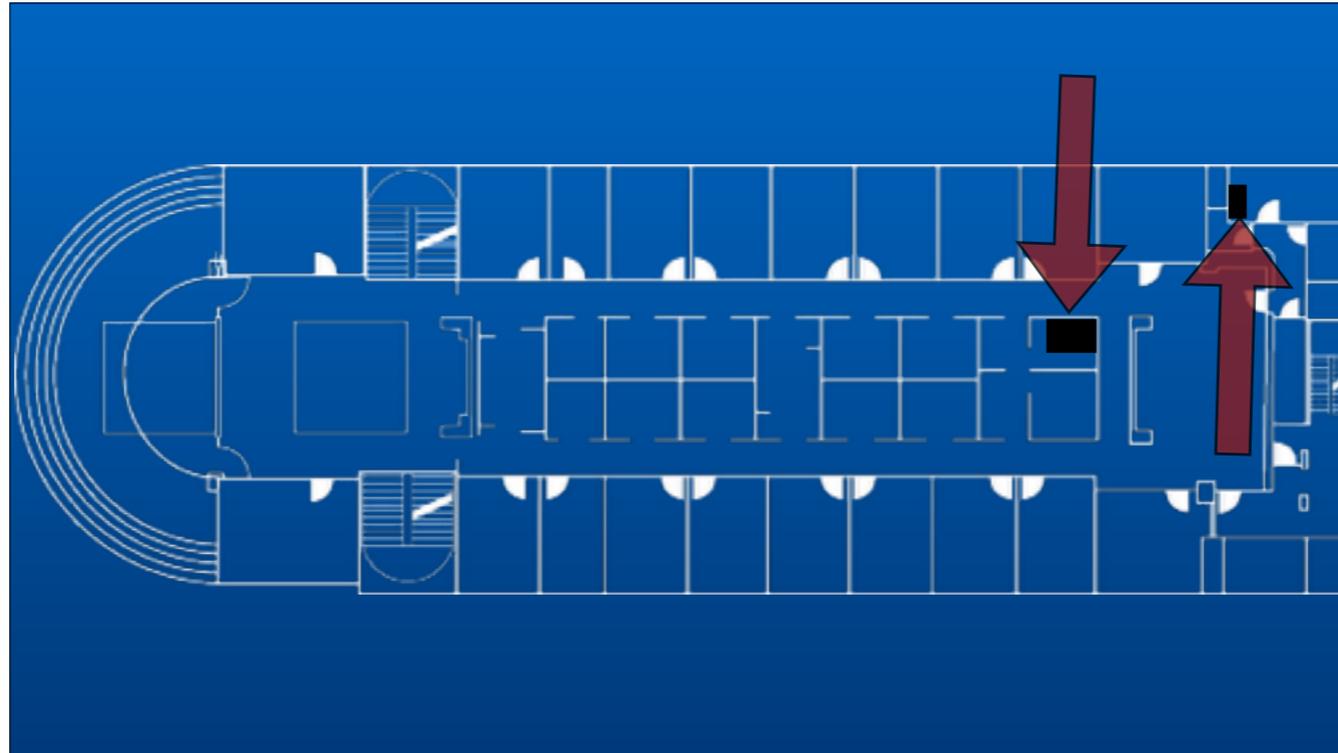
I'm sure the physical security-conscious of you are cringing at the ease of circumventing the door in this space, but I'm happy to say that for 13 years, nobody ever scaled the wall.

Also, I never worried about them overheating in here

Drawback? **<click to zoom>**

Take a look where this rack was placed.

One of the first lessons from our relocation project was learned about a dozen years ago, when that rack was installed: putting a rack alongside a wall is OK, but never back a rack into a corner- you will need room to walk behind it. Working with the back left of this rack was rather inconvenient.



In the original building layout, we had our technology infrastructure in 2 places on the main floor we were just looking at:

<click for arrow>

The first is right here: this is the space with the servers regrettably backed into a corner

The second is **<click for arrow>** here, a 2 post, wall mounted rack with networking gear: switches, firewall, patch panels, ISP handoffs.



Specifically:

In that rack backed into the corner is where we had most devices in the computing and/or storage category- from the top down: **<click to zoom>**

File storage

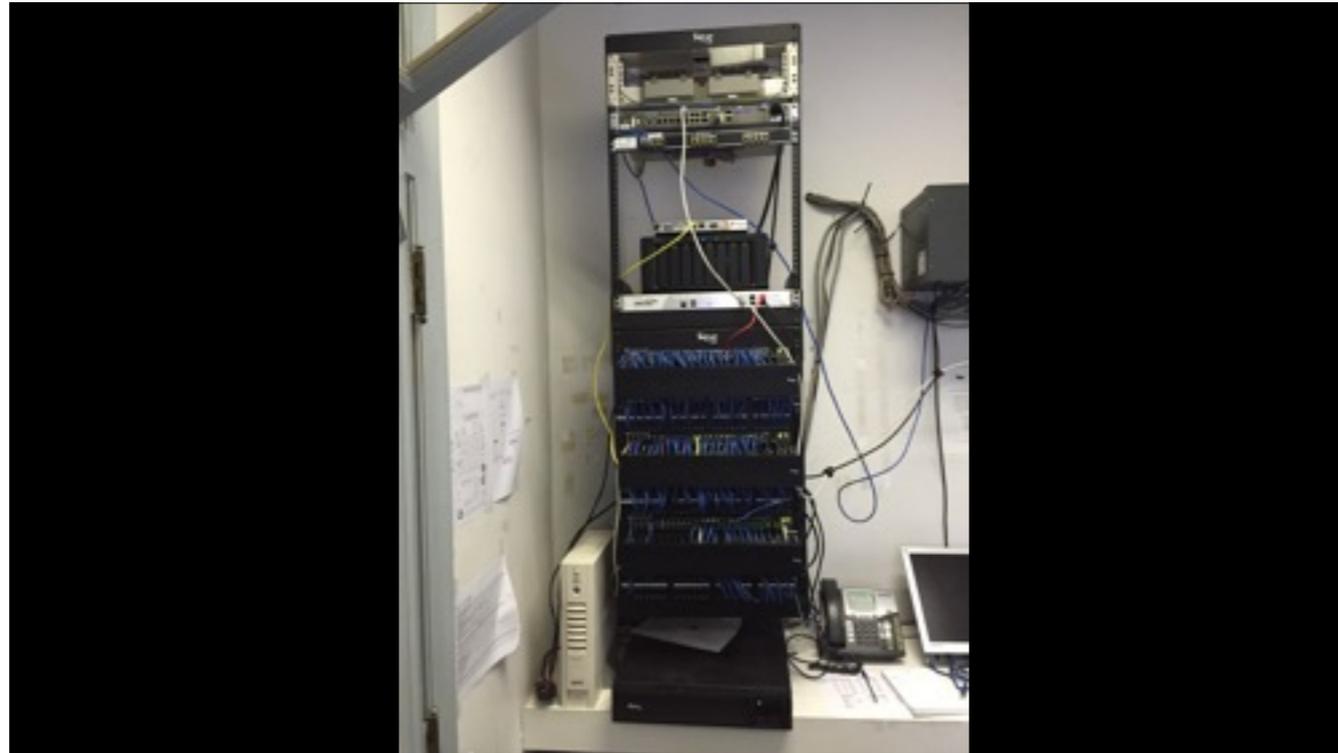
Backup and monitoring server

Mac Mini we use for machine deployment using Munki, Autopkg and DeployStudio and it's storage

virtualization infrastructure

16 Bay RAID for backups

2 UPS



The second area holds the networking gear in a 2 post wall mounted rack:

So in the rack we have:

Splice tray from our fiber ISP

Ethernet and PRI handoffs from fiber

Wifi Controller hardware

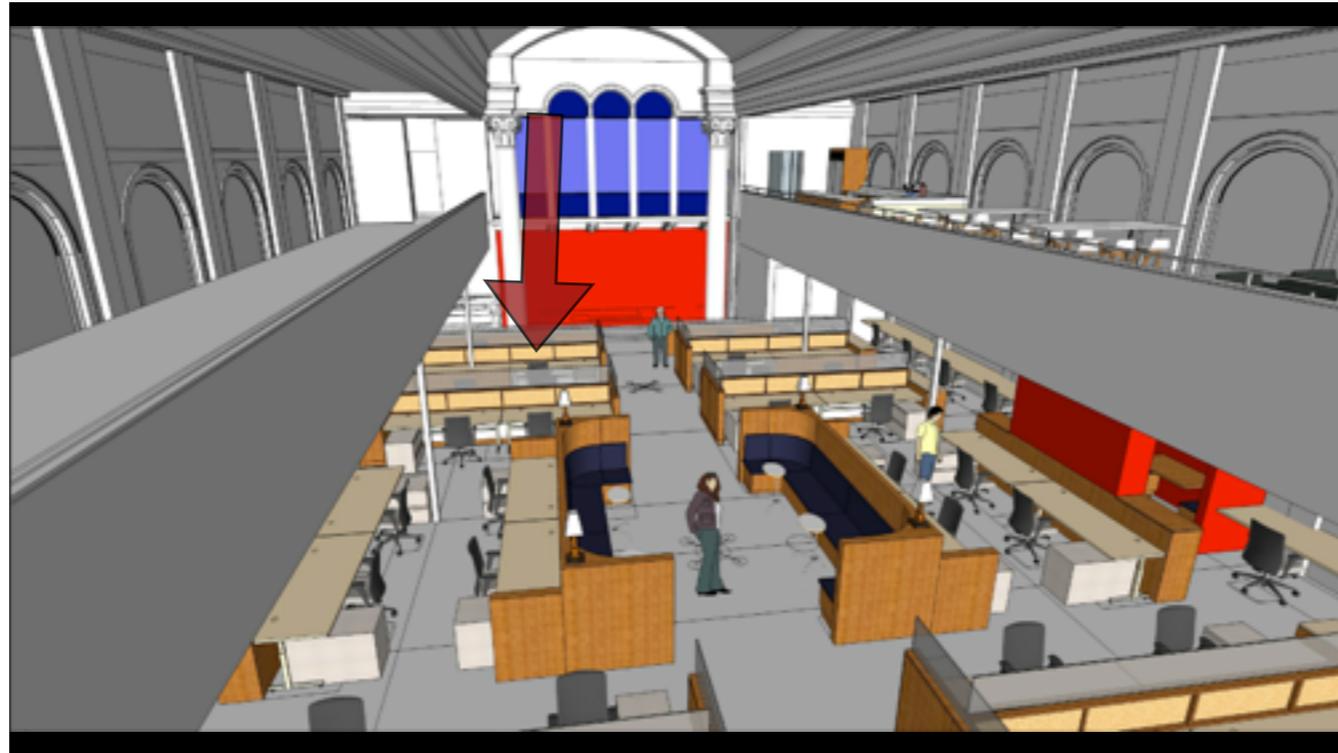
A NAS

Firewall **<click to advance>**

patch panels for every network jack in the building

and set of 3 stacked switches

This was all in the company mailroom- fully available for any employee or stranger to walk in and unplug cables. If you get to choose where to locate the networking in a project, I wouldn't put it in the mailroom, but this happened long before I was hired, and is not uncommon in small businesses.



On Feb 2nd of this year, at an all-staff meeting, it was announced that a significant building remodeling project was to start *in 2 weeks*. In this architect rendering of the plans that we were shown, my existing server room is here **<click for arrow>**

The networking rack is out of this view, but in the back left, and also part of the remodeling scope. This meant that both my servers and all our networking would have to be moved, but the remodeling was going to start before that was executed or possibly even planned.

Staff purged unnecessary items from offices, packed up some for offsite storage, and took the bare necessities as they doubled up with others in downstairs workspaces, or went to folding tables we imported to serve as temporary desks in other parts of the building.



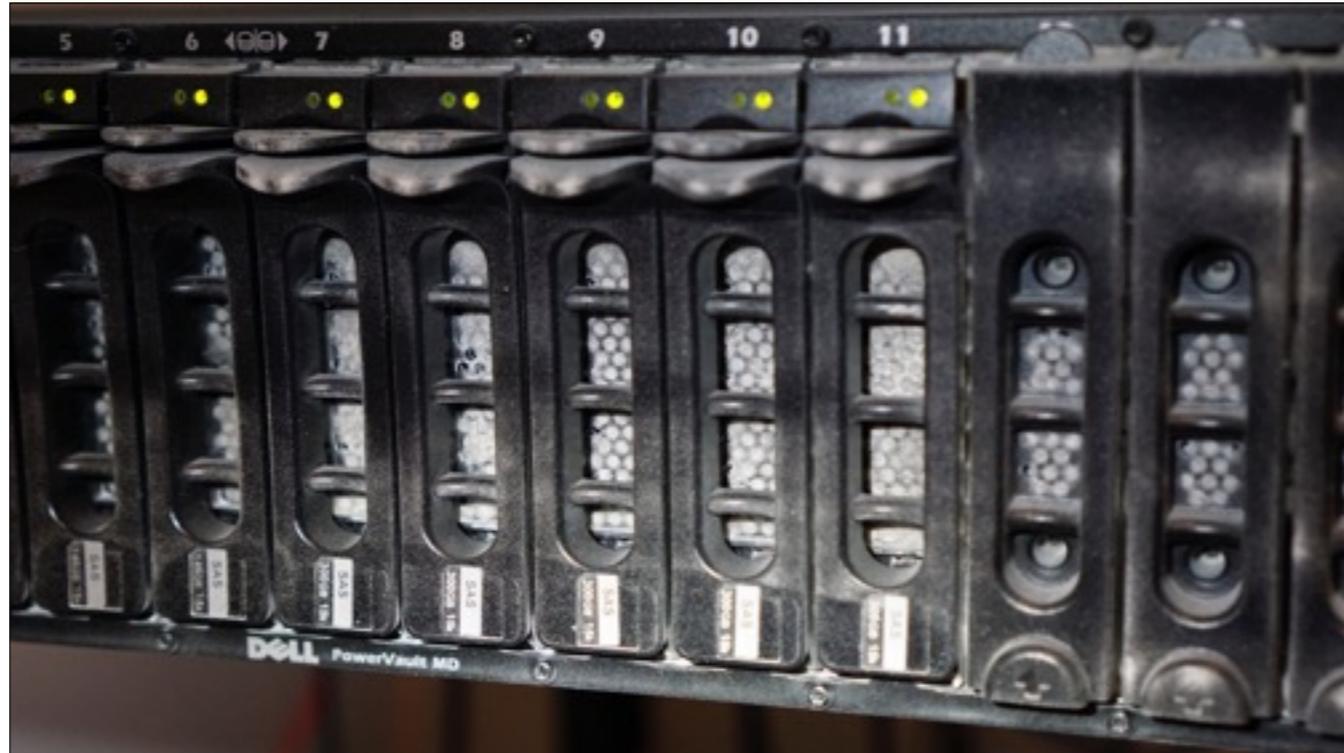
When the destruction crew arrived in 2 weeks, this is what they accomplished over 2 1/2 days. **<click to play>**

As we were going straight into remodeling without preparing and relocating servers first, they remained **<click for arrow>**

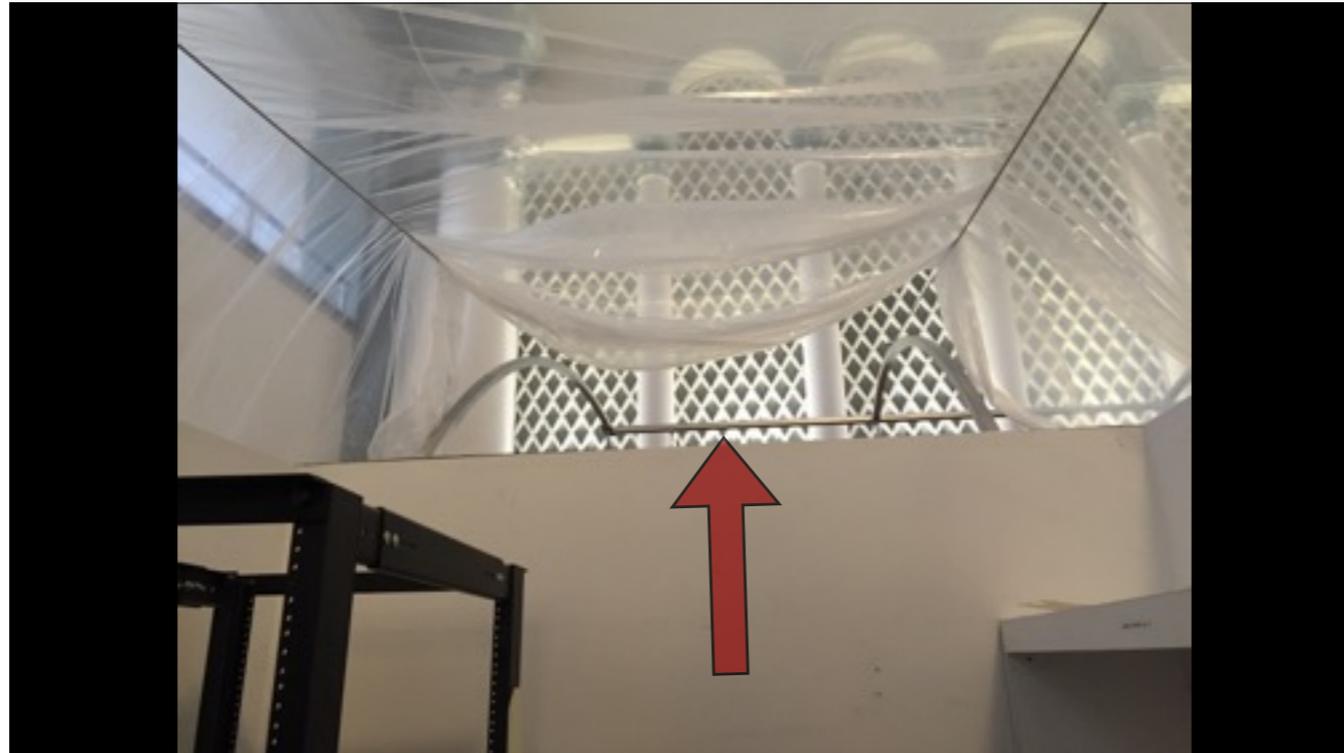
To make this happen a lot of sledgehammers and sawzalls were used: there were many times I could feel the floor vibrating under me. Many times I cringed, uncertain how close we were to sending dozens of hard drive heads crashing into their platters. I'm happy to say that despite how discomforting that was, we lost no hard drives (or any equipment) during the construction time.

Some of the more memorable events during the removal of the old offices:

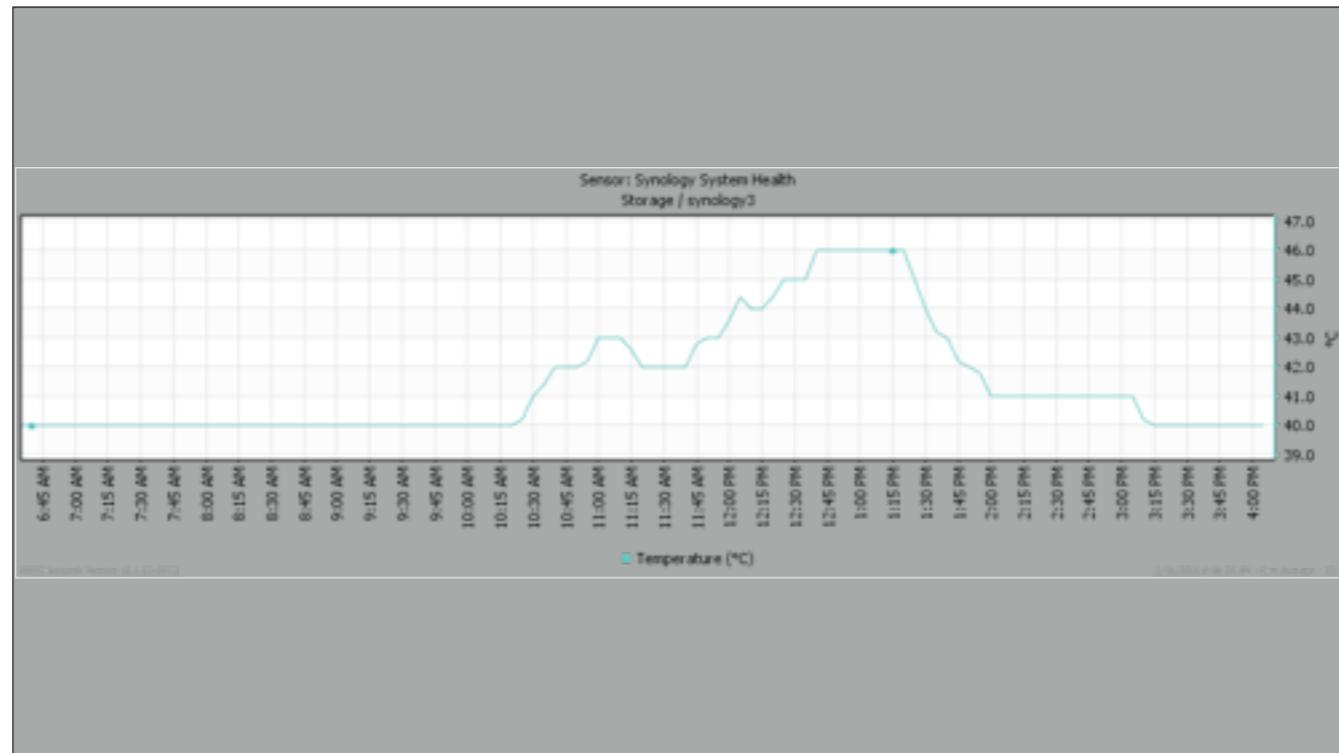
- on Day 1 of remodeling, I walked into work to work at 8AM to hear my UPS and servers in audible alarm mode, because the electrician was turning off breakers to determine what went where
- the day that we had our entire phone system going offline many times, then returning. That was traced back to each blow of a sledgehammer to a nearby concrete wall.
- numerous other unscheduled UPS confirmations, tied power tools drawing from the same circuits
- a few cut Ethernet or phone lines
- The day the dust triggered a smoke alarm, which automatically dispatched the fire department



Speaking of dust...as drywall was ripped out and sawzsalls took down walls near my running servers, one pretty predictable thing happened: It's messy. Fans draw air over components, and when there's drywall dust in the air, your servers are inhaling it. This started to concern me, to the point of seeking a way to shield my rack from this dust.



So we had an idea: we could cover the open server area. The construction crew was using a thin plastic sheet to try to restrict dust- it would work here too. Draped over these cables that hold a lighting fixture above, it'll keep the dust out, and heat can vent out the open area [<click for arrow>](#)- should work great



That wasn't such a good idea! We put that thin sheet over a bit past 10:15A- you can see what happened- it started warming up in that space far more than I ever expected.

It was around 12:40 that we found a middle ground- by bringing this...



An industrial air cleaner the construction crew had. This stands about doorknob height, and exists to inhale dusty air at the top, catch airborne particles in a filter, and put out “clean” air from the bottom.

With this forcing air through the room, we could have the space mostly covered, and manage temperatures.



So bottom line on a construction project where servers are exposed to a lot of drywall dust and vibration: The gear withstood more than I was comfortable with, with no ill effects, even though it got this bad.



As the remodeling progressed, we arranged where the all the technology would be moved to: a lower level space that is the building's electrical room, telco demarc, and of course, assorted junk storage. Overall, this was a sensible destination, because it had ample access to power, and a fair amount of our Ethernet cabling ran through this space already, which is a plus since the patch panels and switches would end up here too.

When this was declared as the destination space, I had 2 immediate concerns:

Cooling- after seeing what a little sheet of plastic did to ambient temperatures, I was worried about this enclosed space heating up. This was handled this by adding an air conditioner just for this room at those back windows.

Second **is** those back windows- this is a downtown, ground floor, exterior room, vs an interior space on an upper level. Desired security is still on the to-do list.

Fortunately, this space was just big enough to put a 2 post telco rack along the right wall and the 4 post server rack immediately to its left and provide the 36 inches of clearance around the electrical panels on the left wall, as required by the National Electrical Code.



<https://xkcd.com/705/>

I hope you too can relate to this- I want to be that italicized *sysadmin*, who doesn't let things go down- even though the services I provide are almost exclusively internal-facing, so the userbase was well aware of what was going on, I don't like my servers to be offline. But as you saw, the server location was holding up remodeling work, so I started to go through my menu of options to to keep things running during a relocation.



I considered the option of moving the gear while it was still up, in the way these guys kept physical server running and online via mobile phone data and a VPN while they moved it between 2 data centers.

Via the subway.

With ample battery runtime, multiple power supplies and some clever wireless bridging, I figured out a way I should be able to pick up my gear and relocate it to the new space live, but I rejected that plan because one misstep could lead to a really hard to justify disaster. Additionally, I welcomed the opportunity to part ways with our existing rack, because

The best thing about standards...

- 10-32: “10” is not a measurement: an ANSI standard. 32 threads / inch
- 12-24: “12” is not a measurement: an ANSI standard. 24 threads / inch
- M5: 5mm screw
- M6: 6mm screw



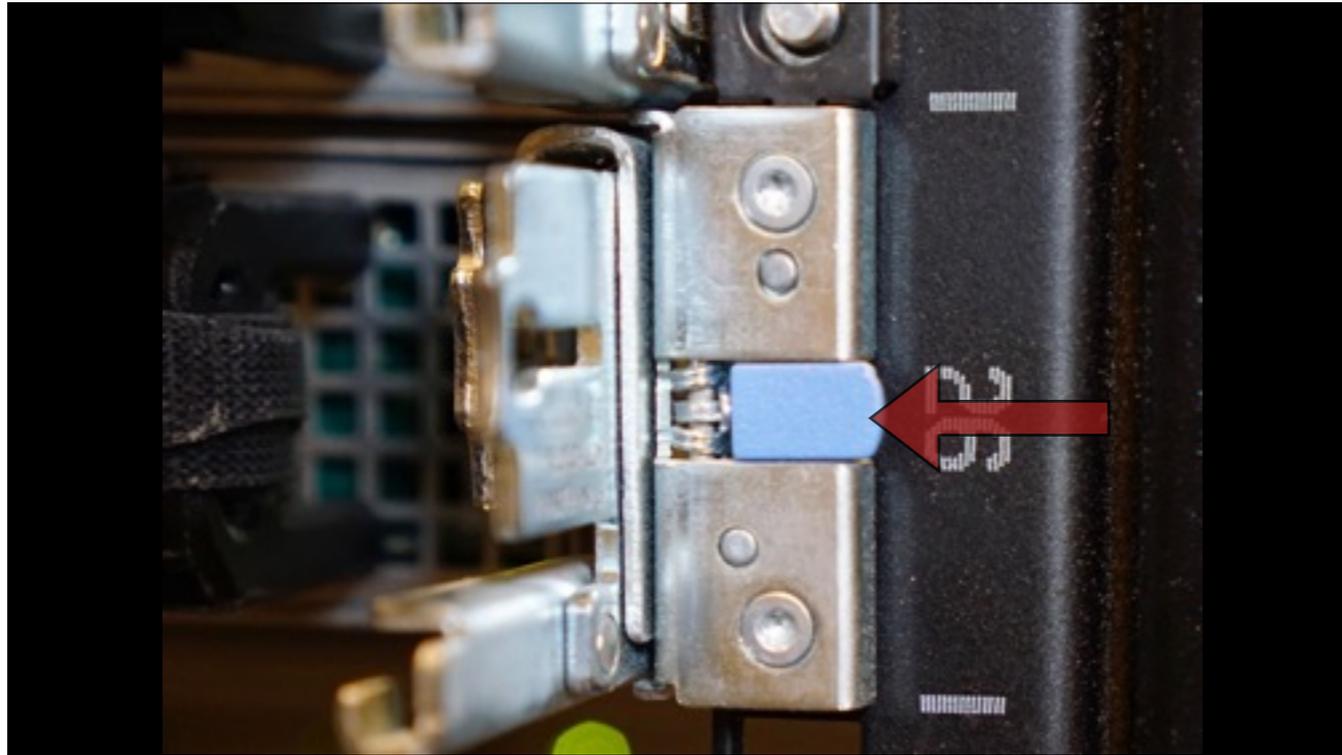
1) Years ago, we bought a 4-post threaded rack for servers. I would not buy this style again: because lining up rails on the proper front/back pairings was always hard (because the specific rack units weren't labeled) and you have to be sure not to grab the wrong thread pattern screw: this rack was threaded for 10-32 **<click>** and 12-24 **<click>** so there was ample opportunity to pick up the wrong screw for the space you're targeting. Some equipment vendors include metric **<click>** M5 and M6 in their hardware, and the M5 is just enough off of 10-32 to kinda fit, but not properly.

2nd problem with a threaded rack: If someone tried too hard to make the wrong screw work, there's an opportunity to strip a hole. Since they're part of the rack, when that happens, that rack space is now practically unusable.

3) The most recent gear I needed to rack was only available with rails for square holes: I had to buy a shelf to sit that unit on. **<click>** Or, one can use threaded to square hole adapters- which we will see again later in this story.



When I say square hole rack, this is what I mean. Rack rails that snap into square holes make racking easy. There's nothing more to do than to click them into the holes: no tools involved. Dell has "Rapid Rails" and "Ready Rails" HP calls them "Quick Deploy", these have become the standard for mounting servers in 4 post racks. When they need to come out, **<click to advance>**



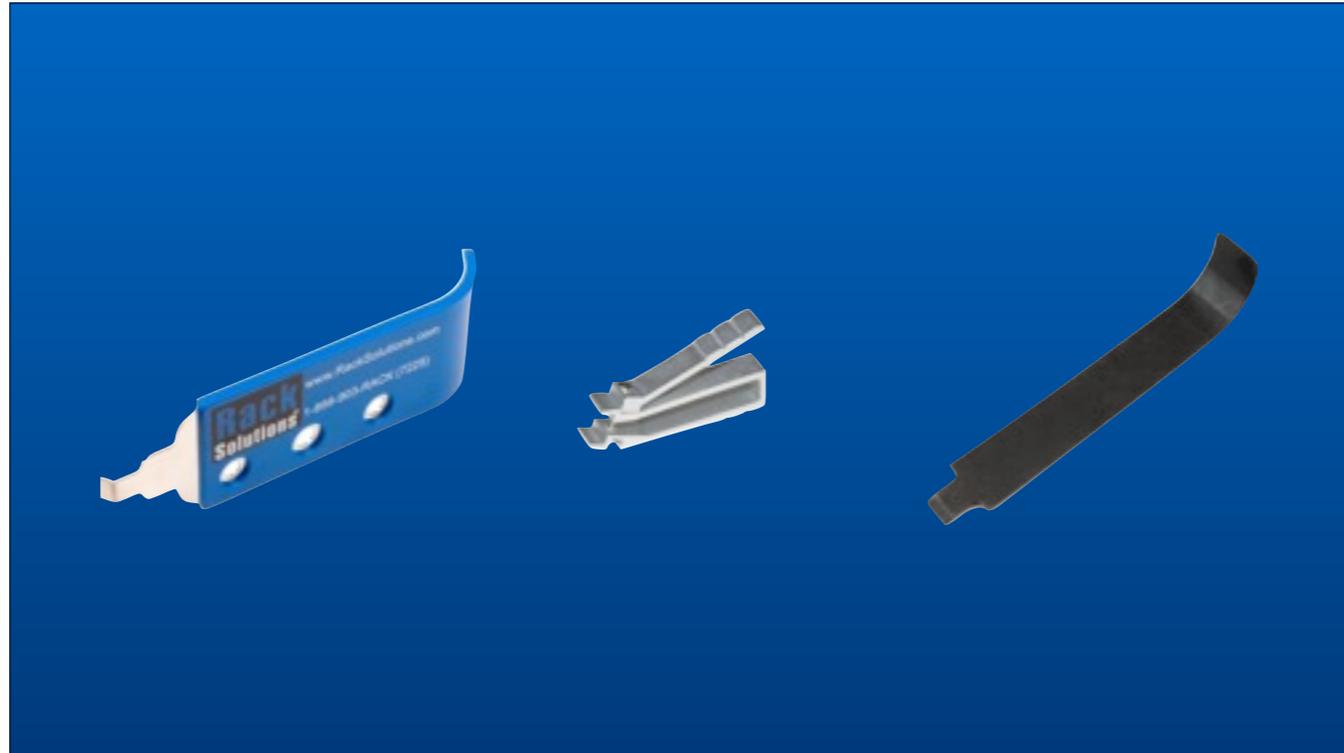
they're easily released from the rack by the spring releases in the middle of each rail face.



These rails are awesome, but some things need a nut and a bolt. This is where your square rack is the most flexible kind: it is also a threaded rack, of any type you need it to be, thanks to cage nuts. **<click>** As the name implies, they're nuts in a holder (cage), that can be snapped into your rack.

When installing cage nuts:

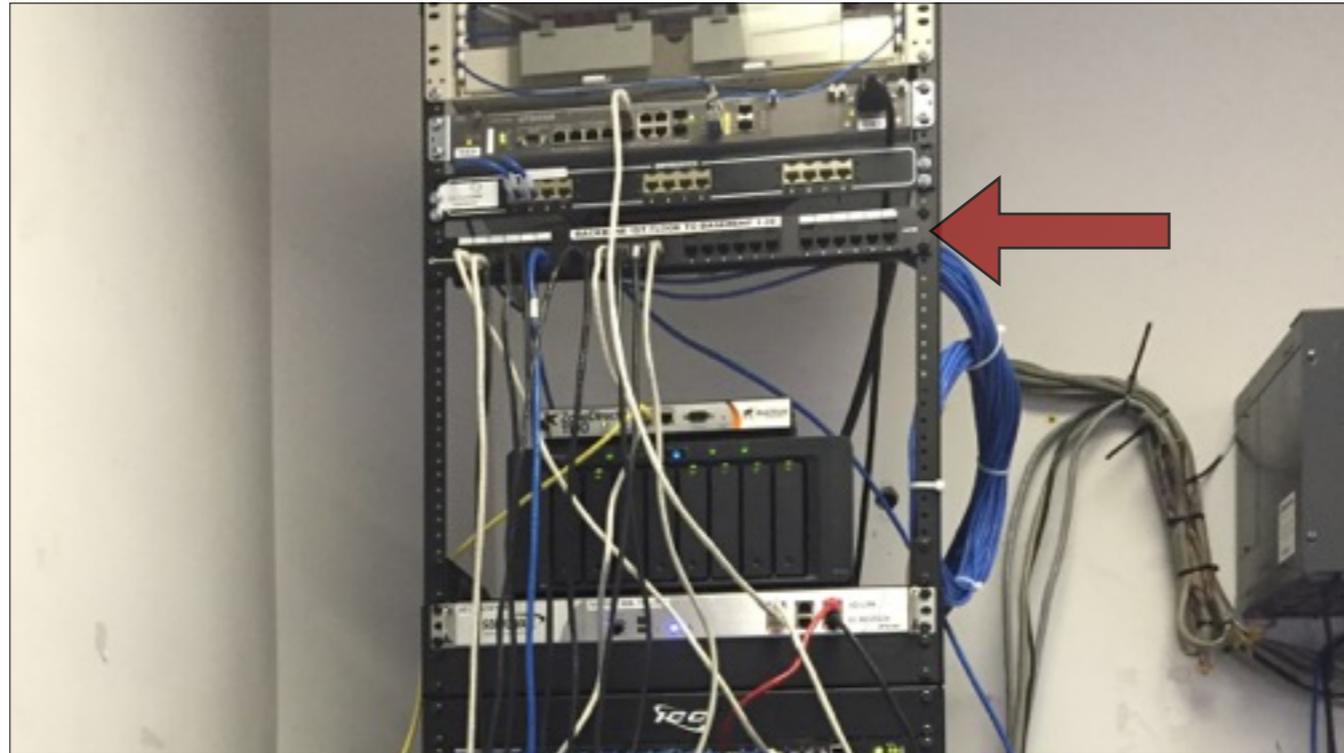
- 1- There's no absolute right or wrong in orienting the wings horizontally or vertically.
- 2- The part that has a significant right or wrong is where the nuts go. They must be on the **opposite** side of the rack as what you're mounting, so the the screw passes **<click>** through the device, through the rail hole, and lastly into the cage nut, to pinch it all together when tightened.



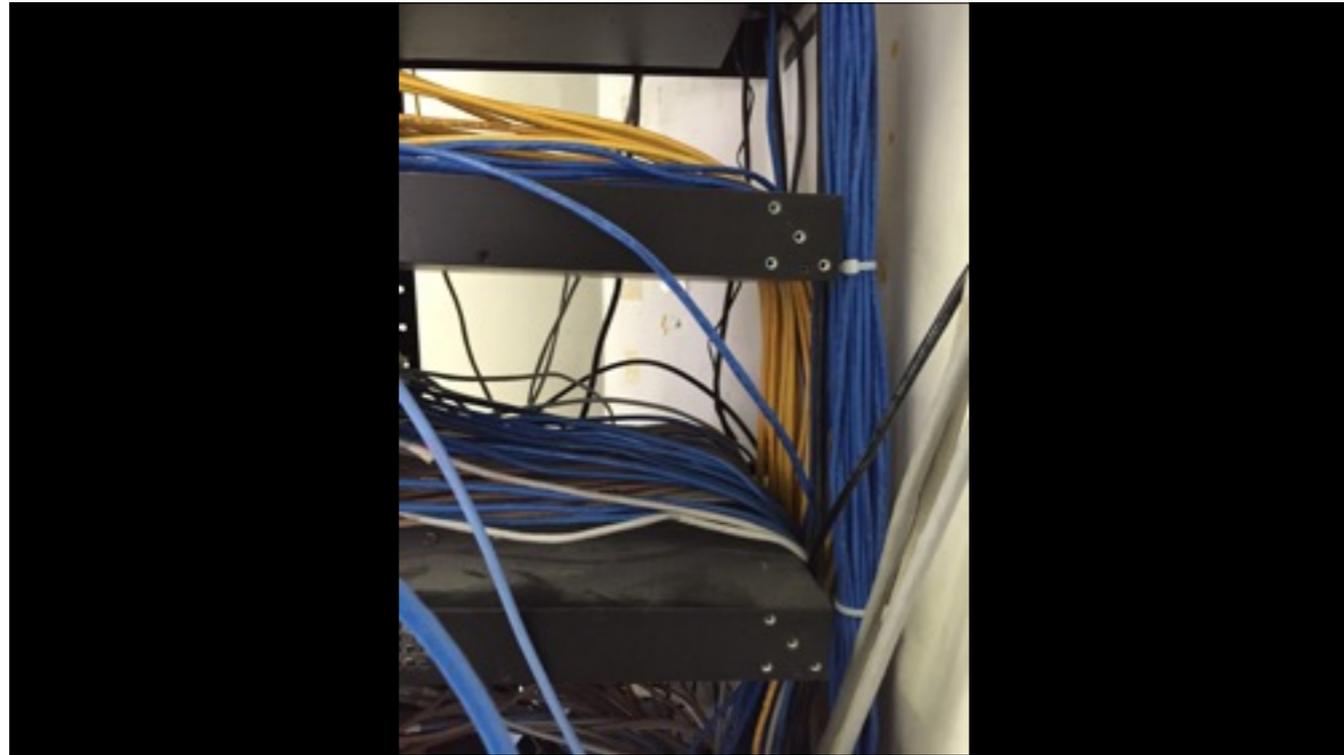
We managed to do all our cage nut installations by hand or with a screwdriver, but they can be rough on your fingertips. A cage nut tool can save you from injury.



For 2 post gear, threaded remains the standard, as you're directly screwing your gear to the rack, vs installing it in the rails that are attached to the rack. I recommend you note what size your 2 post rack is threaded for, and forbid all other screws from your rack area.

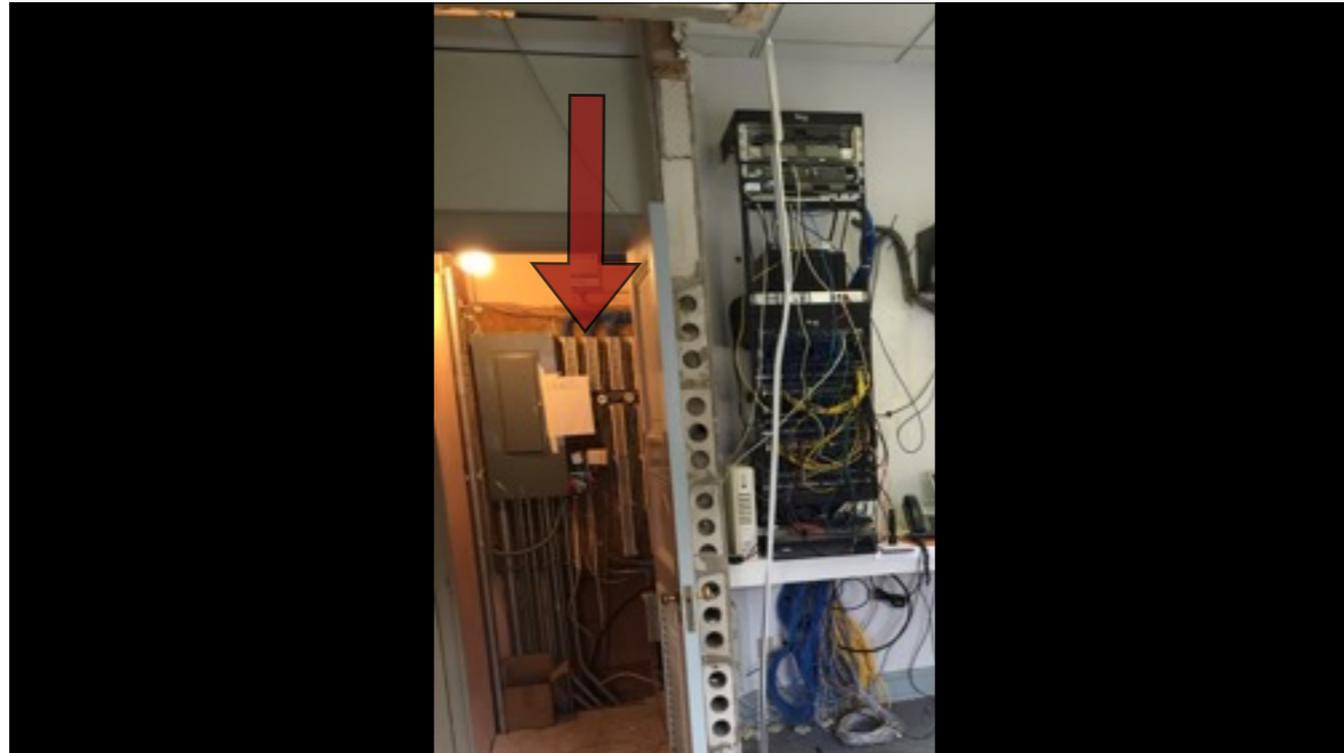


We had the project's low voltage subcontractor install 2 new racks in the electrical room. In order to be able to first move the servers and connect them back to the network, a temporary patch panel was installed in the existing switch area **<click for arrow>** and they ran the 20 cables down to the new server room, terminated on a matching panel, so when hardware was moved, we could redirect patch cables from the old patch panel to the new, to connect servers back up to where the switches remained.



One more thing I learned about racks in this project: If you have a project that calls for a wall mounted 2-post rack (like my old switch rack here), pay attention to it's depth vs the depth of your switches. This shows what the back of my switches looked like- you can see they're just a couple of inches off the wall.

This ended up being fine for their time in this rack, but one more effect of this project was **<next slide>**



that the space where all our existing digital phones were terminated **<click for arrow>** was also part of the remodeling scope. Old phone system was old: relocating these punchdowns (called 66 blocks) was not a reasonable thing to do: we were dumping the phone system for a VoIP migration also.

In doing my prep work to become a VoIP admin, I learned something new: while we had selected 3 48 port stacked PoE switches for our last upgrade, with future VoIP in mind, I was not aware that I needed to be concerned with both the “power budget” on a switch (meaning total Watts of power it can supply to endpoints), but also seemingly arbitrary vendor limitations. In their stock configuration, while all 48 ports are PoE ports, the stock power supply of my switches will only power 24 ports, even if you are well under the power budget. Per the vendor documentation, if a 25th PoE device was plugged in, it was not expected to work.

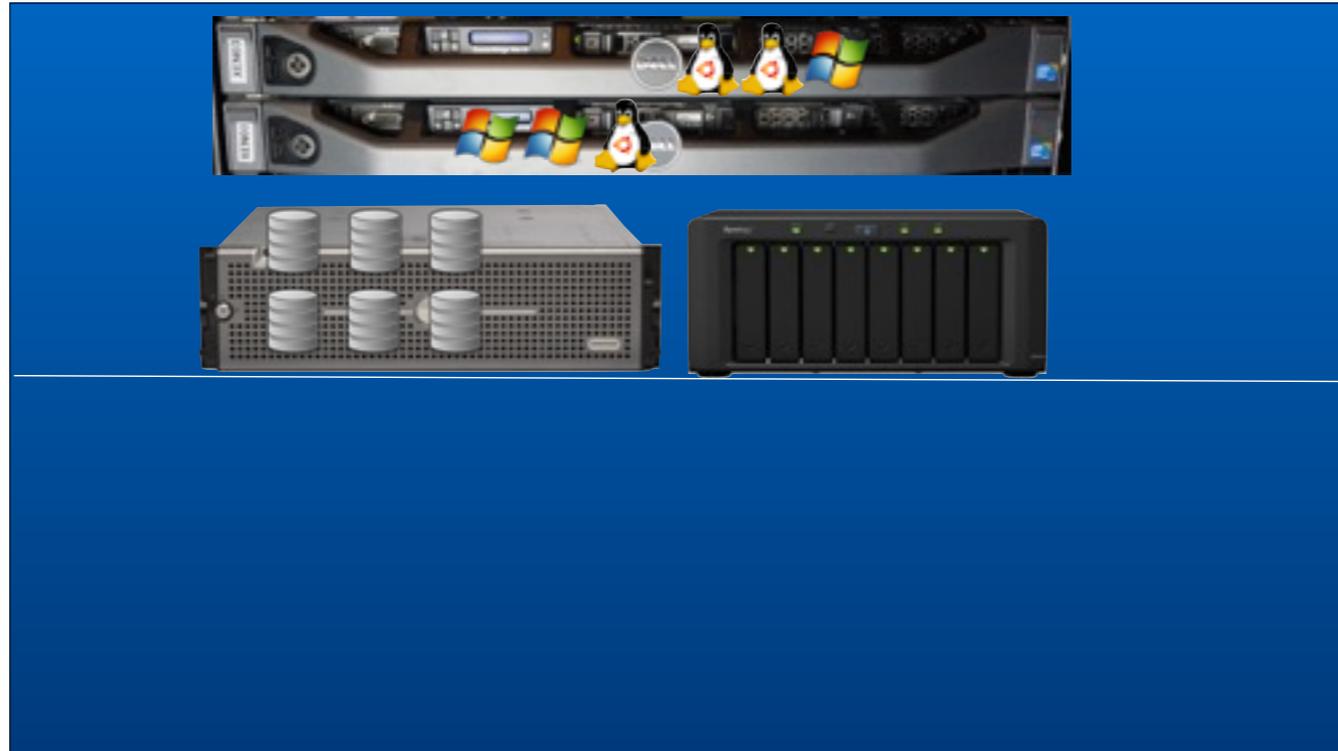
With adding about 100 new PoE phones to my network, this was going to be a problem.

Fortunately, for my switches there is an easy solution to this:



Addition of redundant power supplies (through these cables on the right) provides both a backup in case of issues with the main power supply, and allows the switch to power all 48 ports.

Now back to the point on depth of the 2 post rack: there's no way I would have been able to fit this power supply plug in while using the 2 post. Fortunately, the remodeling project solved that for me.



The second option I considered to maintain uptime while relocating was based on cool virtualization tricks. I provide our Windows and Linux servers via XenServer- a bare metal hypervisor in the same category as VMWare ESXi. A feature that both of these products offer is the ability to relocate (or “migrate”) any virtual machine’s virtual disks between shared storage devices that multiple servers can see, and also to move running virtual machines between physical hosts. It would be possible to:

- migrate all VMs to a single server
- shut down the XenServer with no load on it
- move it to the new rack
- bring it back up
- migrate all VM disks to one of the NFS shares
- shut down the main storage and move it
- migrate all VMs to the first moved server
- shut down that host, relocate it
- rebalance VMs
- move VM disks to higher performance directly attached storage
- relocate the NAS at our convenience

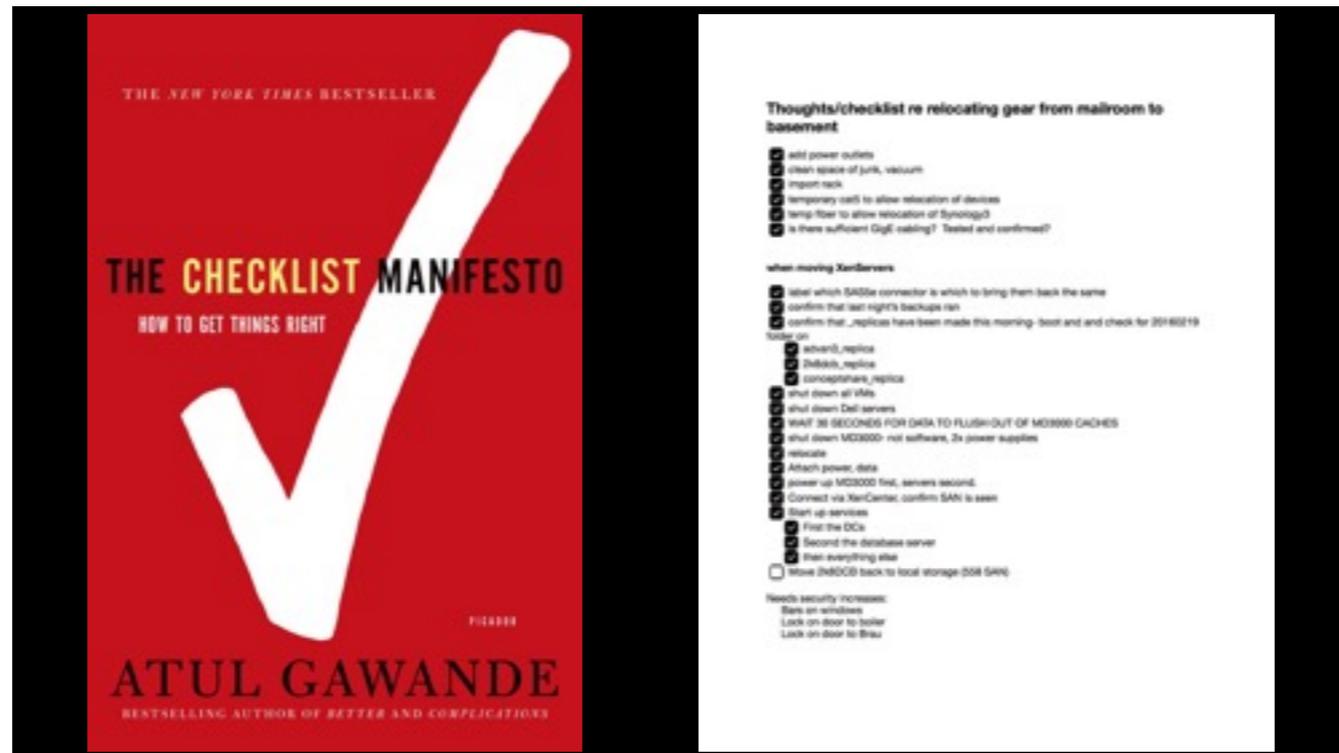
If service downtime was completely unacceptable, these tools can keep virtual services up while physical infrastructure is unavailable- they’re quite incredible. It still amazes me that this is a thing that can be done.

One downside to moving VMs and storage around in XenServer 6.5 is that performance is capped to 20% of an interface's bandwidth. This means a standard copper Gigabit Ethernet port gives about USB2 category performance for these migrations.

	Message	Server / Pool
▼	✓ Migrating VM 'PHDVBA to Synology1' from 'XEN01' to 'XEN03' Migrated Time: 00:01:20	XEN03
▼	✗ Migrating VM 'PHDVBA to Synology3' from 'XEN01' to 'XEN03' Internal error: Xenops_interface.Failed_to_shutdown() Time: 00:21:14	XEN03
▼	✗ Moving virtual disk 'ADVAN3 E (data) drive'... Not enough server memory is available to perform this operation	XEN01
▼	✗ Migrating 1 virtual disks to Local storage Not enough server memory is available to perform this operation	Hiebing pool
▶	✓ Migrating VM 'PHDVBA to s3 & replicates' from 'XEN01' to 'XEN03'	XEN03

These migrations are wonderful when they work, but I've been frustrated by system failures that would halt progress. Besides the above, I've experienced VM migrations that get stuck at 99%, and cannot be persuaded to complete.

I asked in the official Citrix forums for input from the full time XenServer admins, and those with more experience advised that in this circumstance, a scheduled downtime to shut it all down, move it, and bring it all up would be the safest and most reliable way to do it. We advised staff that on Saturday, Feb 20th services would be interrupted, and came in to shut things down and move them.



Before the migration day came, I took the approach used by pilots, surgeons and many others who need to ensure a process is executed properly, and made a checklist of all the prerequisites and steps that would be needed to relocate the hardware successfully. A great book on this topic is Atul Gawande's *The Checklist Manifesto*.

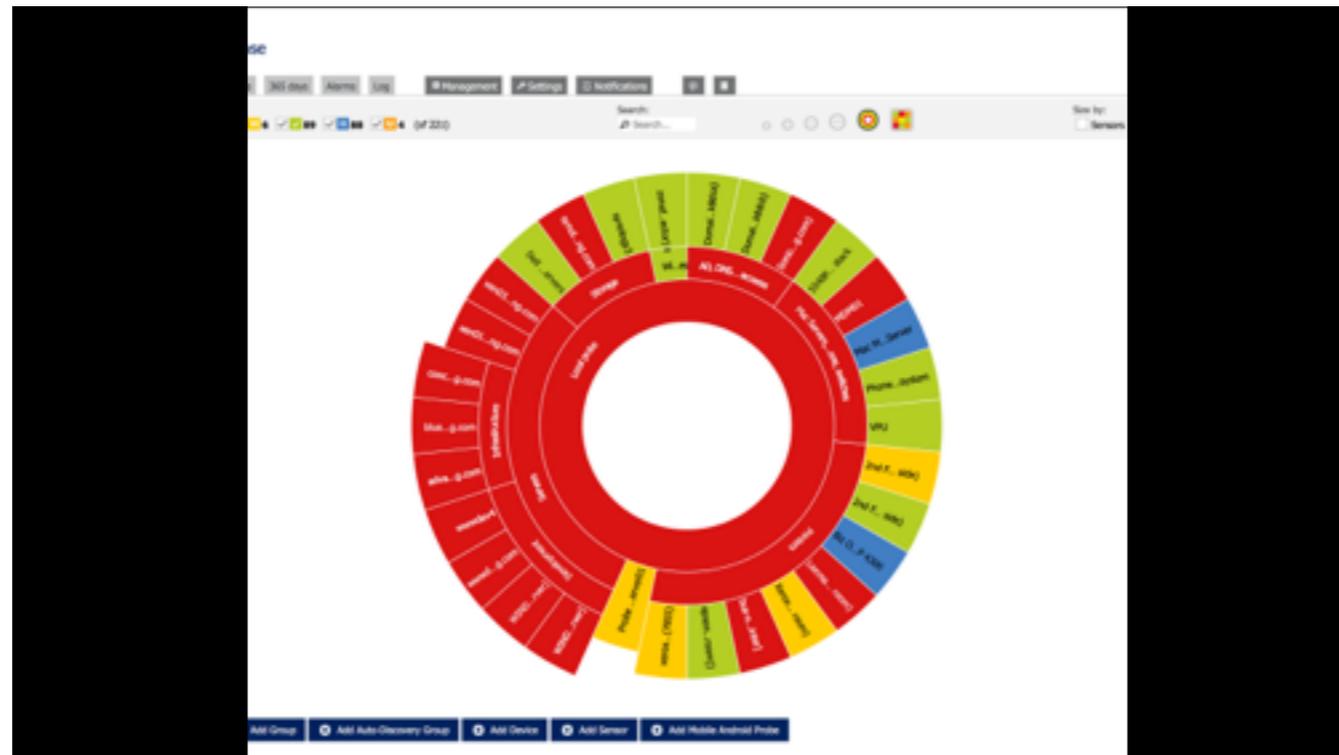
My move day checklist was to:

- Verify last night's backups and replicas all executed properly
- Label my SAN cabling and ports, just in case. I've only regretted not being paranoid enough when doing a process for the first time.
- Controlled shutdown of all VMs
- Shut the servers down. Wait 1 minute before shutting down the SAN to make sure all data is flushed from RAM cache.
- Pull it all out of the rack
- Blow out as much dust as possible
- Take out the rails
- Reinstall rails downstairs
- Reinstall gear- matching up SAN cabling
- Power the storage up first, then virtualization servers

If you ever power down all the servers in the office, if you have them, bring up your AD and DNS servers first, and give some time to start all the services. We started with them, but booted up other servers too promptly: AD was not ready to supply Domain level firewall policies to servers: we had some unexpected connectivity issues with other servers until they were rebooted.

- Then SQL, Web, Linux servers
- Confirm!

Despite my concerns that an old storage array might consider this full power down to be the time to not spin a disk back up, it all came online as expected, and the checklist gave confidence I had thought out all critical steps. If they had not come back up, I had confirmed backups to fall back on.

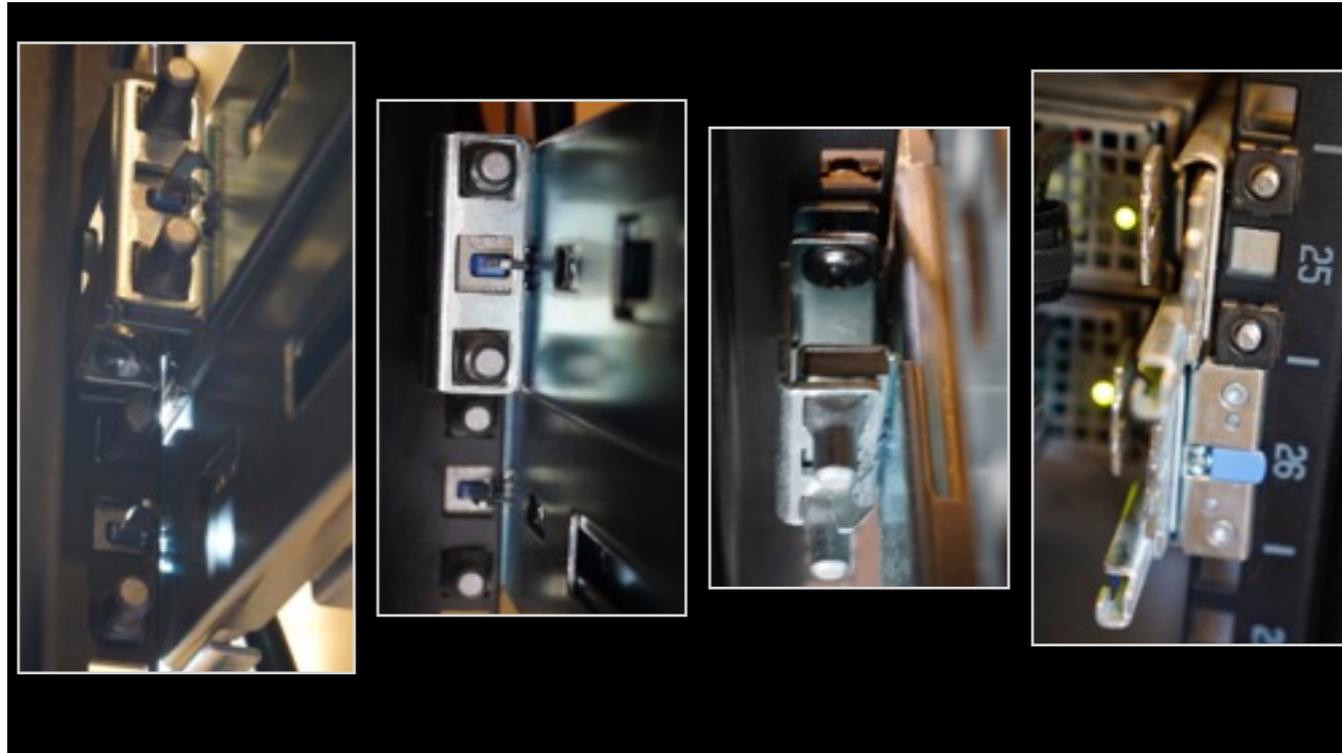


In a day like this, tell your monitoring system not to alert you on every server down event, or your phone/pager/inbox/watch/ is going to be busy.



While we were installing rails into our new rack, we encountered one event that threw us off: we were surprised when the 2nd dell server rails could not be extended far enough to pass by the front and back of the rack to be mounted.

Before this move, the only rack I was experienced with had no depth adjustments. Once it was set and bolted to the floor, it wasn't changing. In a better rack, that might be different. Now that I know this, the 3 bolts that can be loosened to allow the rails to slide within the frame are obvious, but on a Saturday afternoon with rails that won't fit and a virtualization infrastructure that needed to be reassembled, I didn't realize this. So, I got creative...



I happened to have adapters for threaded to square hole rails on hand, and made use of them and cage nuts to reduce the depth of the rack. This isn't the right way to do it, but it's stable, and completely working.



In an official “data center”, it’s common to have multiple power feeds available, so that an interruption to one path doesn’t cut the power to both power supplies in a server. I don’t have 2 independent power feeds into my workplace, but I leveraged all the redundancy I could with the circuits in the building- whenever dual power supplies were available, I made sure that 1 of them was attached to a battery backup, and the other side went to filtered power coming from a different circuit than the one feeding the battery.

Adaptive Load Balancing

- Available from many NAS vendors, XenServer, Windows
- Works on any switch(es)
- Server setup only- no switch configuration
- Basic load balancing (overall bandwidth) and fault tolerance

Another redundancy to consider when hooking the servers back up was networking redundancy: making multiple Ethernet ports transparently work as one.

<click to build>

Adaptive Load Balancing is one option, available on many platforms, though NOT on OS X

<click to build>

Can be done on even if connected to a non-managed switch

<click to build>

Without any switch configuration

<click to build>

When enabled, this provides increased bandwidth to and from the server, and the ability for a network cable to be damaged, or when ports on multiple switches are used, a switch to fail or have it's firmware updated, but the server will stay online. When we reconnected each server to the network, we made sure the members of an ALB bond each went to different switches

LACP

- Link Aggregation Control Protocol
- Only bonding option in OS X, available on Linux, XenServer, Windows, more
- Requires switch ports configured in a Link Aggregation Group (LAG)
- If multiple switches, then stacked.
- Same fault tolerance, more advanced load balancing

The other option is

<click>

Link Aggregation Control Protocol

<click>

LACP is the only bonding available on OS X

<click>

It requires configuration on both the device and switch side, unlike ALB

<click>

For switch redundancy, switches must be "stacked"- meaning that while your group of switches are separate devices, they share one management interface across all their ports, which happens because they share a management backplane- usually a unique cable. You can't LACP across 2 separately managed switches, or switches that aren't managed at all.

<click>

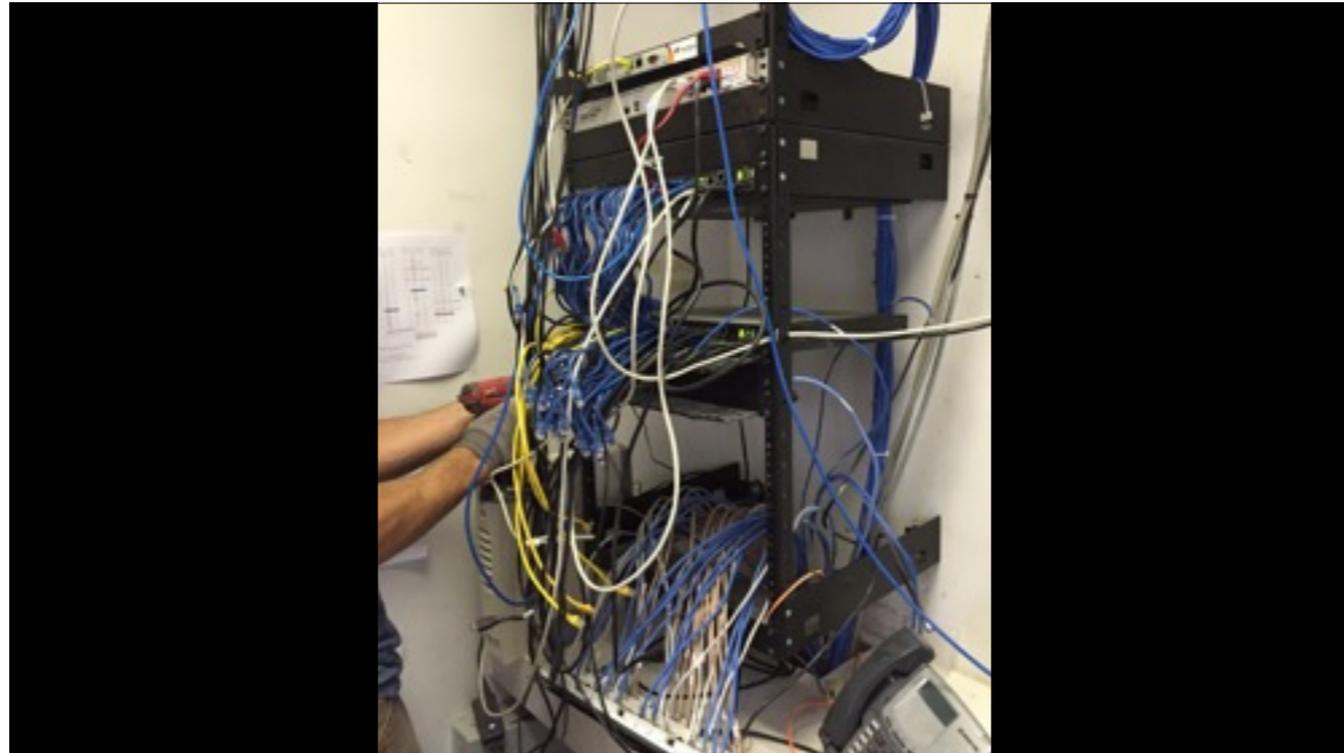
LACP offers better performance, higher configuration overhead

One note about all bonding forms: they increase a server's networking capacity to serve multiple clients simultaneously, it does not allow communications with any single client to go faster.



When all was said and done that day, we went home with our previous room abandoned, and the new space looking like this.

With the servers relocated, that section of remodeling could continue, and we could now focus our attention on phase 2: relocating networking downstairs.



To do that, we had a few facts to consider-

-Cabling in the remodeling zone was going to be run fresh, which was great, because existing cabling was old and poorly done. It was stripped and discarded.

-Before this project, the most recently remodeled area was our lower level. This had benefits that we were moving all the gear to a space where the majority of that floor's wiring passed through, solving for most cable length concerns or routing for that section of the building.

-Because remodeling meant adding more employee workstations, and the wholesale disassembly, relocation and reinvention of our patch panels, we decided to completely do away with our existing station jack identification system, and give all ports new identifiers.

So to relocate these cables, the first step was to document a temporary "lookup table" listing the existing cable identifiers

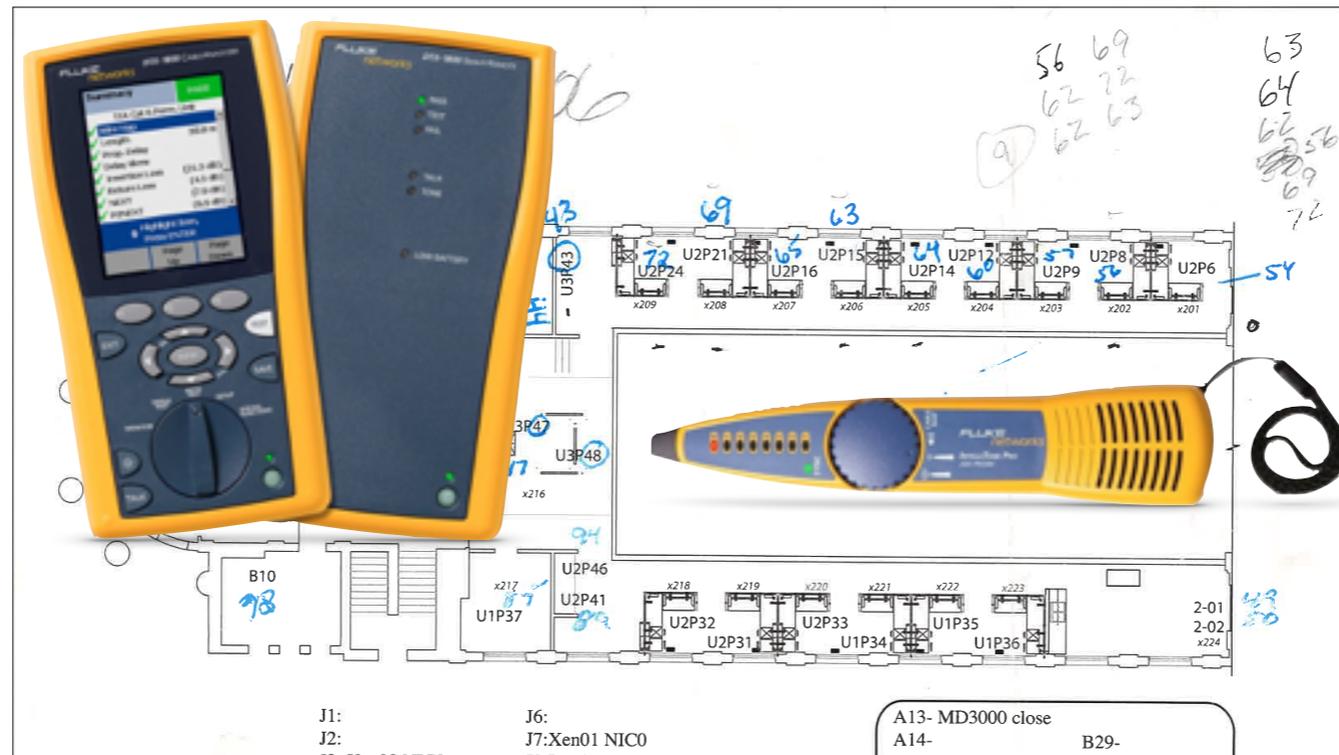
The contractor started by sequentially labeling each cable at the panel and noting that new number on the lookup table.

These labeled cables could then be:

- disconnected from existing patch panels

- routed out of that space- out the wall, down into the crawlspace they ran through, and through the ceiling in the new server room and reterminated in the new downstairs panels, based on their new numbers

We could then bring the switches down, and start patching in all the ports, which we did on the weekend of March 5th. When you're taking all the switches offline and ripping cables from patch panels, we did not try to maintain device connectivity: we gave staff multiple emailed warnings that the building would be without a functioning network for much of that weekend, and to therefore plan ahead: cache project documents locally on Friday, understand you won't access web services that weekend,

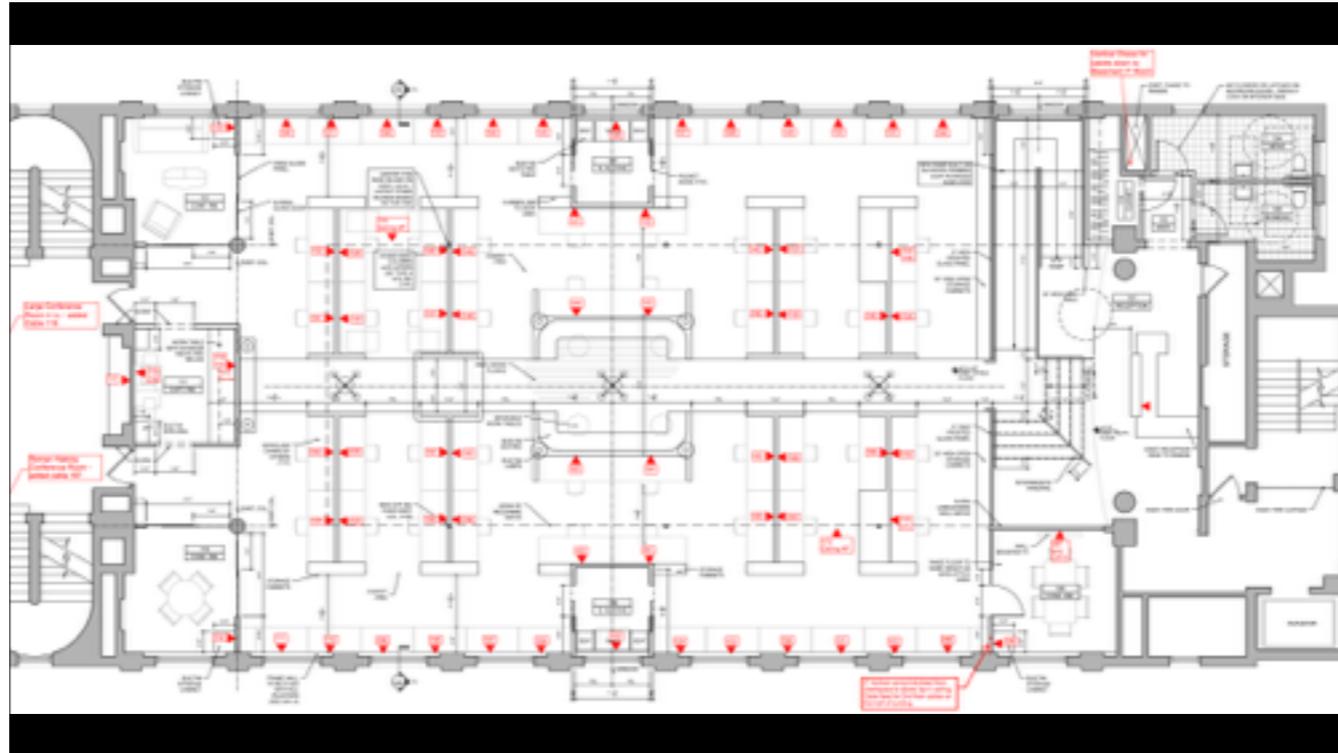


Once each of the cables was re-routed and re-terminated in its new home, it needed to be confirmed that it was functioning properly, and leads to where we think it does. This is a process that takes a pair of techs, 2-way radios, and a cable analyzer. One tech takes the old map, and uses it as his guide to visit every station jack in the building, where he plugs in the remote side of the cable analyzer, and radios the old jack number to the partner standing at the patch panel. The lookup table tells the panel guy what the new panel number is, so he plugs the Analyzer in that side of the cabling. Presuming they're on the right ends, the 2 sides will communicate and perform a cable test- confirming the wire order, continuity, and many other queries.

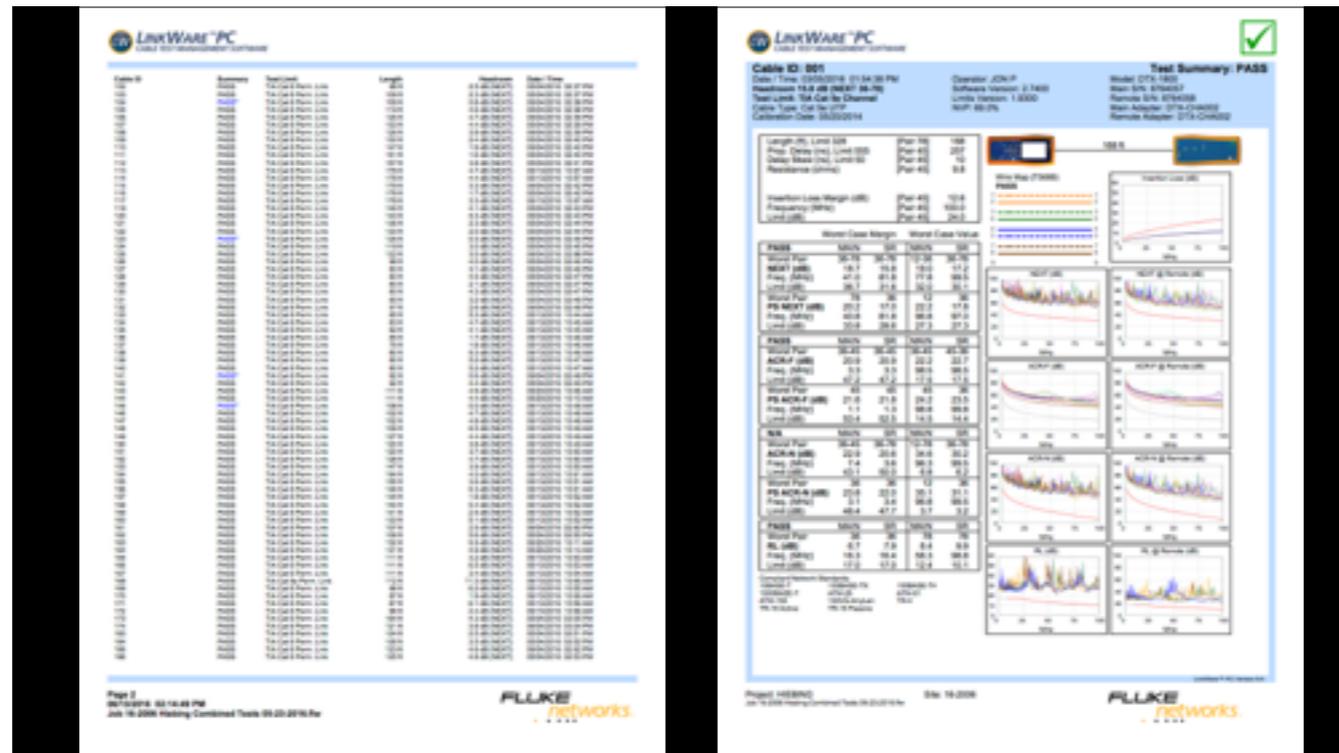
If the remote side plugs into a cable for 15 seconds without seeing the analyzer, it goes into tone mode. The panel guy can then **<click>** pull out a probe and physically pass it by open ports or cables, seeking the one that makes the probe light up and generate a sound- this is the port you seek.



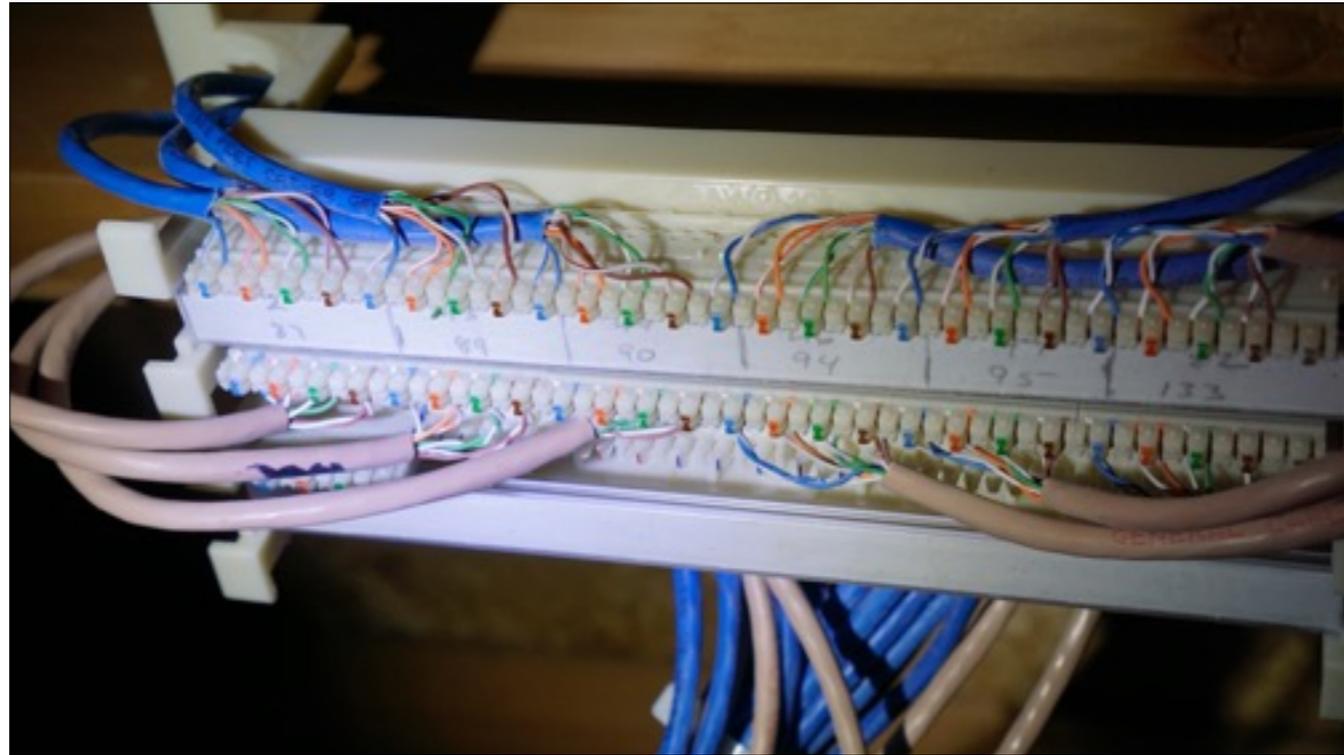
When it all checks out, the station port was relabeled with the new cable number printed on a label printer, and onto the next.



After all the jacks were identified, I ended up with a map that tells me where every jack is, so we know the relationship between the panels and reality. Besides being a searchable PDF, this map is also printed and tacked to the wall next to the switches.



When the testing is completed, the cable analyzer can output a PDF report with a summary overview of all the cable's performance, and detailed documentation of each cable's many test output. You should expect this report from any wiring subcontractor, to verify their work.



When cables weren't long enough to reach the new panel, they were punched down to one side of a "110 block". The other side of each numbered pairing then continues the run all the way down to the basement panel.



Here we see that 110 block, adjacent to a Service loop of spare cable. Service Loops are standard when running cable. Here we see one way to do it: literally extra cable looped and stashed away to allow freedom of movement.

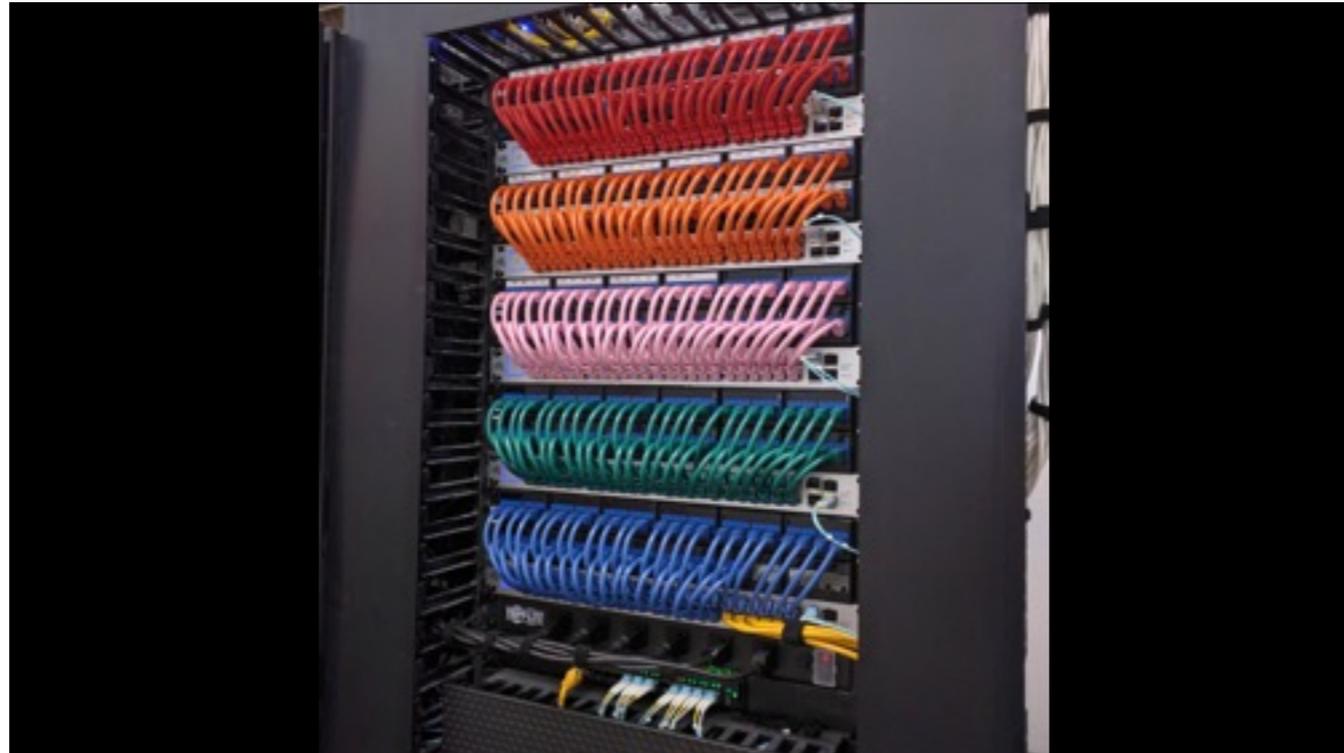


This is another way to route a service loop: note that the blue cables could have been run on a shorter path. By first directing them away from the rack, in a U-shape, then back towards the rack, extra cable is provided, in a format that's less likely to tangle and is easier to keep tidy than looping this thick bundle over on itself.

Another lesson learned about cable access: when we first moved the servers downstairs, we only needed 20 cables back to the original wall mount rack area. But once **every** network jack in the building needed a cable running this space, they would need a way into the room. When the rack was installed, neither of these 2 **<click for arrow>** piped holes in the cement existed...



They got there because one Monday morning I came in to work to find the construction crew in my server room, with this blue tub perched up on a hobbled together 2 legged stand. This was there to catch the muddy cooling and lubrication water from the cement boring machine on the floor directly above, as the construction guys had started drilling those 2 holes I just indicated through the concrete. Fortunately the water and servers stayed separated as designed.



One decision we had to make regarding the network rack was how to arrange the patch panels and switches. One option is to intersperse them, like this:

Pros:

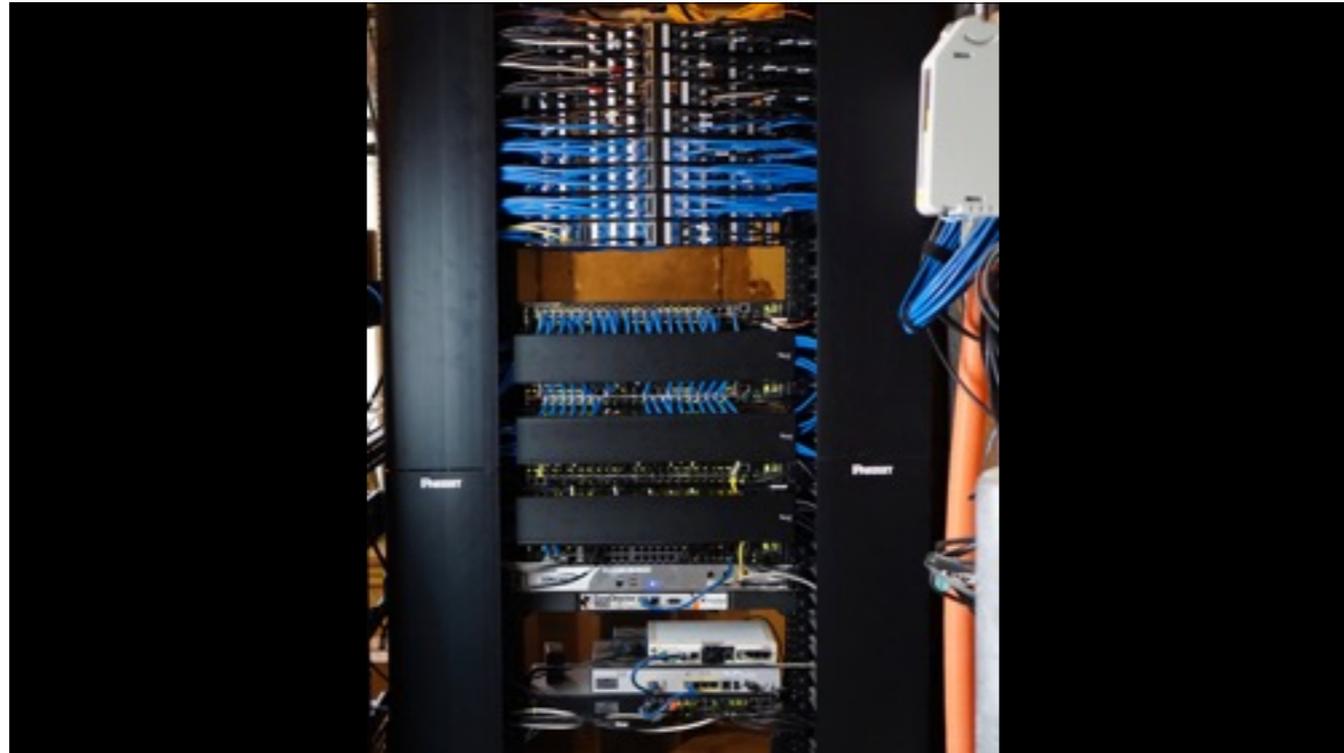
Very efficient use of space: only the fiber has horizontal management

Looks pretty cool

No effort to know which cable goes where- no games of tugging on wires in your horizontal management to see where it goes.

Cons:

Your patch panel layout dictates what switch port you can go to. Sometimes this might be an issue- if only the top patch panel runs to a rack of gear, spreading bonded ports across switches is not compatible with the nice layout.



While the other option is notably prettier, we went with the flexibility of grouping all panels together, then grouping switches below, using horizontal management at the switches to route the cables to the side managers, and up to the panels. V-shaped patch panels help route the cabling out to the side with less strain on the cable boots. At the end of our initial cabling and switch migration, this is what the new rack looked like.

Once the construction progressed enough to run the cabling in the remodeling area, our rack looked like this [click](#) Because we added so many ports, we added a 4th switch, which was adopted into the stack with no downtime. On switches 1-3, we reserved ports 5-46 for staff desks, leaving 1-4, 47 and 48 to servers, wireless APs, ect - this clustering of port by type makes it simpler to apply proper port VLAN configurations.

I've chosen not to apply any form of "this color patch cable for phones, that for servers, 3rd for APs", a cable is a cable in my rack. The color=use methodology is great if you never run out of a specific color for a specific need: once you do and swap in another color, you can't count on it- temporary fixes tend to become permanent. You might note the "mostly black, mostly blue" separation: it's only that way because all the existing cable was to Cat5e standards, where we defaulted to black cables, and the cabling for the remodeled zone is Cat6, and those are blue.

```
copy running-config startup-config
```

or your switch equivalent

After the switches were brought back up post move, I realized that my most recent changes to the stack were no longer there. Depending on the level of gear you're working with, it may support the concept of holding multiple configurations. The configuration present when the switch was started up is the "startup config", and at first, it's the same as the "running config", until changes are made to the configuration. If those changes aren't saved to the startup config through the copy command, they're *supposed* to be wiped on a reboot.

This is our savior in case we really screw up a switch configuration and do something regrettable- a power cycle wipes the error. But it also means to not overlook permanently committing the good changes before powering down a switch.

Before a move, I would also export your switch configuration to your preferred backup and change management location, just in case.



As of today, my office's remodeling is still a work in progress: here's how the space has changed: [<click to advance>](#) But from an IT infrastructure relocation perspective, the project is done. My network and server gear is now out of trafficked areas with restricted access, properly cooled, and has ample room for new equipment.

Lessons learned

- 1) Select the destination for infrastructure- plan early
- 2) Drill holes in cement for cables
- 3) Bring in new racks
- 4) Relocate servers / move staff
- 5) Tear down the main area walls (obsoleting old cabling)
- 6) Relocate networking infrastructure, surviving wiring, migrate phones
- 7) Take down walls in original networking area

If I could do this all over, I'd greatly change the order everything was done in.

1- I had an idea this was coming as a general concept, but much on exactly when. I should have provided more feedback to decision makers that it would be wise to move infrastructure before the remodeling. The proper order should have been **<click and read on screen>**

Lessons learned

- Transparent plastic sheets are good insulation
- Simple > complex
- RTFM
- Seek the experience of those who have gone before you
- Stick to one screw, recognize the intruders
- Racks vs walls: leave room
- Make and follow a checklist
- Be able to explain why your backup and restore plans will work

1) You wouldn't go winter camping with a tent made of it, but thin plastic held heat surprisingly well

2) While lots of XenMotion is neat, it was an optional level of complexity. I consider my servers important, but in reality, a scheduled, advertised downtime was acceptable. The simple route of off, move, on was best.

3) The documentation advised me that I was on route for a bad time if I tried to put 25 phones on one switch, without taking any further steps. While that info saved me from being in a tough spot in my phone deployment, I did not read up that I could adjust the rack to solve my depth problem.

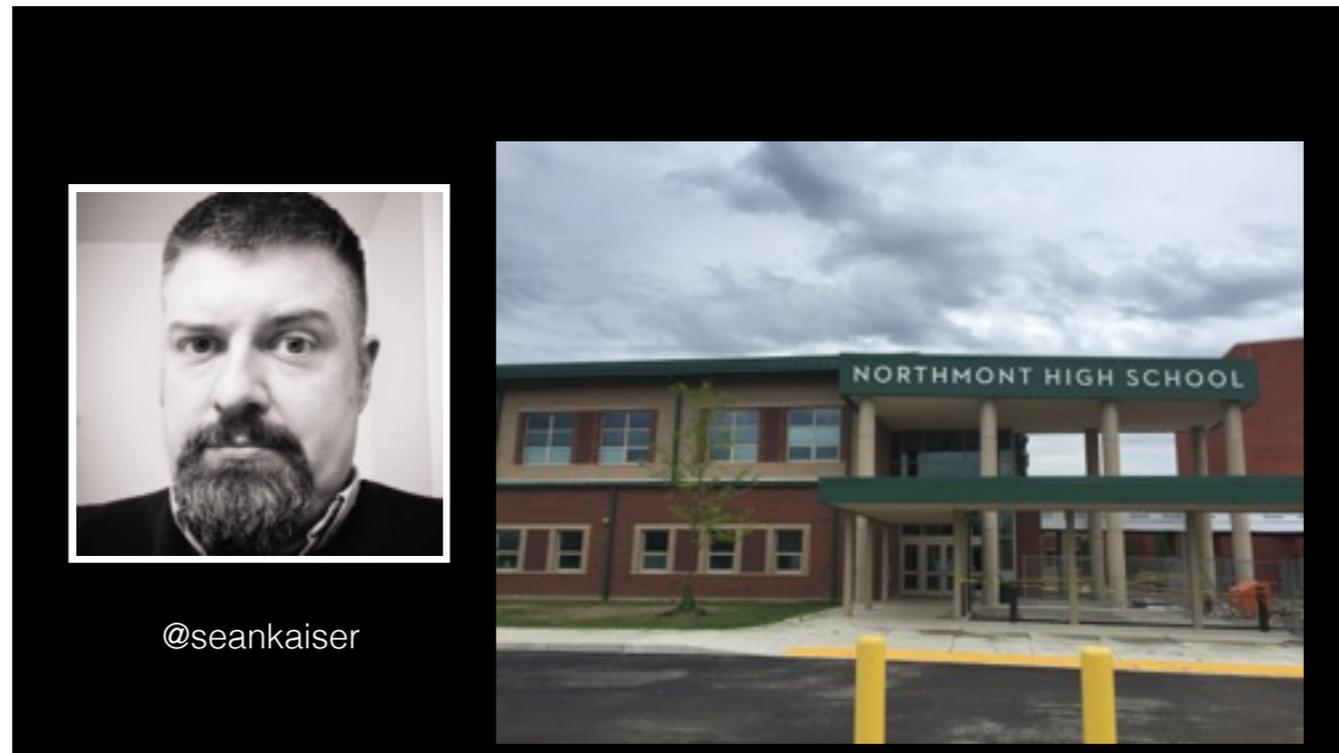
4) You're probably not the first to do a project like this, it's just new to you. If you're unsure how to do something, gather input from online communities- the MacAdmin community is amazing, but it's not the right tool for every query.

5) I only allow 10-32 is allowed in my server room now.

6) If you need to set up a new rack, know how you're going to get a screwdriver to any part of it you'll need to access. Consider the depth of a 2 post vs the depth of gear to go in it, and maybe even gear + add-ons.

7) Checklists are crucial for making sure any process is followed properly, and help you know why you're doing it right

8) Before I took down my virtualization servers, I knew that I had working replicas, and backups. If I had an issue with the SAN coming back up, the replicas would save me. I also didn't allow my production fileserver and it's replica to be offline simultaneously.



Before I start talking about my data center move, I want to jump back to this slide from earlier. This is my “professional” photo from a couple of years ago, but during construction I looked a little different.

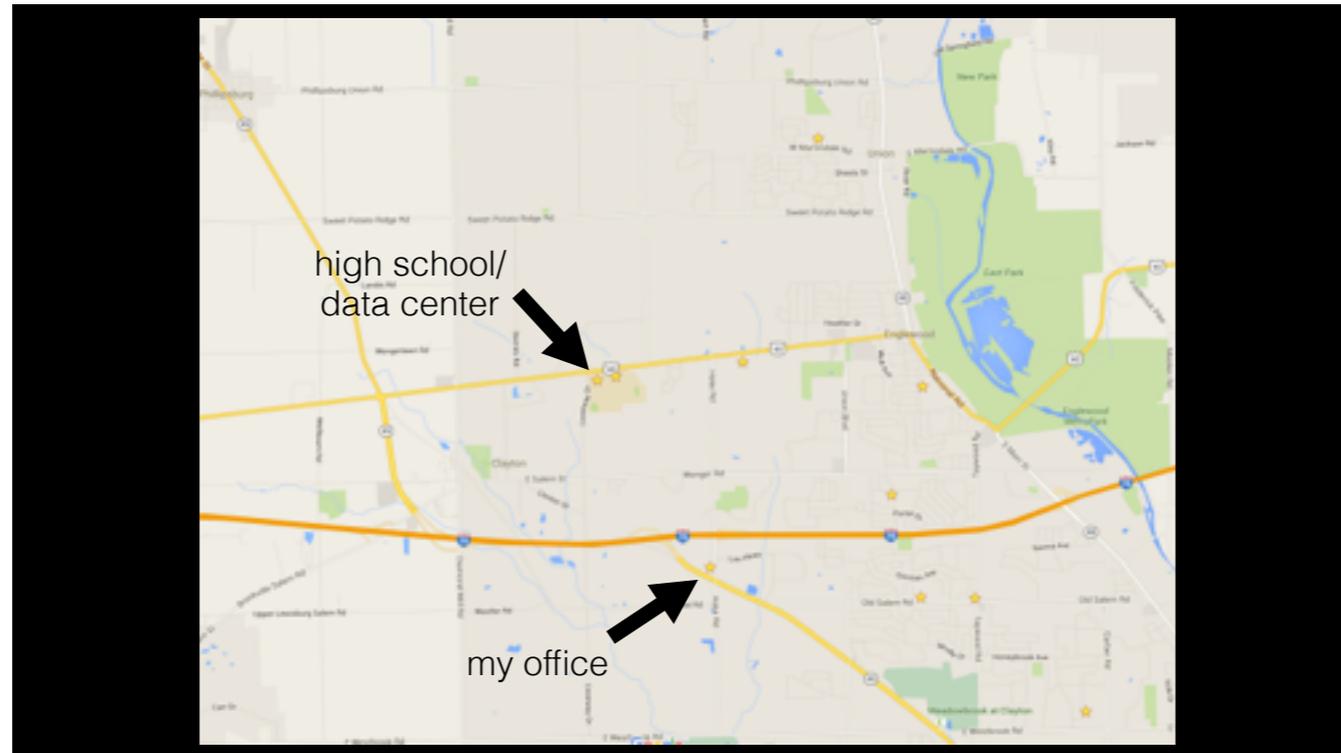
<click for me with goatee/hard hat> I grew a playoff goatee of sorts, kind of like what professional male athletes grow as they reach and participate in their respective playoffs each year. As my goatee progressed, folks started confusing me with someone else.

<click for todd hoffman> I don’t really see it.

<click for side by side> Well, I guess there is some resemblance, we both have goatees and a hard hat. But my goatee was clearly more grey, and I’m not a gold mine boss. Oh well.

<click for regular headshot>

I’m going to talk a bit about a long term construction project that, at least for this presentation, ends with moving into our new data center.



Like Steve, I don't live in the data center. I don't even work in the same building.

<click for arrow to SC> That's where I work during normal times.

<click for arrow to HS> And that's where the high school is, which is where our district data center is located. On a normal day, I can get there in a little over 5 minutes.

District Data Center
prior to 2006



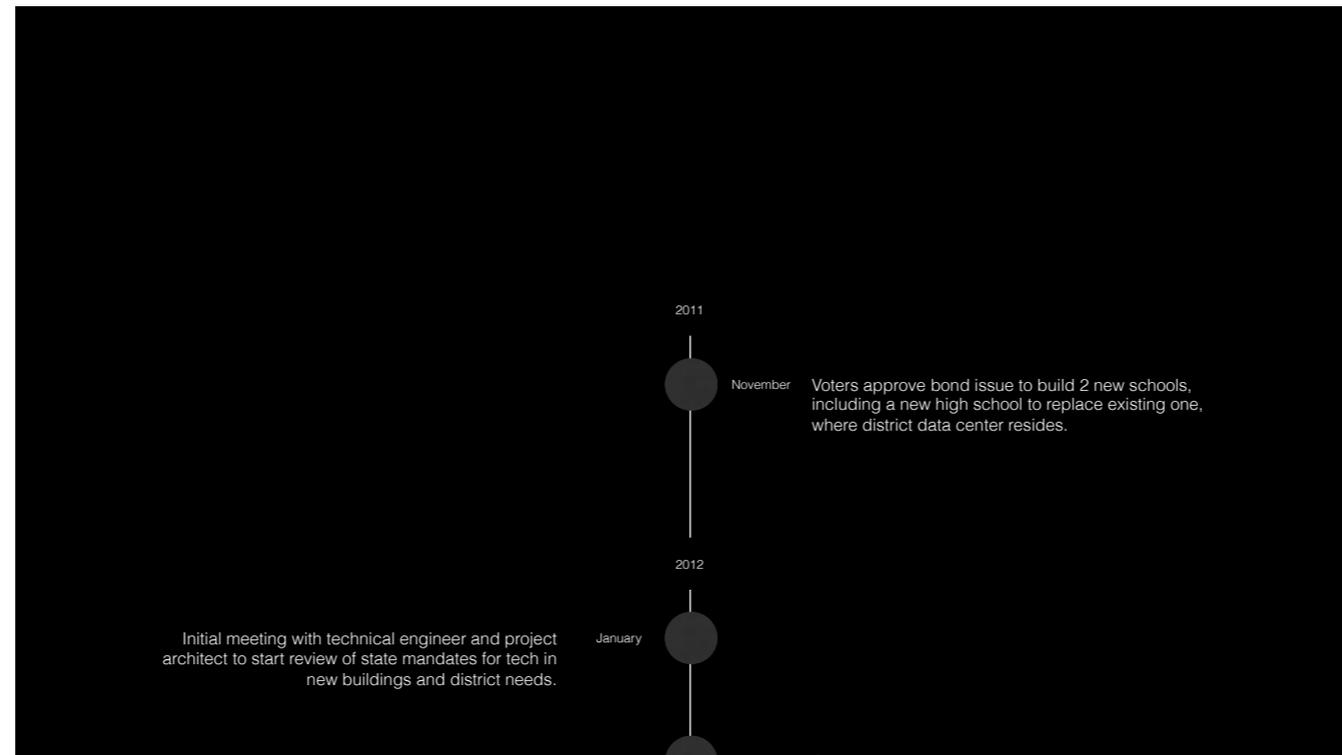
Here's a little trip down memory road. When I first started at Northmont in 2000, and until early 2006, our data center existed on a cart. We shared the room with the media center on one end, and the social studies department had a work area at the other end, and we were separated by a couple of big cabinets. Like Steve's original area, it was behind a locked door, but all it would have taken was a teacher to push over the cabinet and boom, they'd be in the data center. Of course, the library staff had access to the data center end of the room since their cabinets were on that side. But as you can see, there wasn't much there at the time.

District Data Center
prior to move to new high school



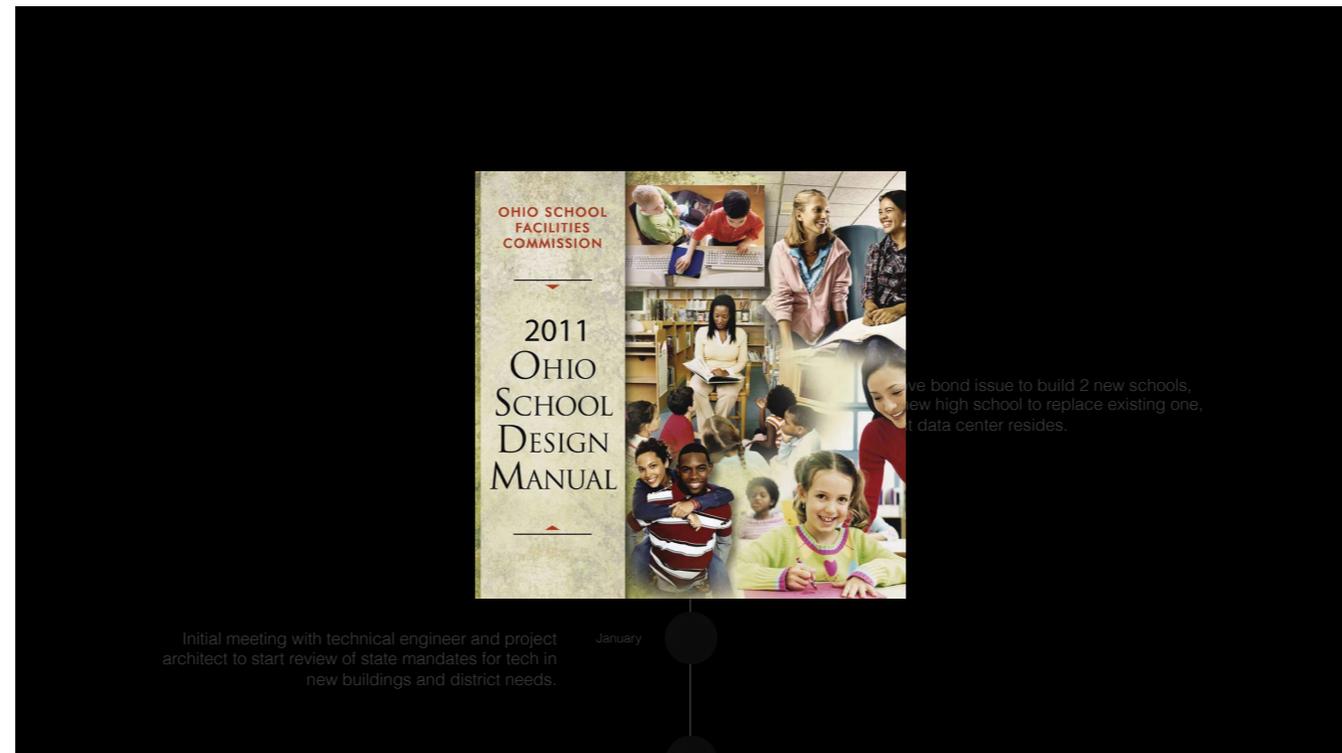
By 2006, we had taken the entire room over, and installed a couple of 4 post racks along with an old 23 inch wide rack that we put shelves on. That was awesome for servers that weren't easily rack-mountable. Our solution to Steve's rack orientation/placement issue was to mount the racks against the wall so the side was up against the wall. I do not recommend doing that, because sometimes threaded hole rails have to be mounted to the inside of the C channel of the rack, and if the rack is against the wall, there's very limited space. As you can see in the right image, we set that 4 post rack about a foot or so off the wall, and that was sufficient to be able to stand between the rack and the wall (though not necessarily very comfortably.)

It wasn't a proper data center, but we took space that was made available to us, and made it work as well as we could.



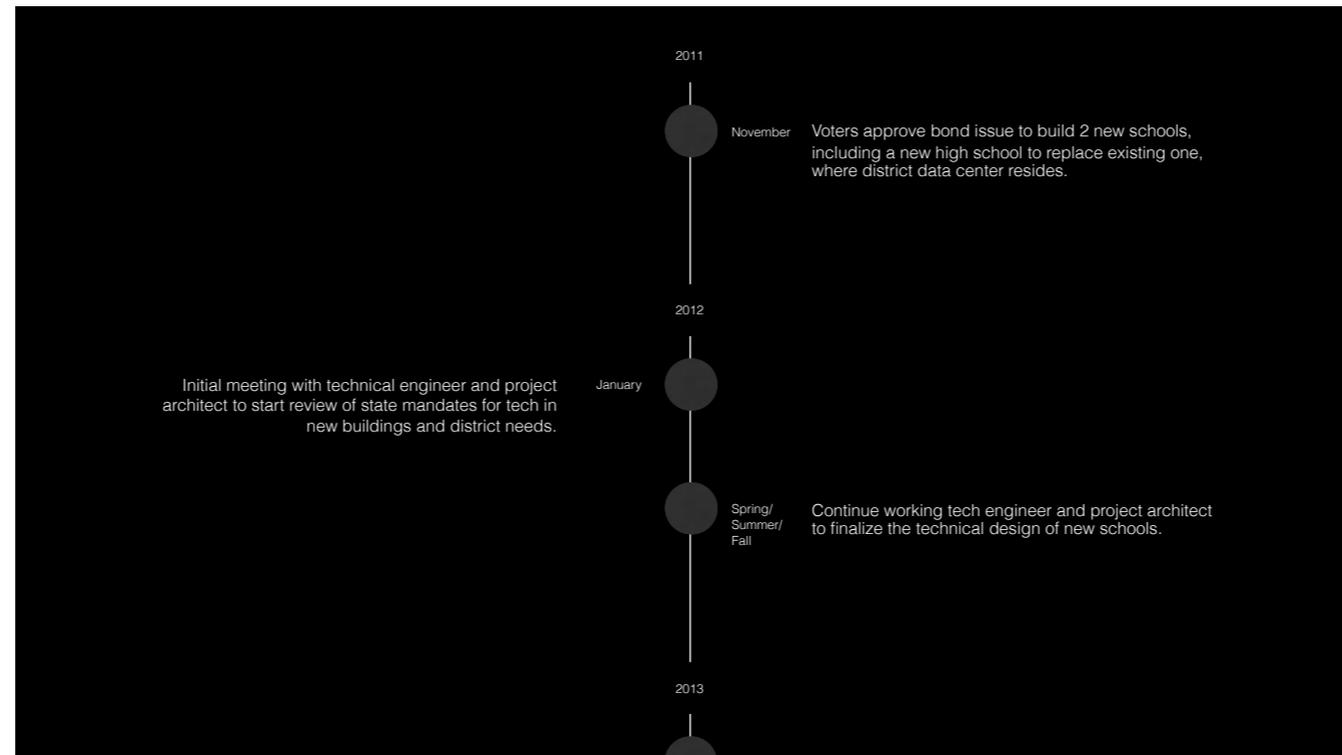
During 2011, our community was given an opportunity to build 2 new schools, co-funded by the state of Ohio. The big project included closing/demolishing an elementary school, building a new early learning center for preschool through first grade, building a new high school, and then closing/demolishing the old high school. The early learning center was slated to open in the fall of 2014, and the new high school in fall of 2015. Fortunately the community's residents recognized the awesome opportunity we were given, and approved a bond issue to raise funds to pay for our share of the project.

<click for design manual> Because of the co-funding by the state of Ohio, the construction project was guided by the state's design manual. This is a 2500+ page guide for how much space each building should have based on enrollment numbers, how many classrooms, etc. The manual is updated annually, but you're generally "stuck" with the manual that was current when you started the project.

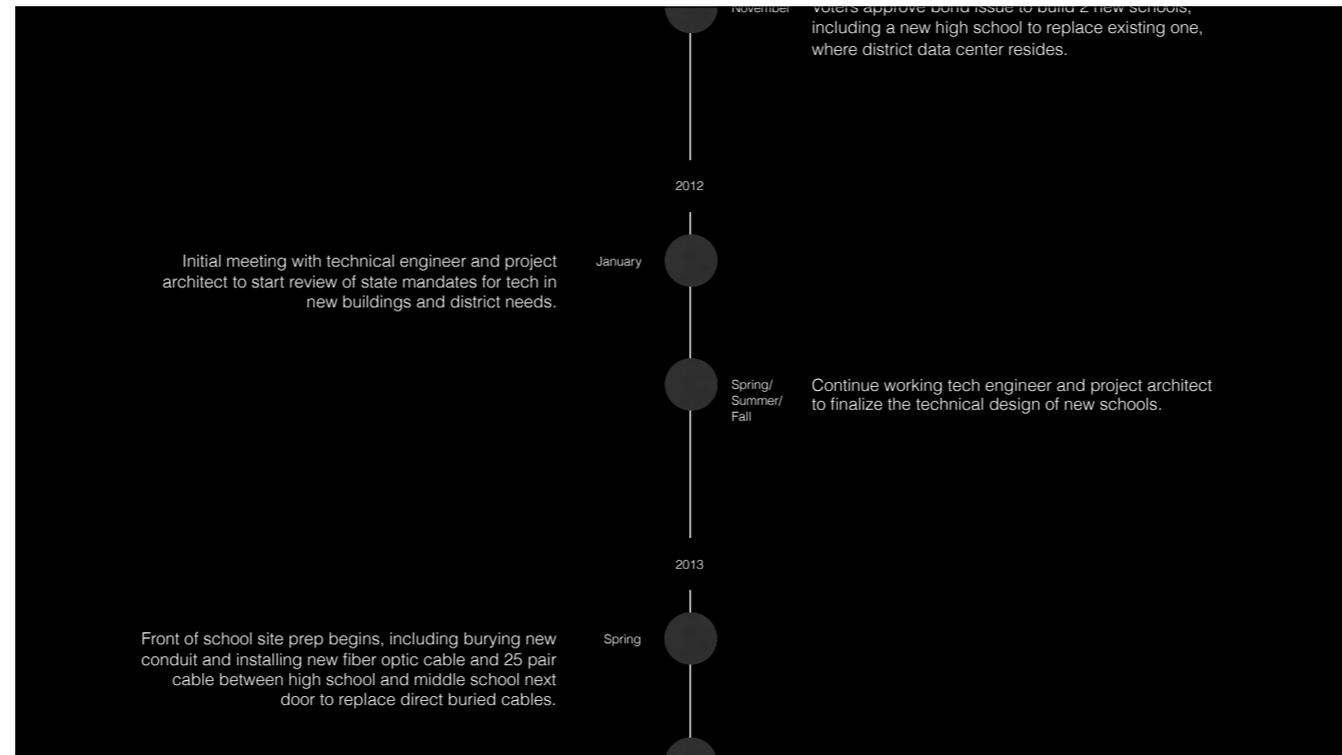


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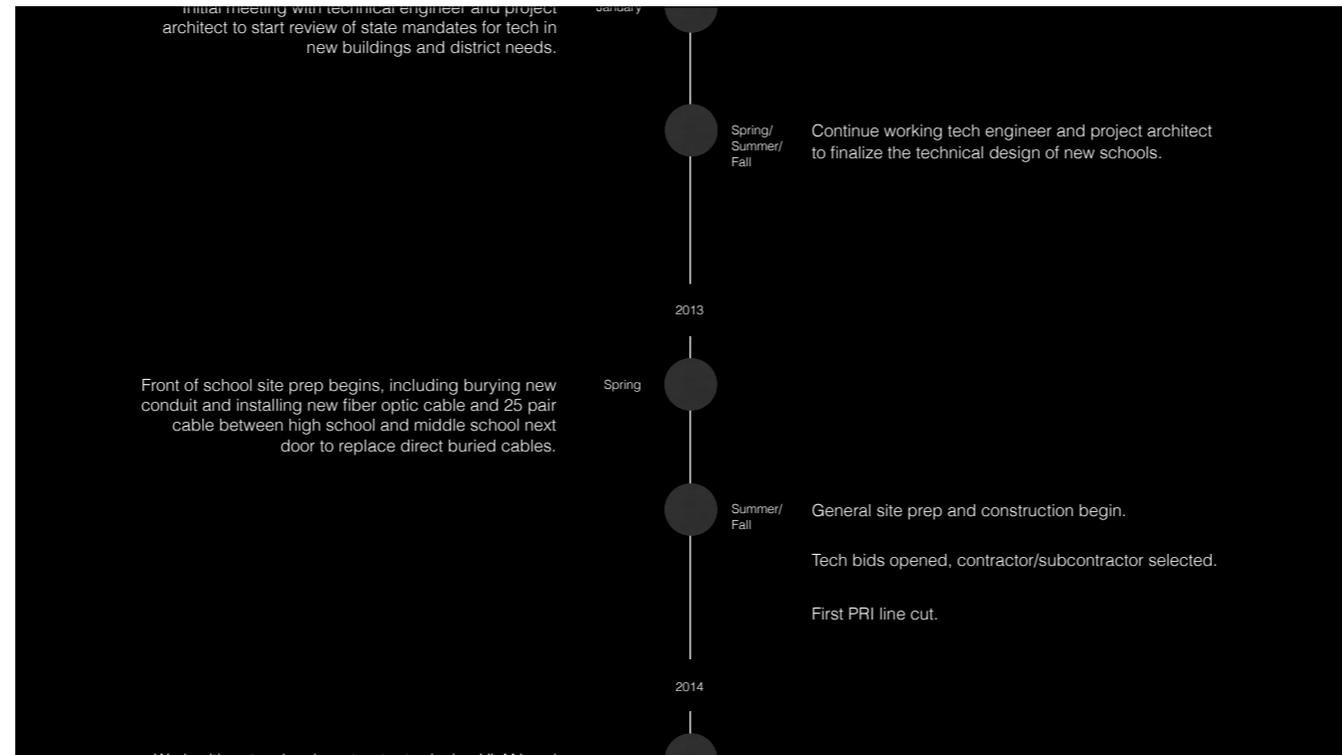
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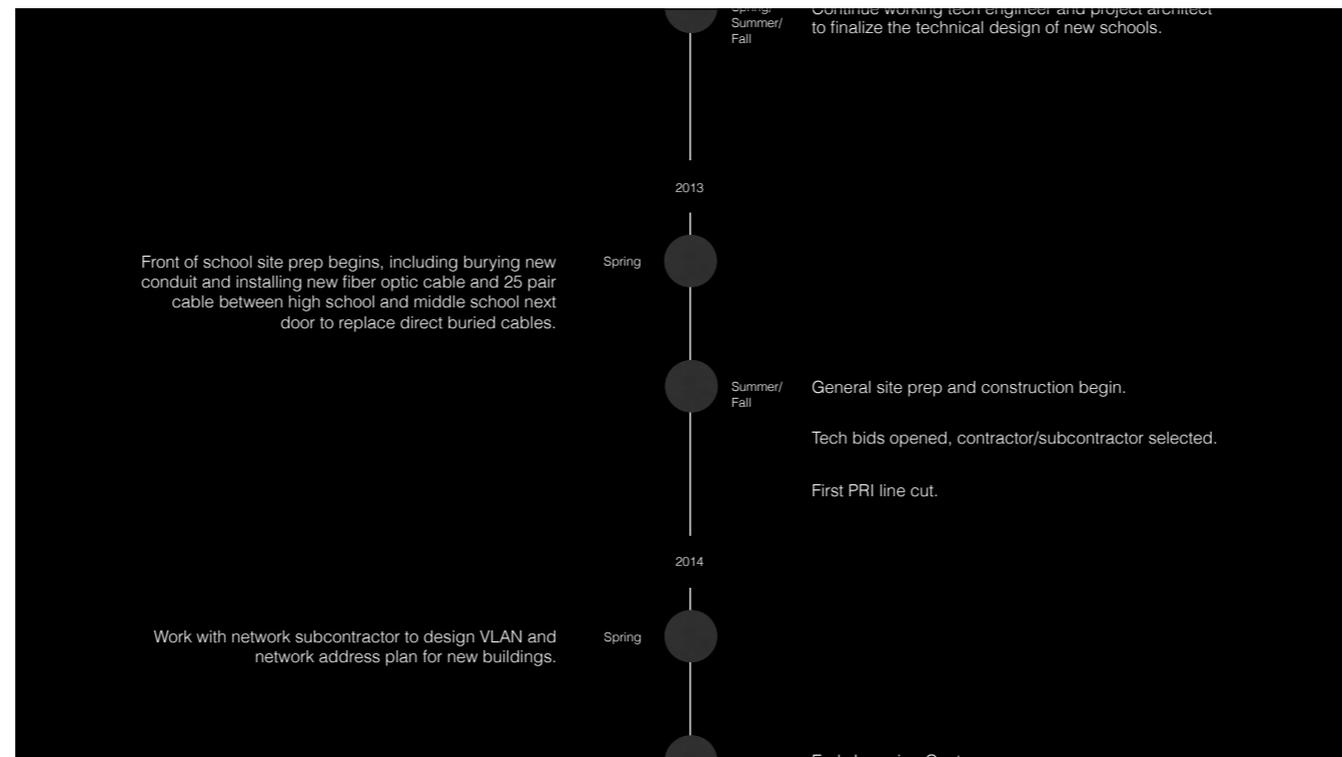
Also included in the design manual is the amount and types of technology that the building would need and therefore get. And how much space the technology spaces would occupy. I first learned some of the details of the design manual in January 2011 as we (our business manager, my supervisor, and myself) met with the technical engineer and the project architect to learn what we'd be getting with the construction, and start shaping our expectations. Since our high school data center was also the district's data center, there was a special clause in the design manual that provided some extra square footage for the room, and a couple of extra server cabinets.



For the better part of 2012, my supervisor and I met regularly with the tech engineer and his colleague, working out the details for what would be listed in the bid specs and supporting drawings, including which vendors we would accept equipment from, etc. For some things, we were able to request a waiver from the state to specify a single vendor because we already had a substantial infrastructure investments with their companies (wifi, phone system, and security camera DVR.)



In late winter/early spring of 2013, we actually started seeing some physical activity at the high school as the construction companies started their work preparing the site. First up was clearing some trees and converting the front lawn of the high school into a parking lot. Our middle school sits right beside the high school, and unlike our other schools, the middle school is connected to the high school via privately owned fiber, which is run between the two schools. And that cable was direct buried, right in the construction zone. We were worried that the fiber would get cut, so we paid to have new fiber (and a 25 pair copper cable) run through newly installed conduit so it hopefully wouldn't be bothered during construction. Fortunately, this was the case. A backhoe operator did find the direct buried fiber shortly after we had switched to the new fiber.



By fall of 2013, bid proposals were opened, bidders vetted, and a winning bid was selected for the tech package for both of the new schools. It was recommended to us to put the tech stuff for both buildings in one bid package so we'd end up with the same equipment in both buildings, even though the high school was scheduled to open (at the time) a year after the early learning center.

Also, things were really starting to move at the construction site. The ground where the new building would be built was determined by soil samples and core drilling to be "unsuitable soil", so more than 3000 geopiers had to be drilled/placed. [Click for geopier](#) This is a process in which an auger drills a large hole several feet deep, and then that hole is filled with gravel, compacted, refilled, recompact, etc. The idea being that the force of the packed gravel would wedge the soil around it, creating a more solid base, on which a two story, 300,000+ sq ft building would be built.

[Click for telco cable cut](#) There were also some old oil tanks buried behind the old high school, and they needed to be removed before construction began (due to limited access to that area once the new building started taking shape.) Unfortunately, the 25 pair cable that carried our high school and middle school's POTS lines, as well as the district's PRI line for all in/outbound phone calls, got cut one weekend. We discovered we couldn't make outside calls on Monday morning, and once the local telco came onsite, it was discovered that the 25 pair cable had been cut. The backhoe operator had caught it, and supposedly didn't realize it was a live line, and they hid it behind the [click for arrow to barricade](#) concrete barricade you see in the picture, and never mentioned it to anyone. Unfortunately, the construction company was based in Indianapolis, and they had the key to the backhoe which was parked on top of the other end of the cable, so we had to wait for someone to drive almost 2 hours to move the backhoe so the telco could then splice the line back together.

[Click for blueprints](#) The worst part of the situation is that the cable was marked on blueprints, and had also been marked by the utility locating service prior to digging. We had no in/outbound phone capabilities for an entire school day, and the high school and middle school had no ability to call 911 if necessary (fortunately, it wasn't.) The telco 25 pair cable ended up getting cut 2 more times during construction.

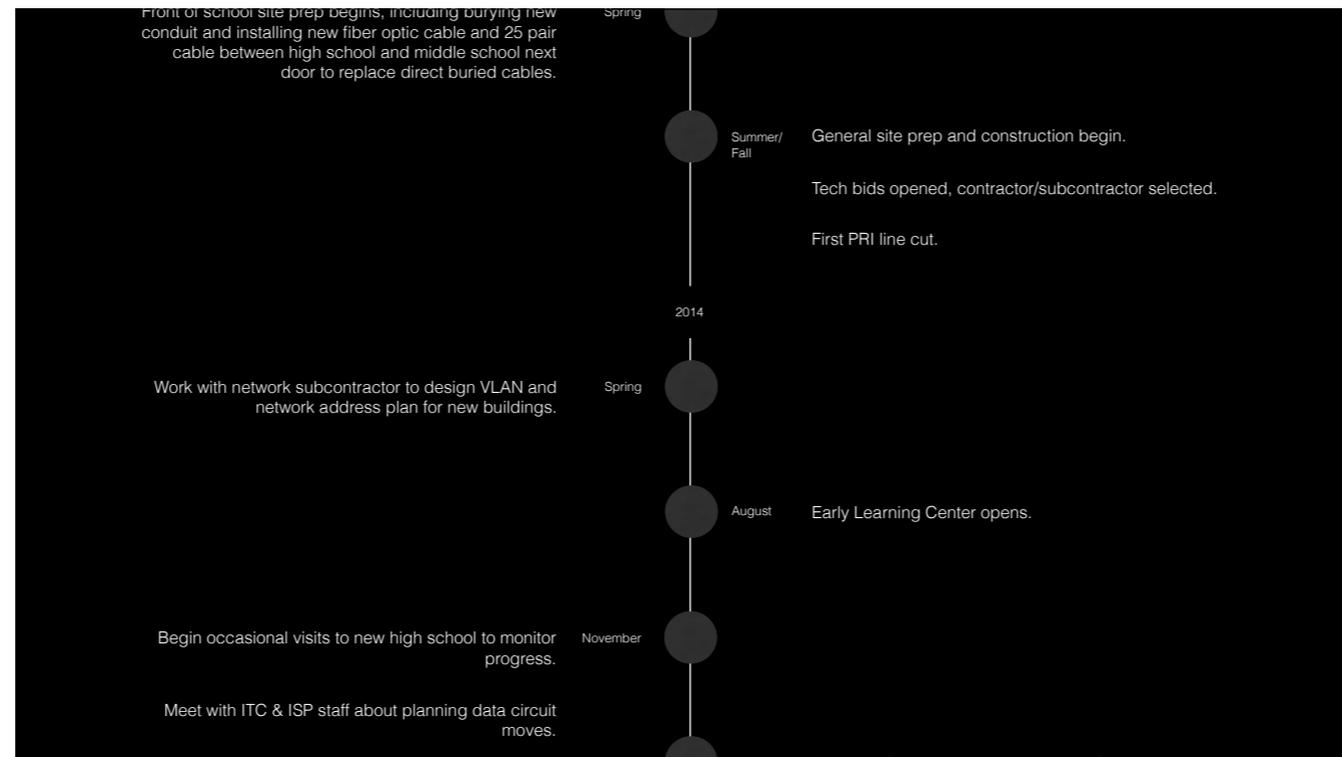


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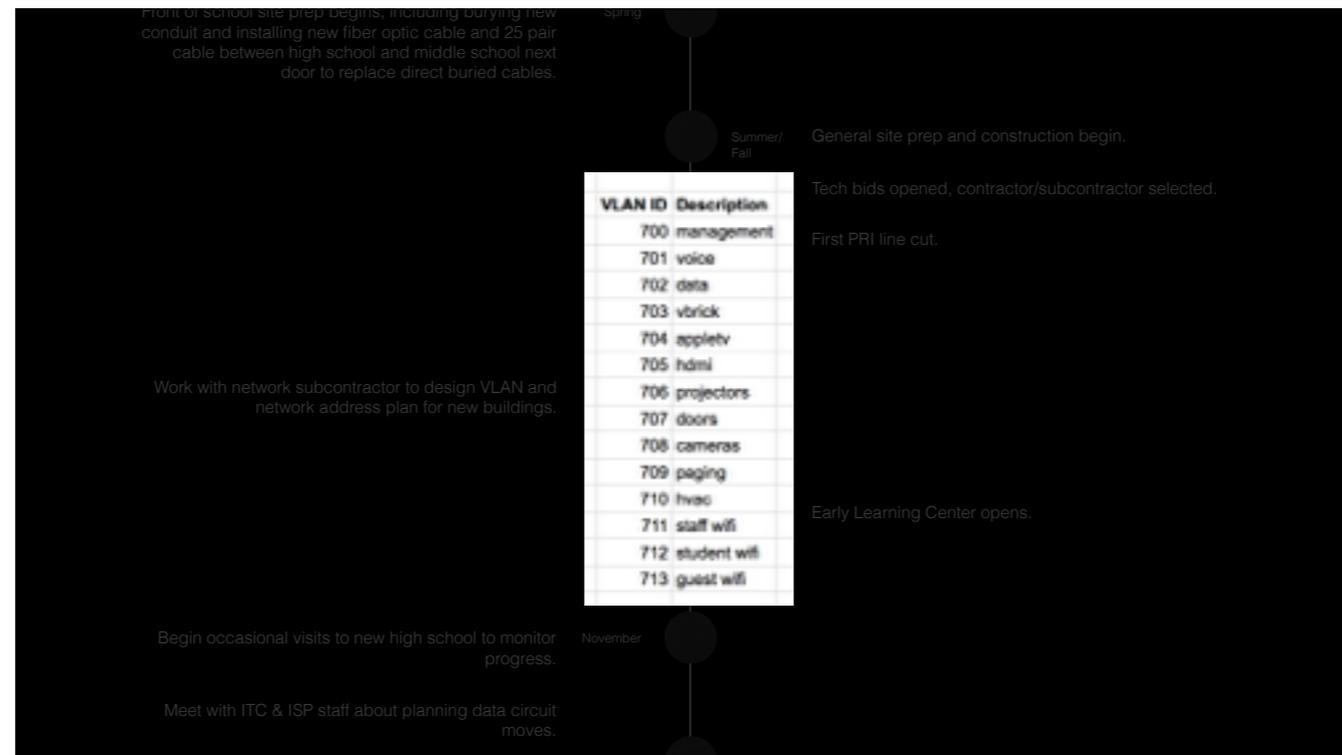
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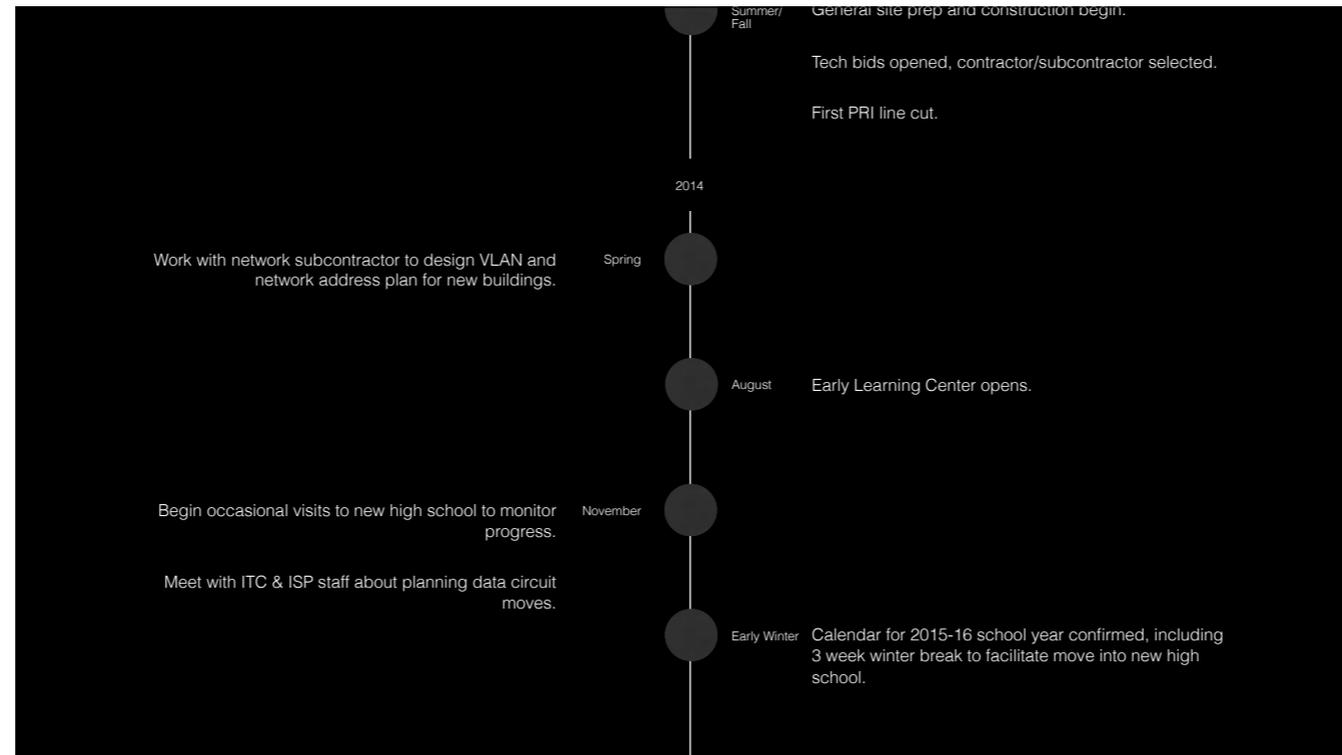
By the spring of 2014, we were starting to design the network at layer 3. Since we were installing lots of different systems (cameras, video on demand in classrooms, plus the “regular” network stuff), we decided to segment things out by use.

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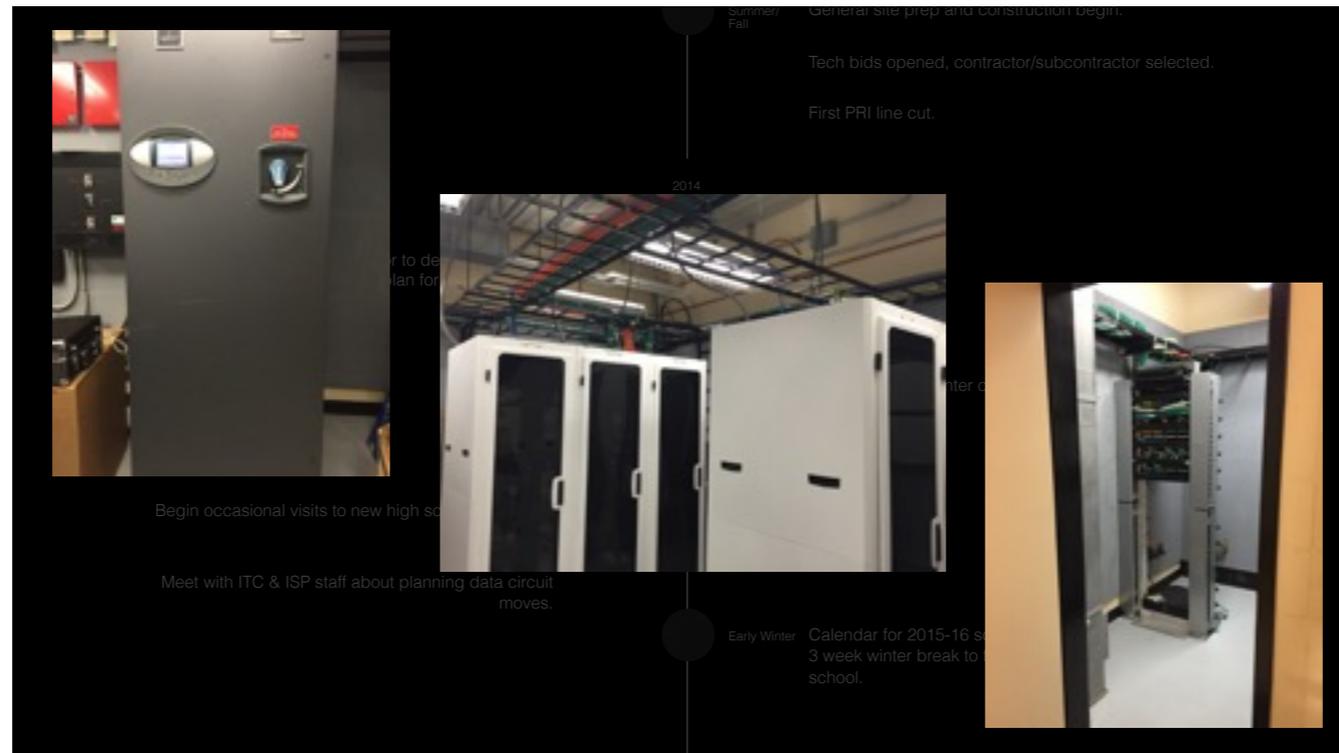
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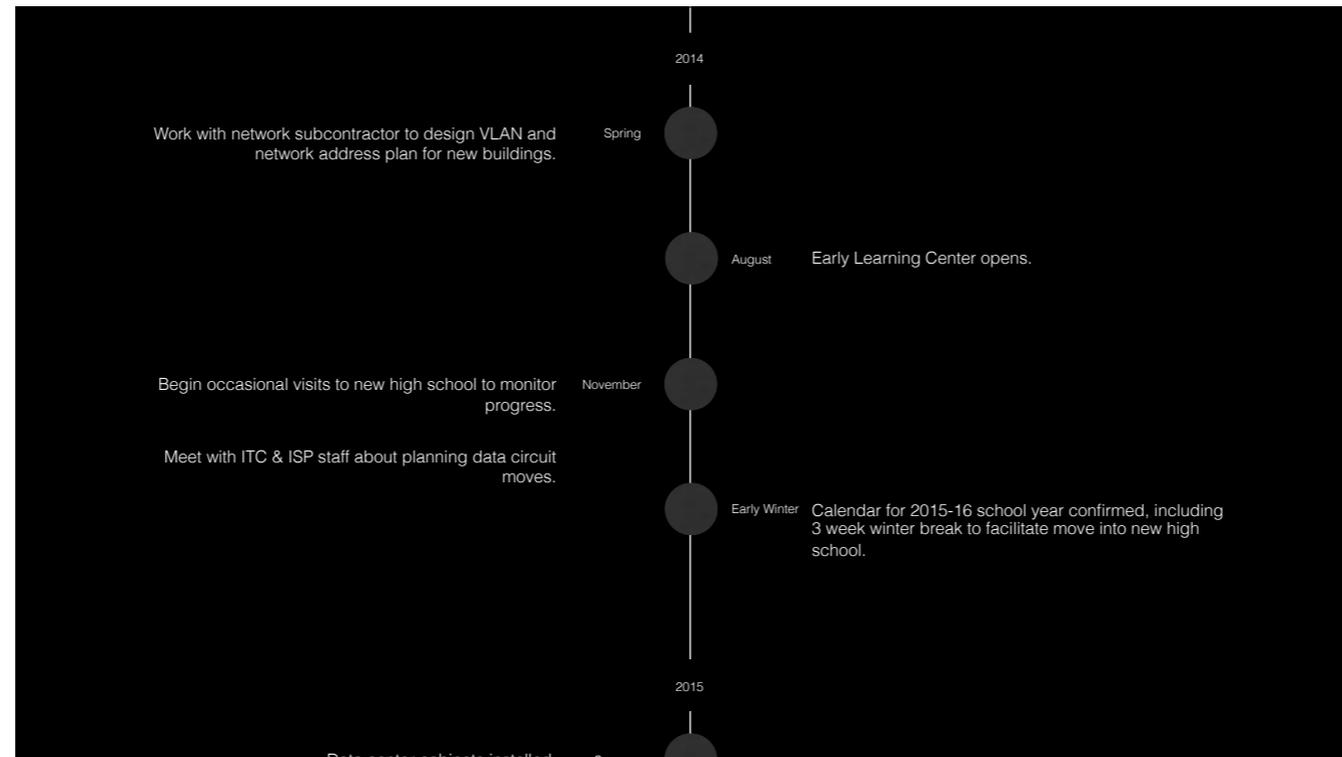
We opened the early learning center at the beginning of the 2014-15 school year. This gave us our first taste of what having a properly designed network and data center was like.

<click for pictures> Gone were carts and open racks for servers. Gone were fiber cable runs without having orange tube conduit to protect the fiber. Gone was having a room without proper cooling. And most importantly, gone was having a network rack in a shared closet that also had custodians' mops, trashcans, and other supplies.

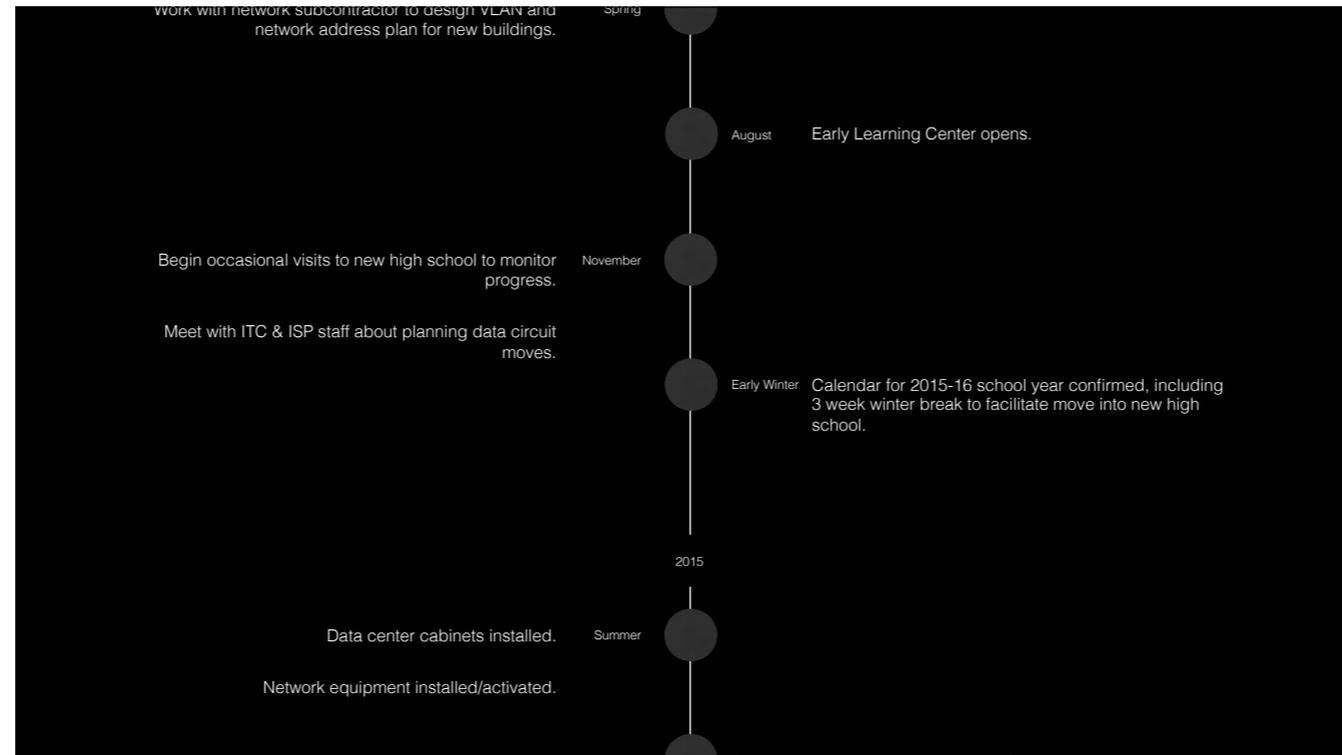


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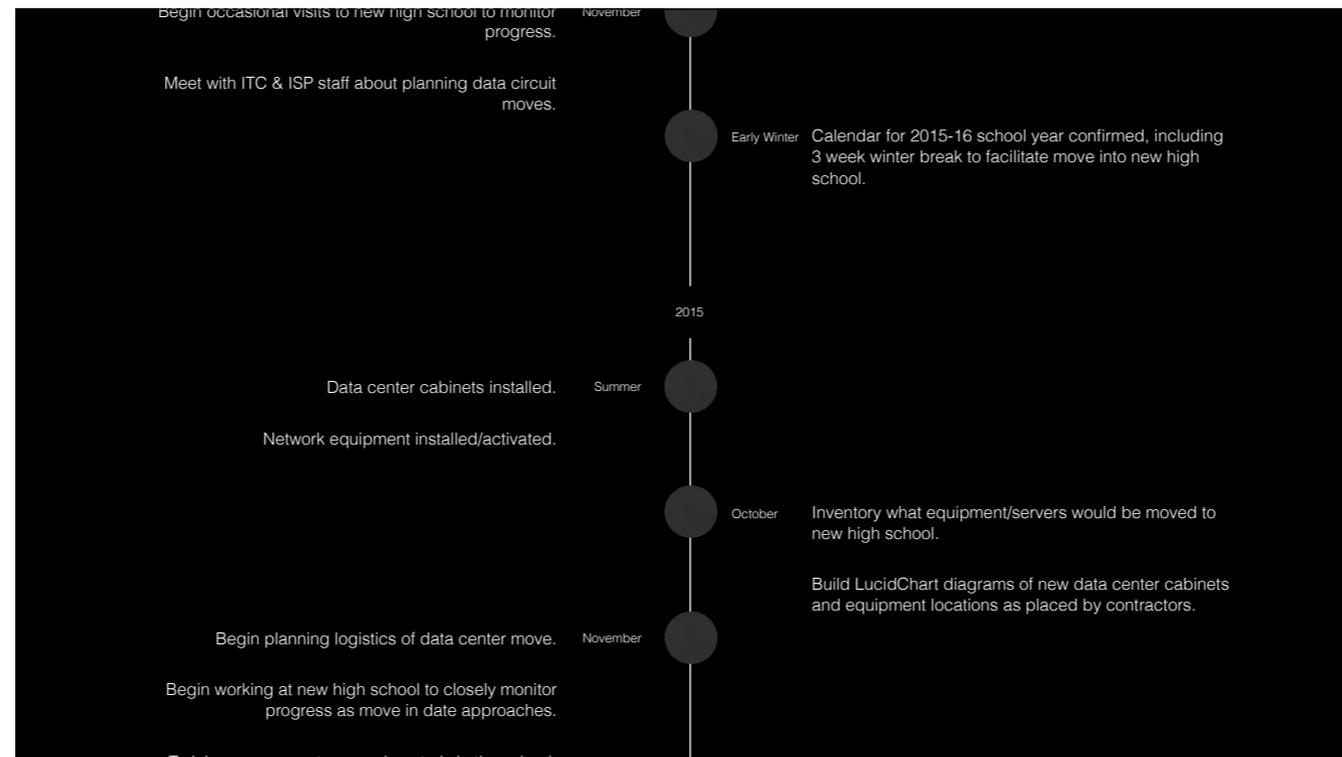
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By November 2014, things had progressed enough at the new high school that we (my supervisor and I) started making occasional visits to check on the progress. We also had our first meeting with our ITC and the ISP that provides the connectivity between the buildings in the district and the ITC, to start planning where they'd enter the building, start talking timelines, etc. Since the local electric utility company owns the poles in the area, the ISP needed to work out pole rights to run their cables.



Given the extreme cold during the winters of 2013 & 14, construction fell behind, and it was determined that the high school wouldn't be ready to move into for the beginning of the 2015/16 school year. As such, as the district set the calendar for that school year, an extra week was added to winter break to give everyone the time it would take to move classroom supplies, tech equipment, etc., from the old building to the new. We lost a week of summer break in exchange, but having the extra week for the move was well worth it.



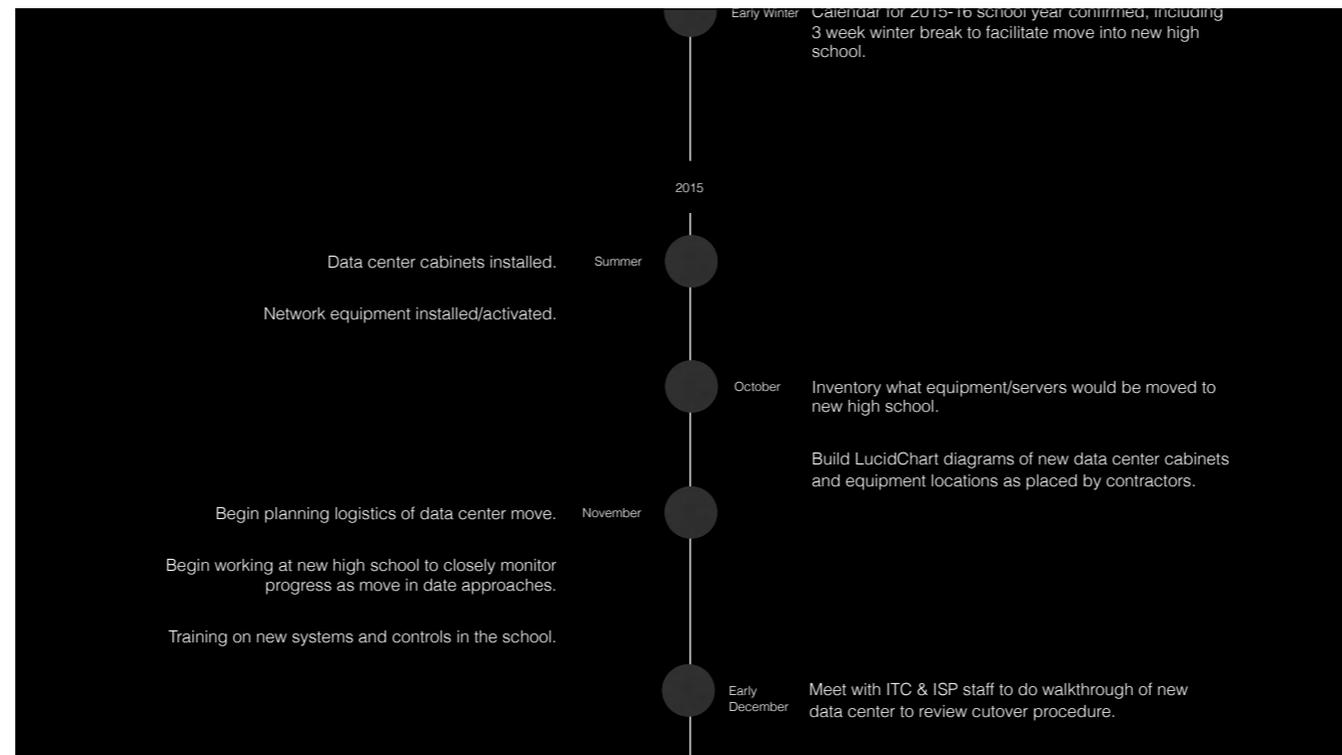
The contractors installed the data center cabinets, terminated over 2500 cat 6 and 6a drops (there is somewhere in the neighborhood of 110 miles of copper cable in the building), switches, wireless access points, fiber and copper patch cords in summer 2015, and we worked with our ITC and ISP folks to get a temporary internet connection activated. Given the expanded network, and the mid-year move, our ISP recommended setting up a whole new IP subnet for the new high school since there wasn't going to be a way to connect the new school to the old school's network.

<click for cabinet pics> All told, in the new building, there are 9 different switch stacks, most of which have between 4 and 6 48-port switches. That's a lot of switches and ports.



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In October 2015, we started finalizing what systems would make the move to the new high school

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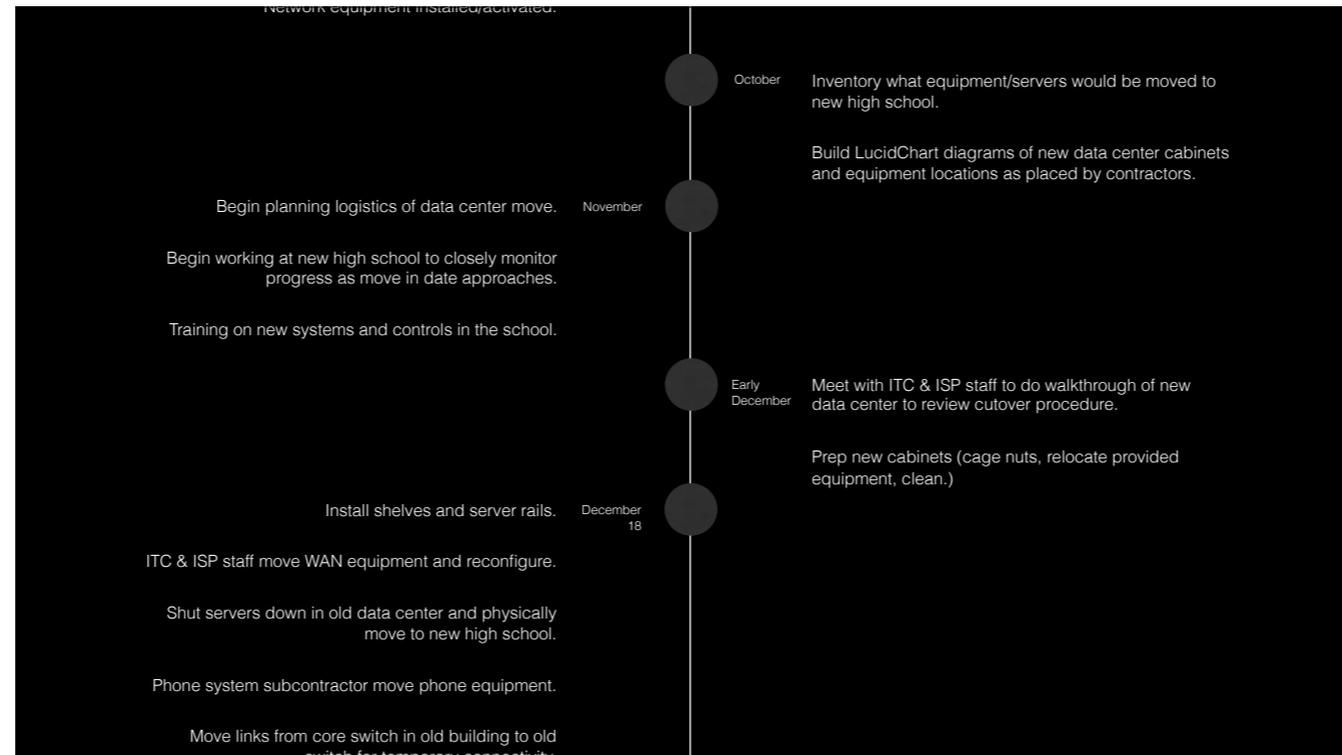
By November 2015, I knew what we'd be moving over, so it was time to start figuring out what went where. I knew I wanted to keep like systems together, and tried to put building specific systems in one area and district-wide systems in another.

<click for lucid chart> I spent a *lot* of time in Lucid Charts working this plan out. I also realized it would be easier during actual installation/move time if I

<click for lucid chart zoom> numbered the rack slots on the diagram. That might have been my best idea of the entire project.

<click for timeline return> My supervisor had begun working out of the front office in the new building earlier in the month, and I "moved in" around Thanksgiving, to be onsite to confirm things in the data cabinets, be available for subcontractors' questions, etc.

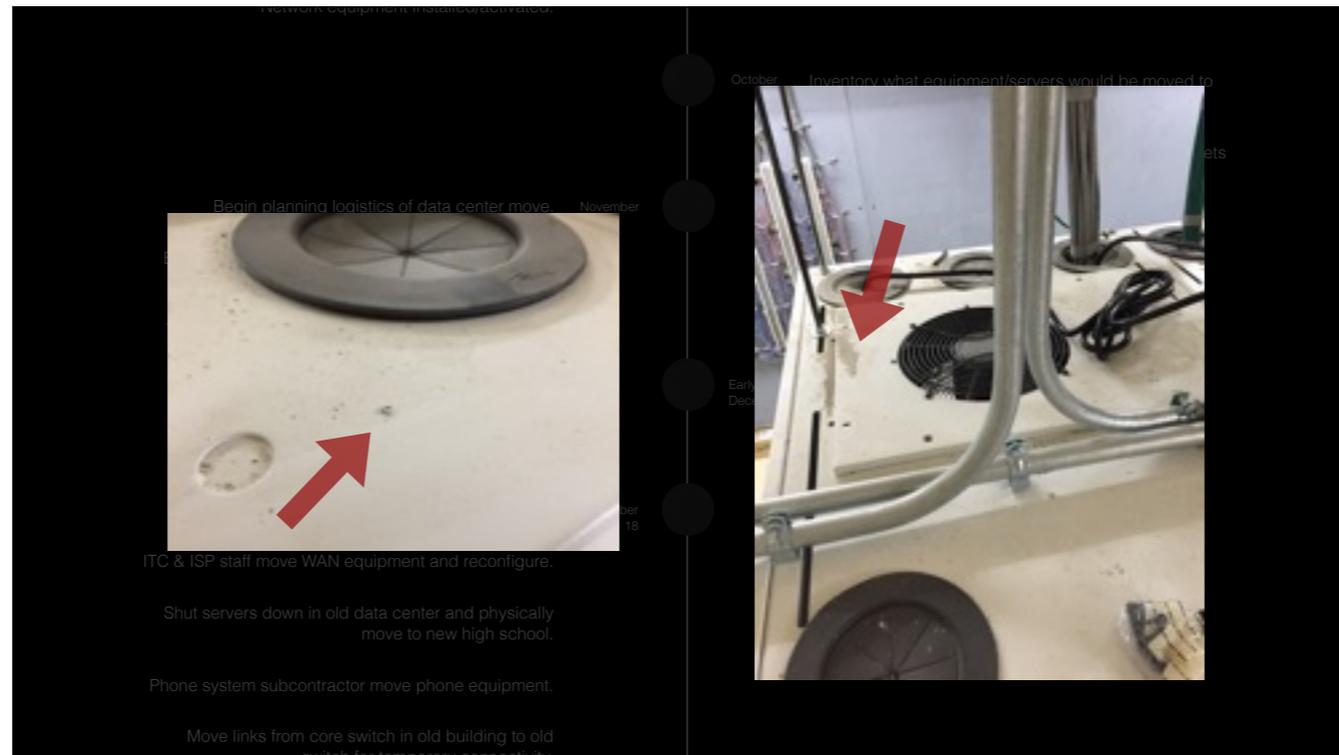
One of the nice things about doing a project that's guided by a detailed design manual published by the state is that one of the requirements is that lots of training be provided. Our team spent many hours being trained on everything from the phone system to the wifi to the generator, automated transfer switch, and UPS in the data center.



My supervisor and I met with our ITC and ISP folks and showed them around the new data center and confirmed the cutover plans early in December 2015, which set the stage for a successful move later in the month.

Since I knew where things were going to go in the cabinets by this point, and once I had organized things in the data center from construction], I started prepping the cabinets by installing the cage nuts. I also moved some of the provided equipment (mostly the KVM switches and keyboard/monitor trays). We didn't have our official occupy permit for the building yet, so the building wasn't ours yet, so I couldn't do much more than that. I wish I had known about the cage nut tools that Steve showed you earlier. My thumbs wouldn't have been nearly as sore as they ended up being.

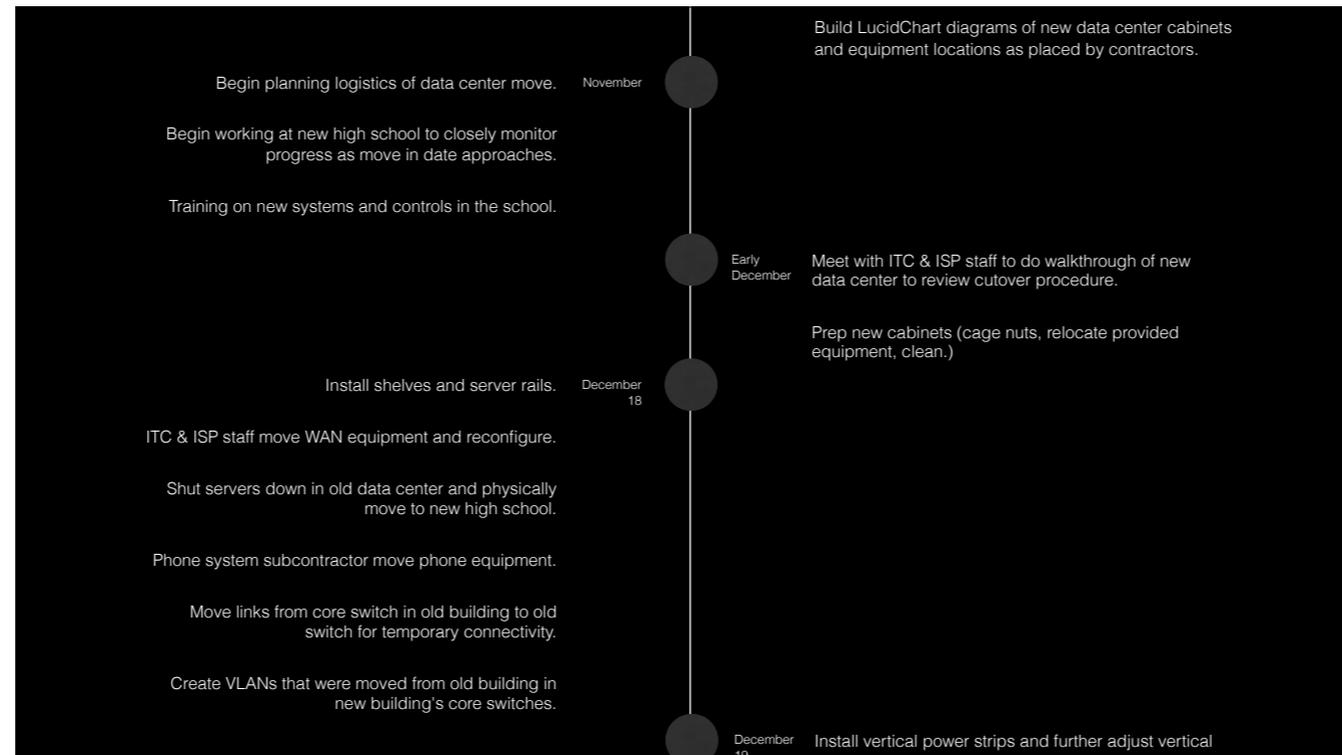
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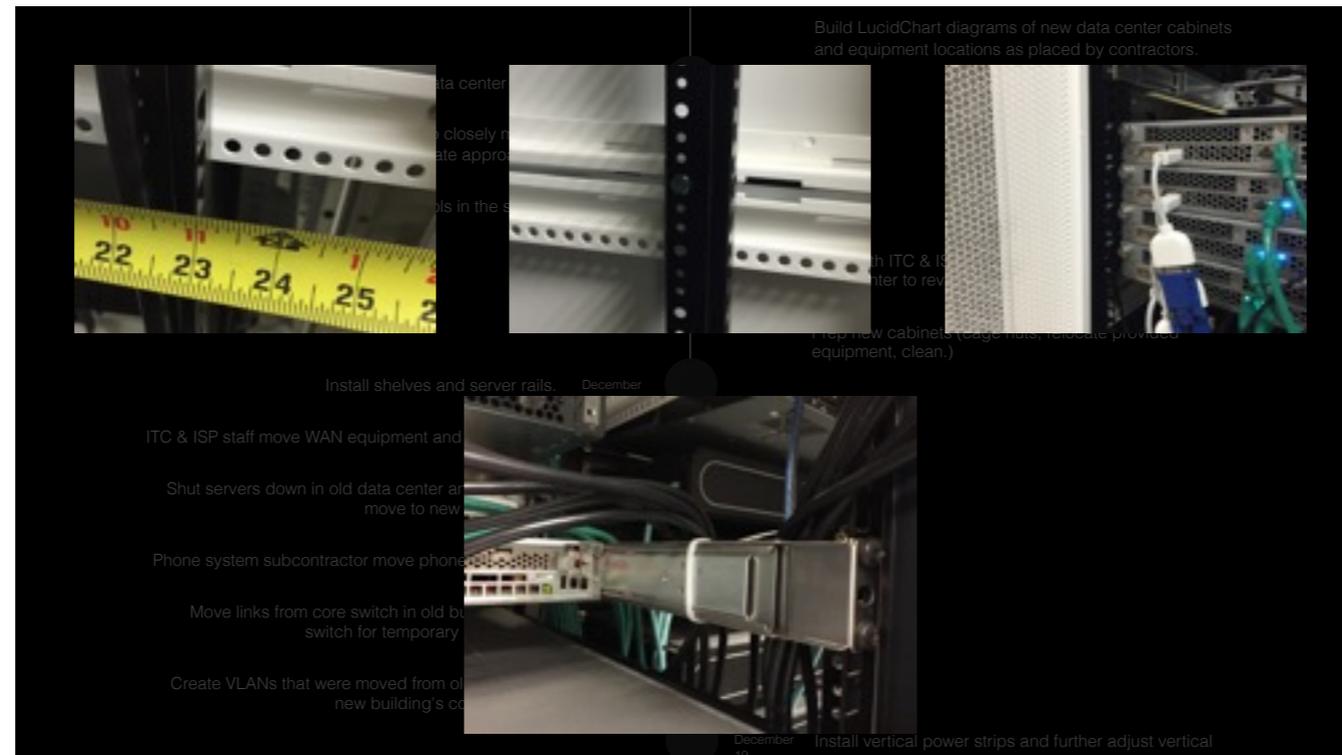
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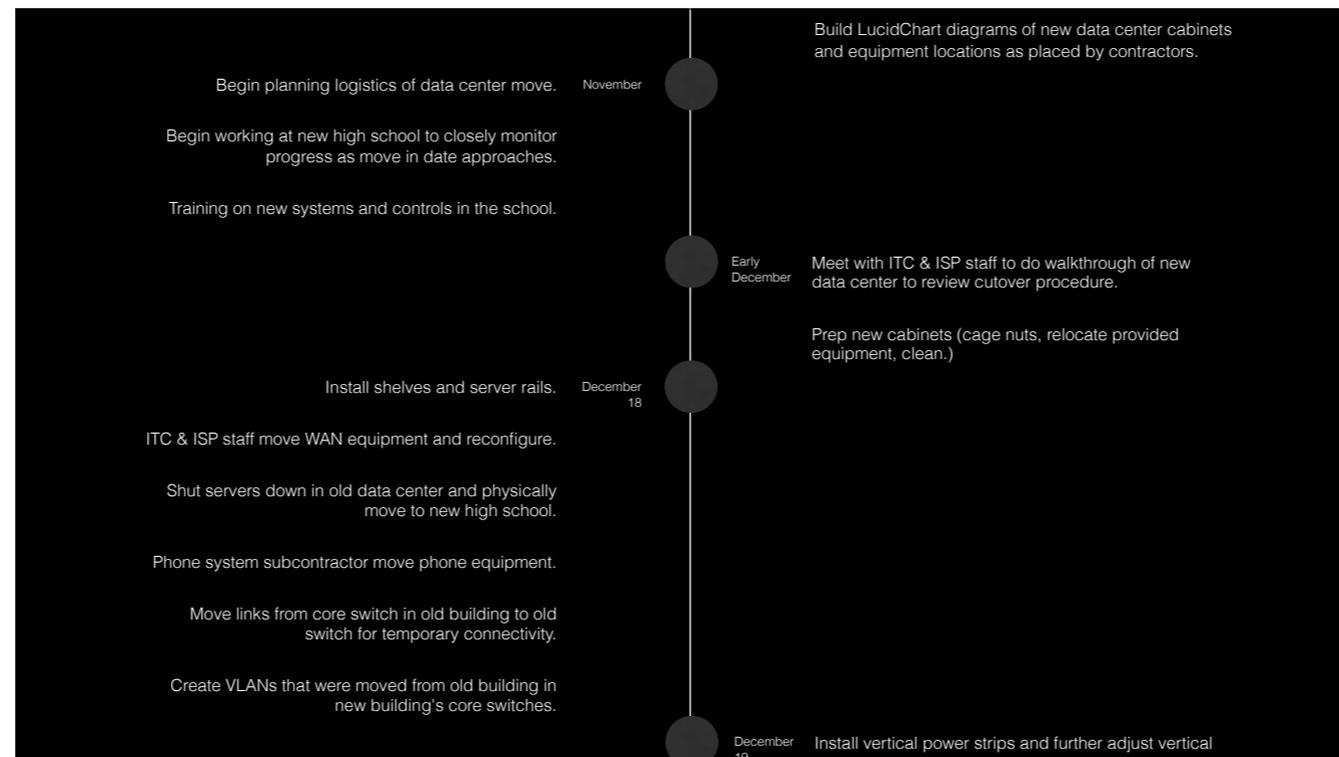
Finally, it was the big day... Friday, December 18 2015. Initially we (my supervisor and I) had planned on starting the move at noon. As we started checking with folks in the district that would be working that day (it was the first day of our winter break), our food service department reminded us that they needed their system and our internet connection to be live until at least 2pm so they could finish closing things out for the month. And our treasurer's office reminded us it was payroll week, and since we wanted to be paid for our work, we waited until 4pm as they requested. Once we started, the entire district's network connectivity would be lost, as would the phones. And we had until 8am Monday morning to have critical systems back online.

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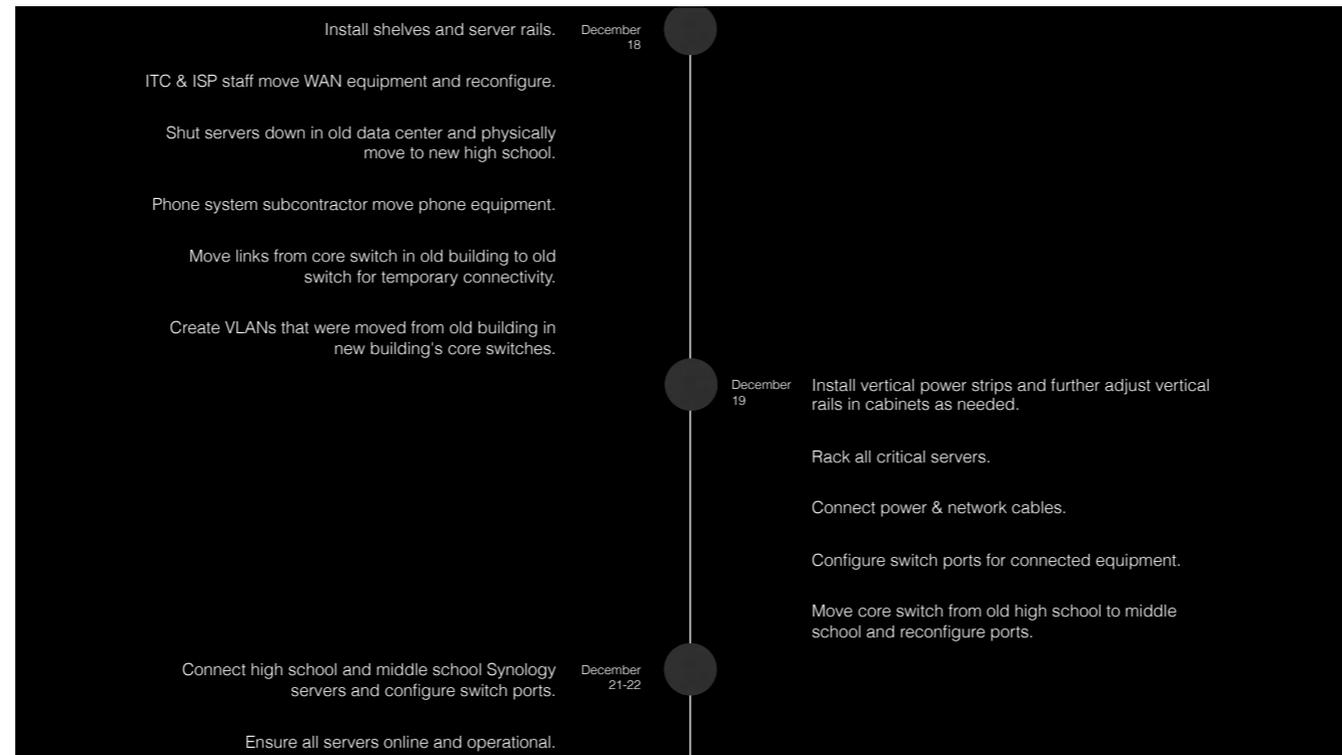
Once we got the go ahead that payroll processing was complete, our ITC and ISP's staff (who had arrived early) handled the move of their equipment and changed configurations (since the district's traffic was going to the old high school and now we needed it to go over to the new one.) Our phone system subcontractor took care of shutting the phone system down, moving it, and reconfiguring those servers. We had an issue with the local telco who didn't show up to move the PRI circuit, despite saying they would be there. Uh oh. Our phone subcontractor considered flying a cable between the closest points between the old and new buildings and utilizing existing cabling near those points, but decided that wasn't a good option. I remembered we had the 25 pair cable between the old high school and the middle school, and there was a new 25 pair cable between the middle school and the new high school, so the phone guys set off to bridge things through the middle school. It took some ingenuity and a CSU to boost the signal, but it worked, and held until the telco was able to get someone onsite on Monday the 21st. One crisis averted. In and outbound phones would be operational as promised.

While all of that phone excitement was being worked out, I went through the process of shutting the servers down at the old high school (we have a mix of physical and virtual servers, and all together I think I probably shut around 40 systems down), and as servers were ready, the rest of our team started unracking them. Once everything was ready to move, the team pushed a couple of flatbed carts of through the old high school, across a small courtyard, and into the new high school, and left them for me in a room across the hallway from the data center, which we had adopted as our staging area and department headquarters for winter break.

By the time we got the old data center unloaded, a temporary switch setup to keep the wifi and cameras operational at the old high school, and the phone system folks were ready to move that equipment over to the new building, our ITC & ISP folks were already done getting everything switched over for the district's network to star out from the new high school. Their entire time onsite was right around 2 hours, and that included the part where they stood around waiting for "go time" since they showed up a little early. And that was mainly because they knew the plan because of the various meetings we'd had with them ahead of time.

I spent the rest of the evening learning the syntax of the core switches in the new data center in order to configure the VLANs that we were moving from the old building so that I didn't have to re-address servers after the move. That was a huge time saver... we're talking DNS, LDAP, various web servers, etc. Move them to new data center, in a building that has a brand new IP subnet, but be able to continue to use the existing addresses.

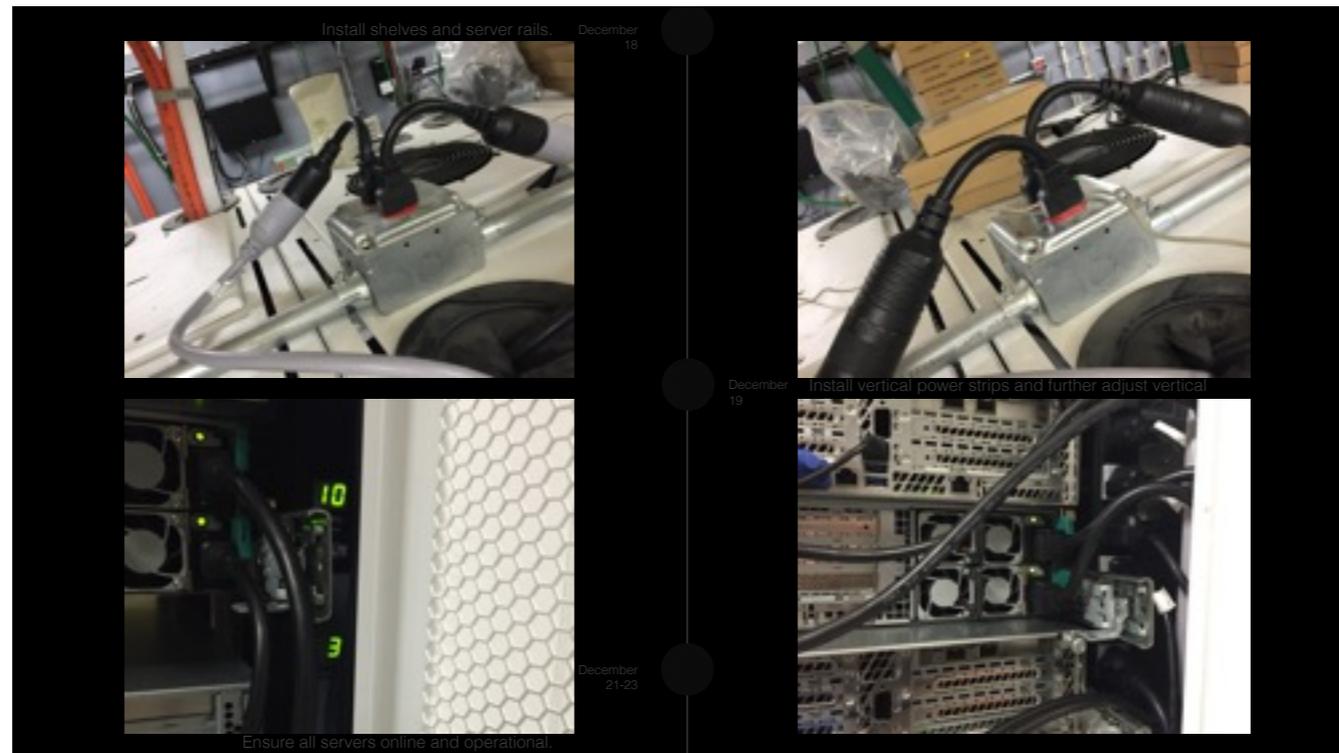
By the end of the night, I'd been at work from 8 in the morning until around 1 the next morning. And that was just day 1.



On Saturday, we were back at it, making final adjustments to the cabinets as we worked to get critical servers (the physical virtual hosts which include the DHCP server for the high school and middle school and our OpenLDAP server, as well as physical servers such as our DNS servers.)

<click for power pics> The rack mounted power distribution units (PDUs) that were provided in the cabinets only had 8 outlets each, which wasn't enough for the number of servers we were installing, so we purchased some vertical PDUs that had 2 circuits in each, with outlets alternating between the two circuits. I wanted this setup, especially since most of our servers have dual power supplies. Since each cabinet has its own electric circuit on top of the cabinet, I put the grey circuit from each PDU on one cabinet circuit and the black circuit on the other. The PDUs have a display showing the current amperage load per circuit, so I was able to monitor that as we powered servers up. I just had to remember to add the numbers from the two PDUs together to make sure we stayed under the 20 amp breaker limit.

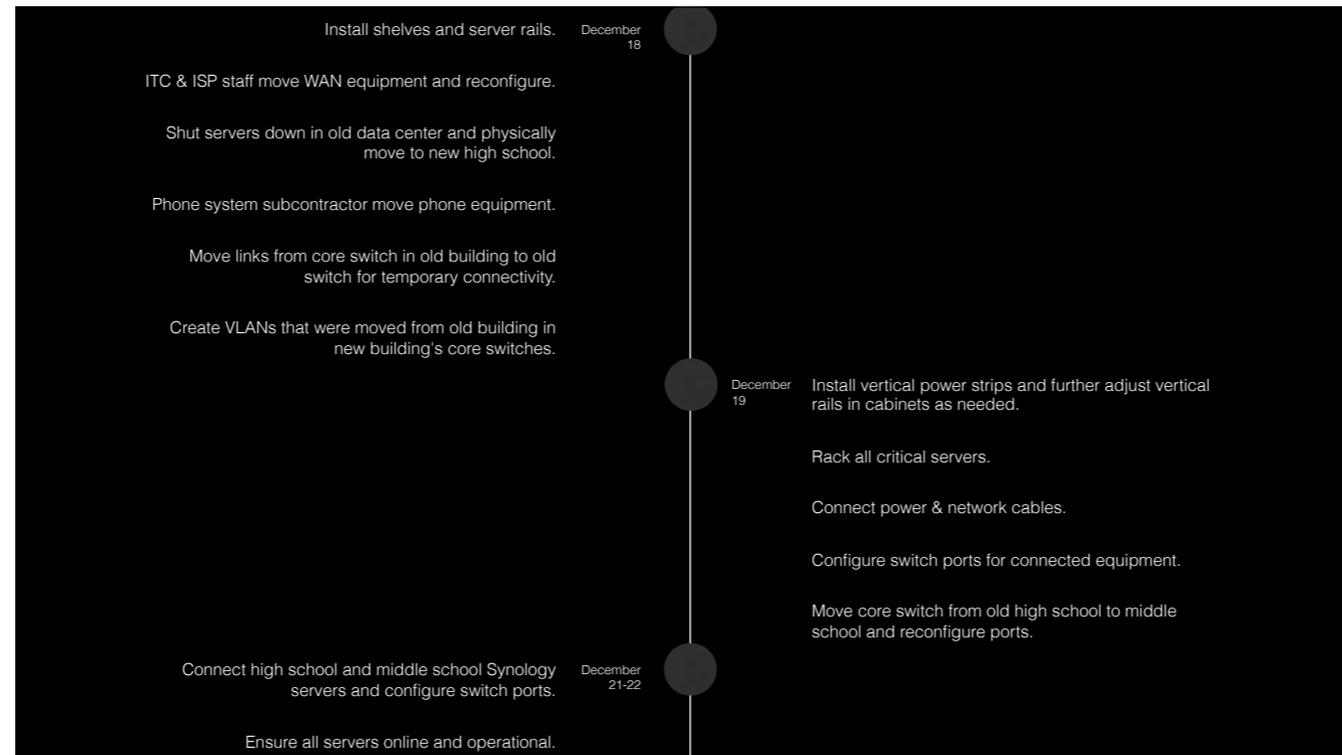
<click for power zoom> As you can see, the power outlets nearly line up with the server power supplies, and I alternated circuits for dual power supply systems.



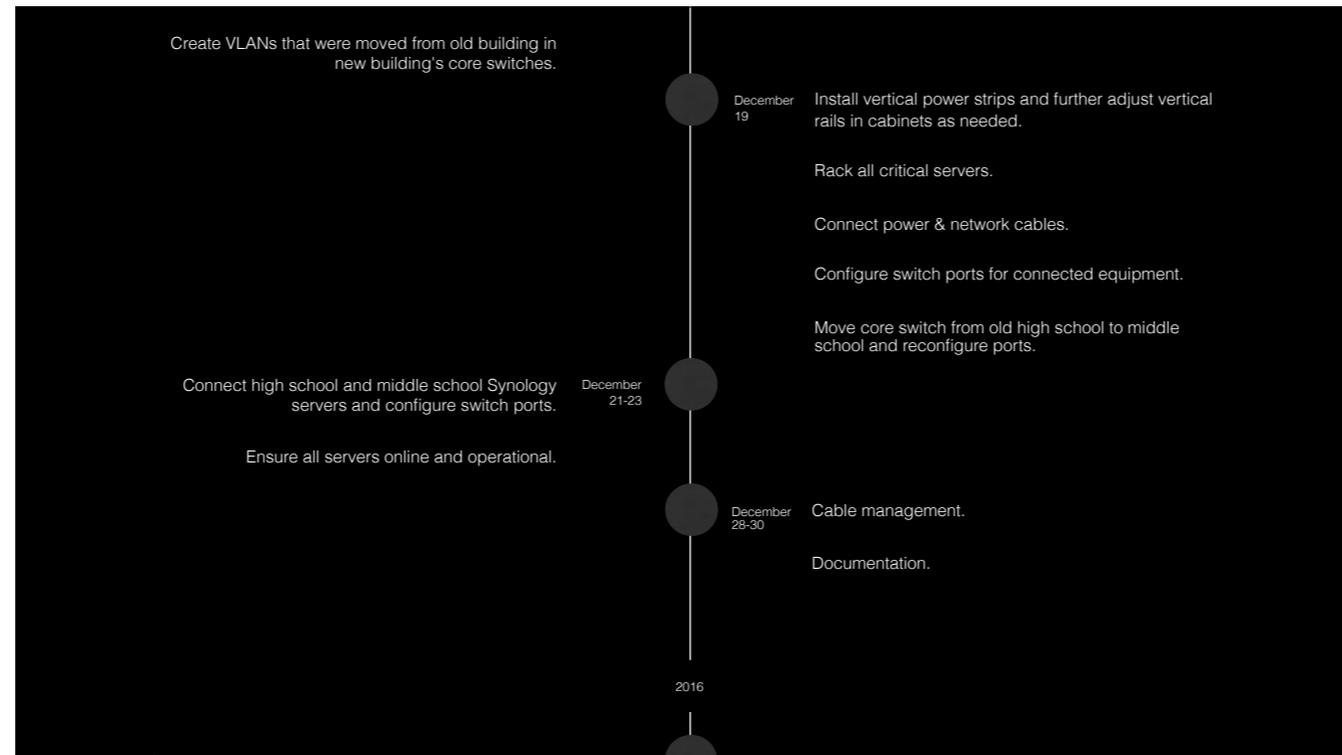
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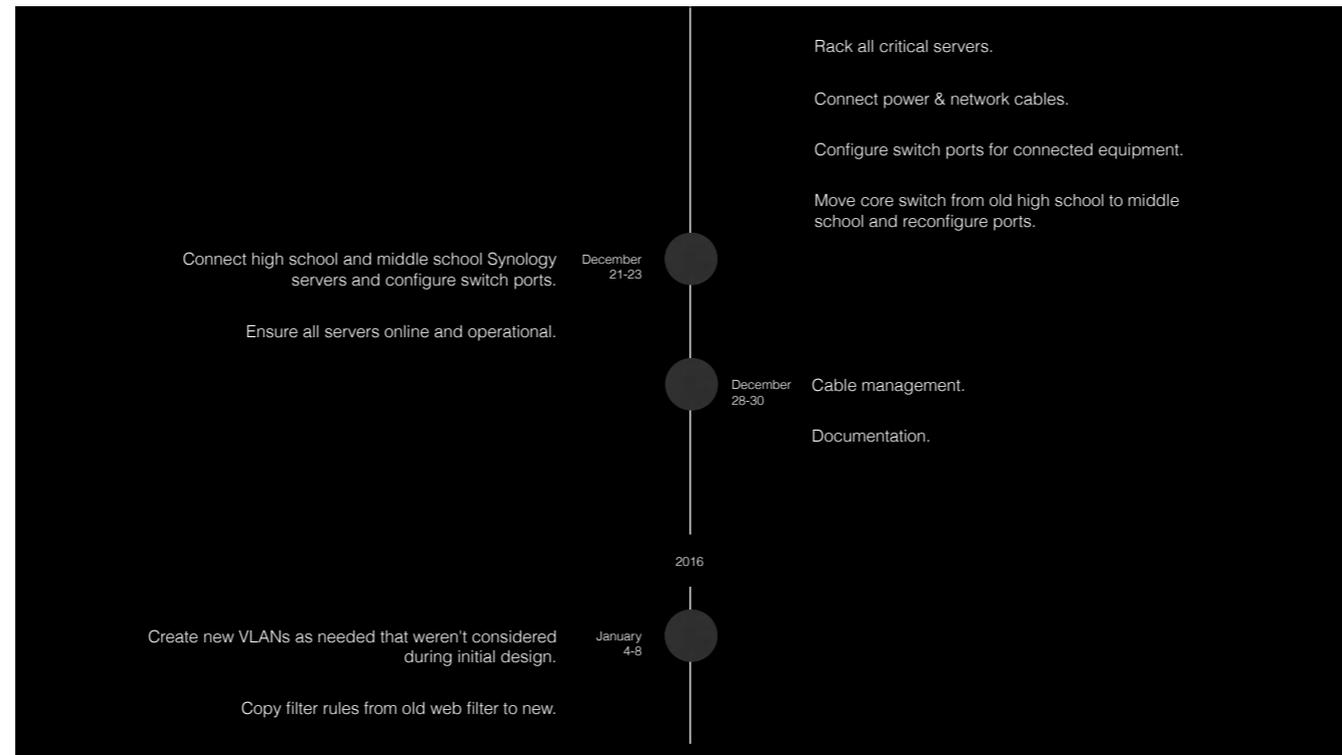
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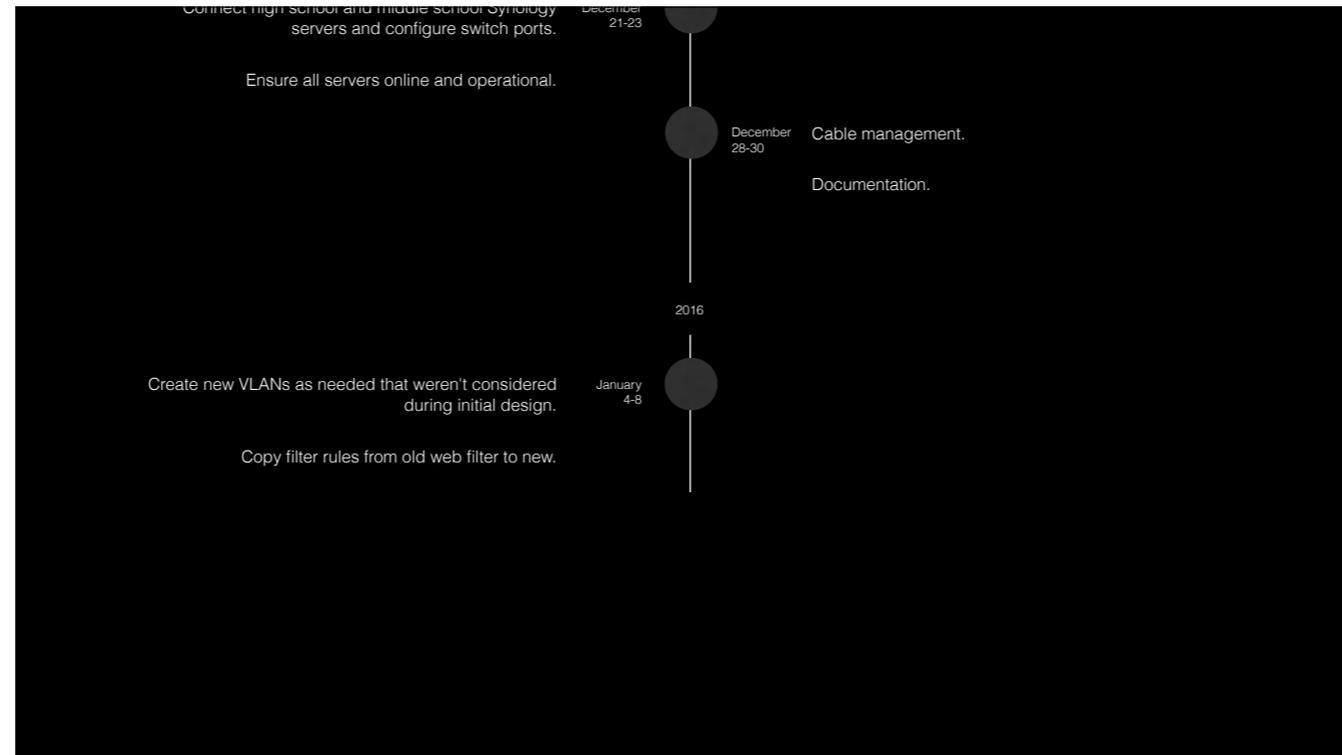
As I mentioned earlier, the middle school's network connection is via privately owned fiber, and the core switch there couldn't handle 10 gig fiber, so we relocated the core switch from the old high school to the middle school (which is why I set up a temporary switch in the old high school as we dismantled the old data center) and added a module that would support 10 gig fiber. We didn't have space for the switch on the existing network rack, so we ended up putting it on a rolling cart beside the rack semi-temporarily (I'm re-working that rack this summer.) Since we had fiber between the old high school and the middle school, connecting the middle school to the new high school brought the old high school back online. We wanted to keep a network connection active there because we have very bad cell reception in all three of the schools on that campus, and part of our group would be in the building pulling the computers and other technology out of classrooms during the 3 week break. We wanted to be able to get in touch with them (and them with us) if needed, and also wanted to keep the cameras active in case we had issues in a completely vacant building at night and on weekends.



Since we got all of the critical systems back online by the end of Saturday, our supervisor gave us the day off on Sunday, and we got back to the move on Monday and worked for three days finishing things up, getting the synology servers back online, setting up 4 port LACP trunks for each. After that, I tested connectivity for each of the servers that we moved. After working very long hours on the 18th and 19th, working normal hours these three days was great.



After a long Christmas weekend, we focused on getting cables organized in the cabinets and making sure I had documented port assignments and such. Pretty “boring” stuff, but just as critical as actually moving and powering servers back up.



After the long new years weekend, I switched from server administrator to network administrator, as I had to create new VLANs in the core and edge switches for our alternative school and ROTC classroom so we could provide the requested limited and additional access through the new web filter, and spent a couple of days getting the new web filter set up and copied the various allow/block configurations from the old filter to the new one so it was ready to go when school started on January 11.

Challenges

- Limited by state design manual unless locally funded
- Construction timelines
- Shutdown of old school after move

Some of the major challenges of the construction project included being guided by a very strict design manual, which set things like how many square feet spaces got based on our student enrollment numbers, the types of equipment (and amount) that were provided, etc. In most cases, this wasn't a huge issue, but the district was bound to that manual by accepting the co-funded money from the state.

As with any construction project, there's always a "hurry up and wait" mentality. We had a lot of meetings the first year, and then things settled down as the physical construction began. Then as we neared move in, things got hectic again. Now that we've been in the building for a semester, it feels great to be able to look back at the project and everything that was accomplished.

Keeping the old high school online wasn't a huge issue, but we wanted to make sure we maintained surveillance during the load-out process, which required some advance planning to determine which connections needed moved to the temporary switch. It wasn't a pretty cut over, as I didn't spend time doing cable management since it was only temporary, but it worked. As part of our group cleared a part of the building, they then went back and pulled the APs, cameras, and switches. Then once they were all done, several of us went over to help load all of the computers and other equipment that wasn't being moved to the new building into a truck to be taken back to our office for storage and later redistribution.



One of my favorite things about the entire construction project is that we finally have a properly set up data center. As you can see from these pictures, it's quite a difference from what we had at the old building. No more making sacrifices to make things work in a room that was never designed to be a data center. Now we have a room that was designed to be, and is set up as, a proper data center, including proper cooling.

<click for cold/hot aisle labels> As you can see, and is very evident when you're in the room, there's a cold aisle and a hot aisle. All of the servers are oriented so that the back of the server is to the right. The cabinets also have fans at the top to help extract the heat from the cabinets. One of the things I'm not crazy about in the early learning center is that there are two rows of cabinets, oriented with the fronts aiming the same direction. So we have a cold aisle, a "warm" aisle, and a hot aisle. If I had been more closely involved in that building's build-out, I would have requested that they turn the front row of cabinets around so we'd have hot aisles on the outside of the room with a cold aisle down the middle, even though the air conditioning unit would basically be in one of the hot aisles (as it currently is without the swap.) In the high school's data center, the air conditioning unit is located in the cold side of the room. One extra benefit in the high school is that the ceiling is sloped so the taller side is the hot side. That wasn't because it was designed with cold and hot aisles in mind, but rather because the data center sits partially beneath a large stairway.

<click for doors off> One of my favorite things about the cabinets that were installed is that the doors (front and back) can be removed, which makes working in the cabinets much easier. It also ruins the idea of cold aisles and hot aisles though, as the heat just goes wherever it wants to go.

<click for proximity reader> We also specified that we wanted a proximity card reader for access to the data center. We want to know who goes in, which we wouldn't be able to do if we just used keys (which we do for the TRs (telecommunications rooms)... proximity readers are relatively expensive.) My supervisor and I also have the ability to temporarily force the door to be unlocked by double "swiping" our badge, so as we were working during the move, we'd unlock it in the morning, and re-lock it at night before we left (or if we were out doing other things.)

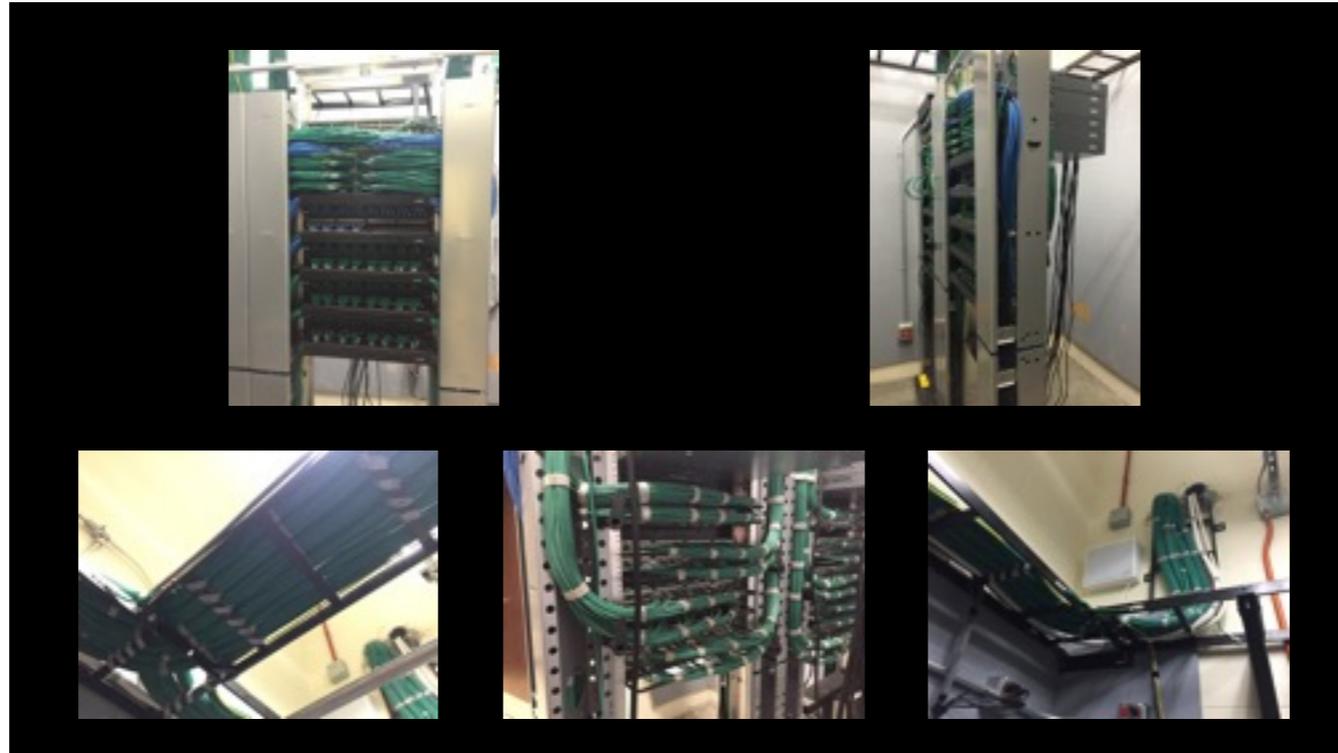


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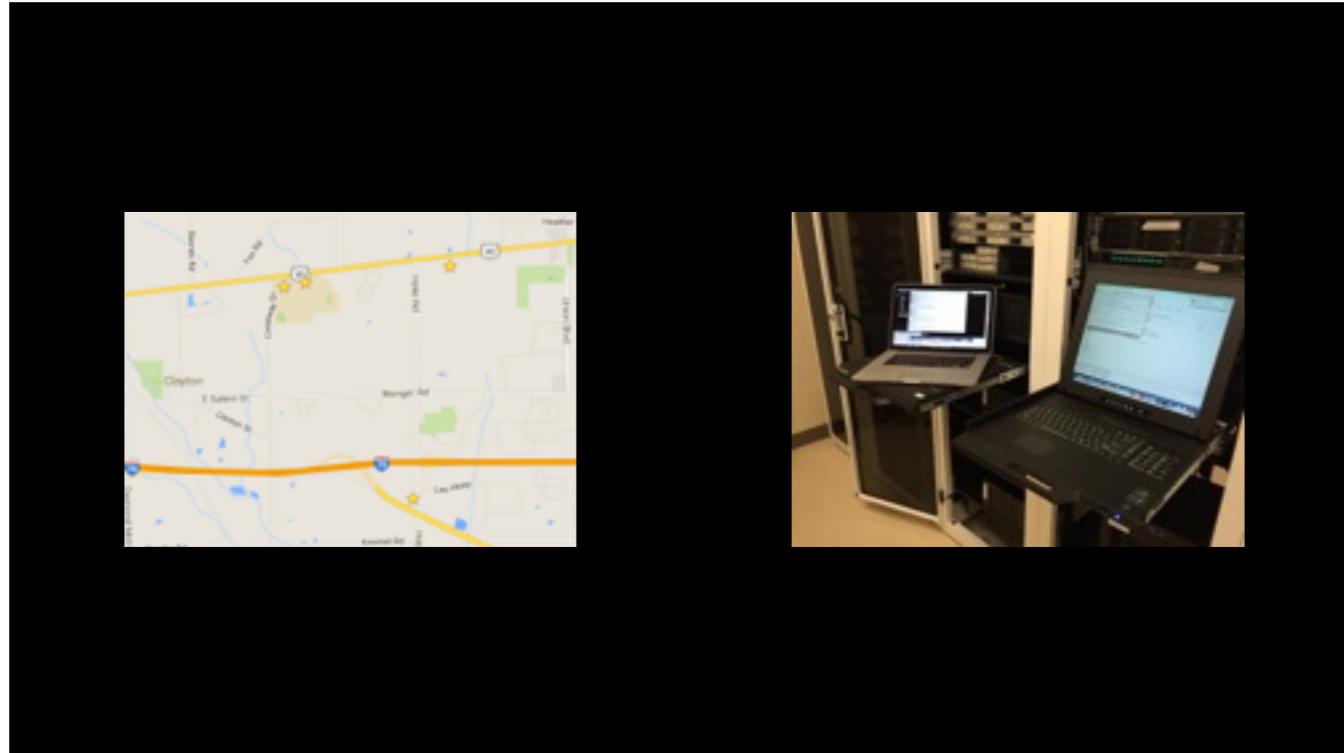
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We also have properly designed and implemented TRs. As I mentioned before, we don't share these rooms with anyone like we do in our older schools.

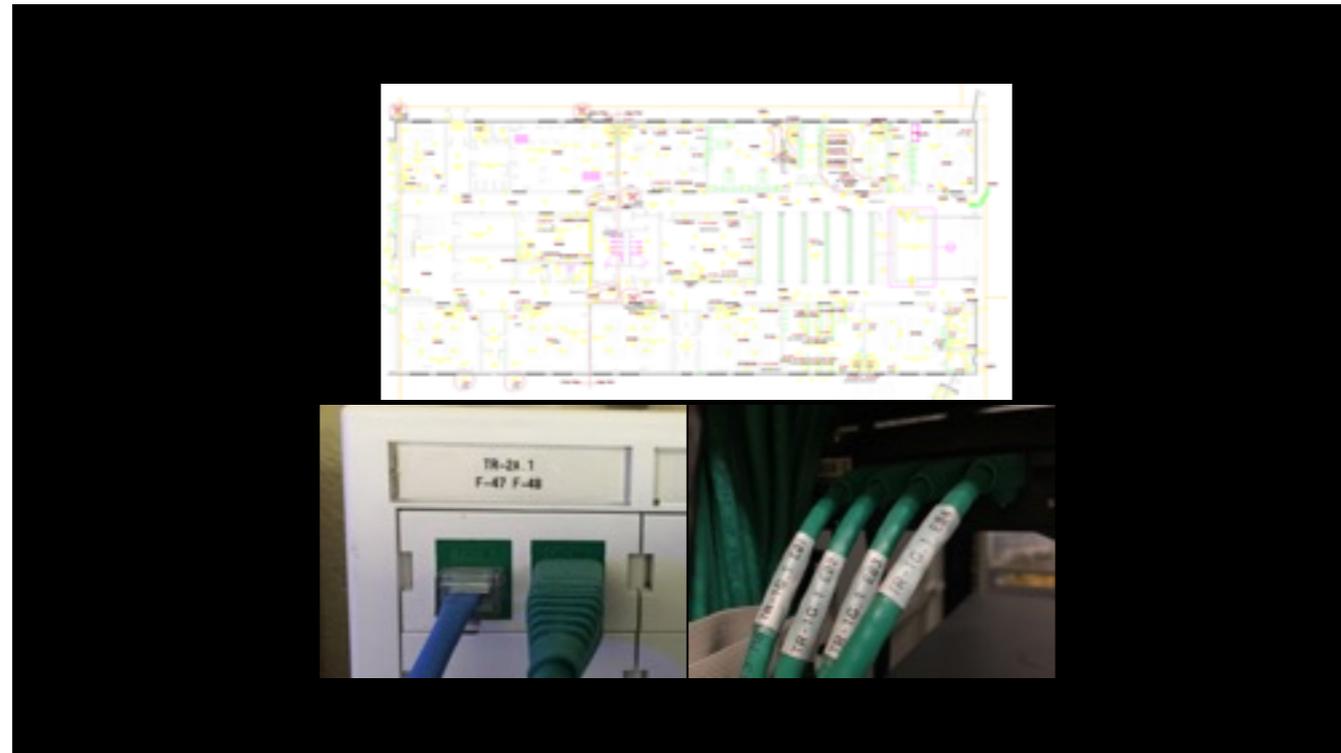


Fortunately the design manual calls for good power management, including a generator to keep critical systems online in case of an extended power outage, automated transfer switches to automatically switch power over to the generator (and back), and UPS units in the data center and TRs during that switchover.

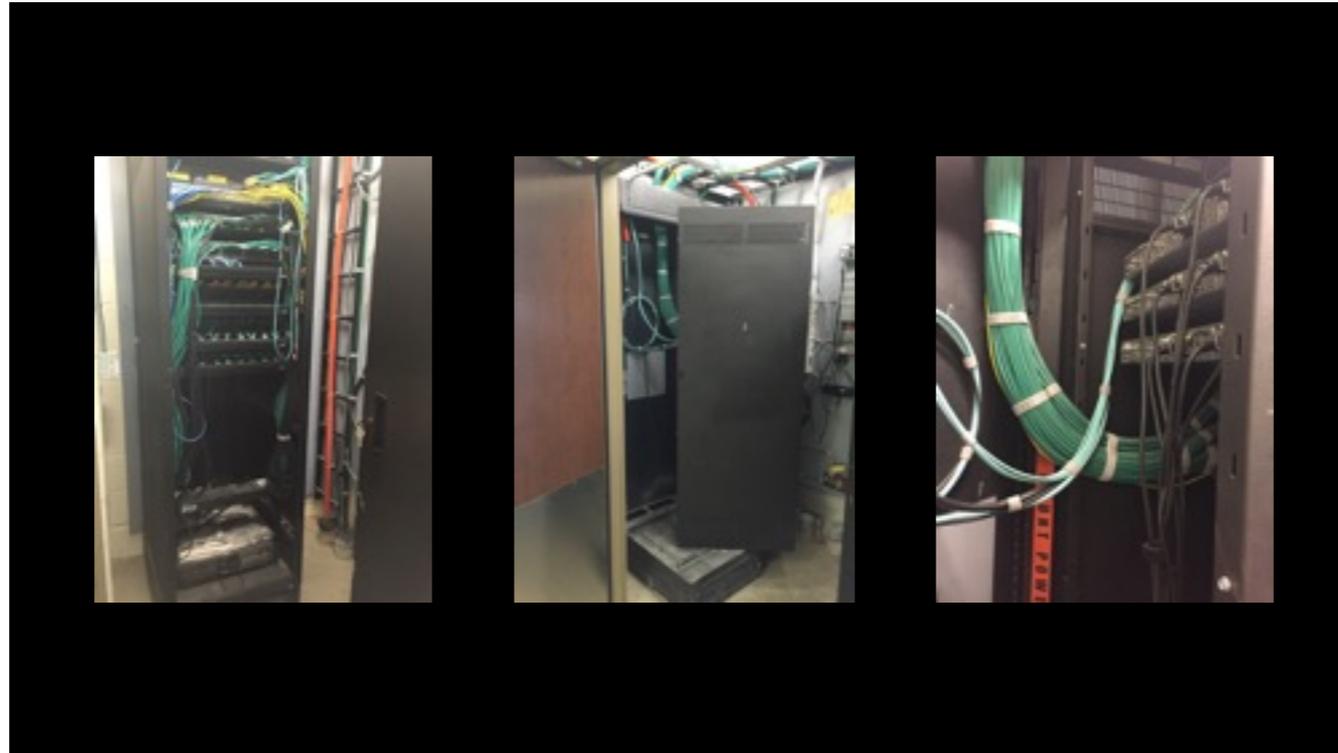


Another great thing, even though this is a relatively minor thing in the grand scheme of things, are the network KVM switches that got installed for us. Since I work remotely, being able to be able to see the console of a machine without having to be in front of it has already been useful a few times.

<click for keyboard/monitor trays> The rack mounted keyboard/monitor trays are awesome as well, as they save space in the rack when not being used. They're also useful as shelves for holding your laptop while working in the data center.



Any project is only as good as the documentation that accompanies it, and our contractor and sub-contractor did a great job with this. Ports are clearly labeled in classrooms and other areas. Cables are also labeled at both ends, and we got great “as built” electronic prints showing port numbers and locations. My challenge now is to get the port numbers documented in some sort of searchable system so that if a user is having trouble with their phone port, I don’t need to ask them to remove the phone from the wall to see the port number, or pull up the electronic prints, scroll to the appropriate area of the building and zoom in on their room to find the port number.



In a couple of our TRs, space was relatively limited, so they used hinged cabinets instead of regular racks. In Steve's pre-renovation area, these cabinets might have been a good option, though I'm not sure they make them deep enough for regular depth servers. In our case, for network equipment, they were perfect.



Here's some before and after pictures, first from Google's eye in the sky before

[<click for google after>](#) and after. As you can see, the new high school was built between and behind the old high school and the middle school.

[<click for aerial before>](#) And here's a closer look from an aerial photographer that documented the progress monthly.

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Now that we're done with the move, I can say that the amount of internal planning, including building a diagram of the target locations of servers in the data cabinets, was critical to our success. The success of our ITC and ISP staff in getting the district's network switched over to the new high school in less than two hours was due in large part to the meetings we had with them, and their coordination when it was time to make the move. I wish now that we would have had similar meetings with our telco and phone system subcontractor. And don't be lazy like me when it comes to documentation. I should have recorded the information in a google sheet instead of a notebook, even if doing so would have taken a little longer initially. This summer one of my tasks is to convert that documentation into google sheets, and I'm really hoping that I can make sense of my notes from almost 6 months ago.

<click for rails picture> And the biggest advice that I have from this project with is this... if you get a rack mountable server, whether you're using the rails for the server or not, label them to know what server they go with. I spent a lot of time the first weekend trying to match rails with servers, and ended up with a stack of rails that I still have no idea what they went with.

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