Designing, building and managing data center networks

Long gone are the days when network engineers/administrators/managers are responsible simply for providing always-on IP transport and access. Network engineers now must provide all of that plus networking inside the data center, as well as between storage, the data center and the core. To begin with, engineers must consider physical data center design, infrastructure and management of the data center.

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Physical considerations for data center network design (an introduction for network pros)

If you work as a network architect for long enough, sooner or later you may be asked to help design a new data center network. Although this probably doesn't sound like a big deal at first, I can assure you that it is not a task to be taken lightly. The way your data center is designed can have a direct impact on limiting the scale, topology, or even functionality of your network. Physical facilities considerations of data center design, such as power consumption and heating and cooling, will have a strong impact on your network design.

**Electrical capacity and the data center network**

Your data center network cannot function without electricity. When you combine that with the fact that electrical power is one of a data center's primary ongoing expenses, it makes sense to take a good look at the data center's electrical capacity up front.

Many years ago, I was doing some after-hours consulting projects. I received a phone call one day from a small company that had recently moved into a new building. They were having some problems with a new UPS they were using.

I had never been to the company's new facility, and I hadn't been involved in the move, so I didn't really know what to expect. When I got there, the server room looked something like the scene from the movie "A Christmas Story" where the father had a zillion plugs feeding into a single outlet. Whoever had set up the room had daisy-chained a bunch of power strips. This meant that every server in the room was plugged into a single 20-amp outlet. Miraculously, the outlet was able to sustain the workload, but the company bought a single UPS and connected it between the wall and the first power strip in the chain. They couldn't understand why this low-end, consumer-grade UPS could not support all those computers and monitors.

The point is that if you are setting up a data center, it is important to figure out what your power consumption is going to be ahead of time so you can make sure the facility has adequate electricity.

Each piece of equipment should have a label that will help you to estimate its power consumption. Once you have made a list of each machine's power consumption, I recommend tacking on 20% as a safety margin. Of course, in a startup data center you may not yet have actually purchased or received the equipment. If that is the case, then I recommend visiting the manufacturer's website for each piece of equipment you are considering. Most hardware manufacturers will post the equipment specs on their website, and this typically includes information about power consumption.

You also have to account for other sources of power consumption. For instance, larger data centers generally have their own cooling systems, which of course consume electricity, as do the lights. You should also plan for future growth by making sure there is plenty of power left over for servers that you might purchase in the future. If you are moving into an existing facility, then I strongly recommend having an electrician inspect the portion of the facility that you plan to use as a data center.
Typically, you are going to need several dedicated electrical circuits in your data center (more or less, depending on the size of the data center). An electrician can verify that the existing circuit breaker box has the capacity to add any extra dedicated circuits that may be necessary.

Another reason why such an inspection is important is that you need to find out whether the outlets that are currently in the area are on the same circuit as anything else. For example, you may find that the planned data center is on the same circuit as the entire next room. I ran into a situation about 10 years ago in which a nursing home's servers kept going offline for no apparent reason. Examining the logs, I noticed a trend in the timing of the failures, so I stuck around late at night to see what was happening. It turned out that the servers were plugged into an outlet that was wired to a light switch. When the last person left, he would turn off the lights, and the servers would go down.

Granted, this was a small facility without a dedicated data center. You would never expect that sort of thing to happen in a "real" data center. Even so, this is a perfect example of why an electrical inspection is so important. Until you get the facility inspected, you have absolutely no idea how it is wired. That outlet that you plan on plugging a server into may be connected to the light switch, or it may be on the same circuit as the copy machine in the next room. You just don't know until you have an inspection done.

When you add up the power consumption needs of your equipment and factor in a margin of safety, and the needs of future servers, you may be shocked at how much power you are going to need. There is a bit of good news, though. Power consumption in the data center is actually on the decline.

Server virtualization plays a big part in this decline. In my own data center, for instance, I have consolidated 12 servers into two. That really cut down on power consumption in terms of how much electricity the servers use and how much power my air conditioners are using. Having fewer servers means you are going to produce less heat, which means the air conditioners won't have to work as hard.

Another reason why power consumption is on the decline is that the equipment itself is becoming more efficient. This is especially true of hard drives. As you gradually replace older servers with new ones, you will generally find that your power consumption goes down.

**Cooling the data center network**

Excessive heat can dramatically shorten the lifespan of servers and other types of networking equipment. Network administrators are usually under a tremendous amount of pressure to keep the network running reliably and to make the most of the IT budget. Having equipment fail because it overheats can result in downtime and expensive repairs.

It actually takes quite a bit more cooling power than you might think to keep a data center cool. One extreme example of this is that when I first started doing freelance writing full time, I had a rack of 14 desktop machines I used as servers in a large room. The heat these machines put out was unbearable, even with the air conditioning running at full blast. The air conditioner simply wasn't designed to keep up with that kind of heat. Modern servers don't give off nearly as much heat as the machines I was using back then, but temperature control
can still be an issue, especially when you have a lot of different pieces of equipment in one room. My recommendation would be to contact a heating and air conditioning specialist who routinely deals with data centers. A knowledgeable person should be able to help you figure out how many BTUs of cooling power it is going to take to keep your data center at the desired temperature.

Another thing that you can do to help with heat dissipation is to arrange your data center in a way that helps cool air to flow into the servers and other network components. One common approach is to use a design technique called hot row/cool row or hot/cold aisle for your data center floor plan.

The basic idea behind this technique is that any piece of hardware that uses cooling fans has an air intake and an air exhaust port. The cooler the air entering the intake port, the cooler the server will run. The hot row/cool row design physically arranges networking components with regard to the location of their air intakes and exhaust ports.

Assume, for instance, that all of your servers have an air intake port on the front, and an exhaust port on the back. If you were to have multiple rows of servers arranged so that all of the servers were facing the same direction, then the front row of servers would be sucking in cool air and expelling hot air. The second row of servers would end up sucking in air that had already been heated by the first row of servers, and then expelling even hotter air. If the hot row/cool row design were applied to this situation, then server racks would be arranged so that the servers were back to back, with the exhaust ports facing each other. That way, the front side of the servers is left exposed to cooler air, rather than air that has already been heated by another server.

Most larger organizations pump cool air through a raised floor in the data center. Strategically placed perforated tiles allow the chilled air to escape in certain areas. I recommend placing these tiles in front of each server rack. That way, there is a source of cool air directly in front of the server’s intake port, which will help the servers to run much cooler.

It is important to remember that some network equipment (especially rack-mounted switches) is designed so that air flows in one side and out the other rather than following the traditional front-to-back airflow design. If such equipment is in use, it is important to arrange the racks so that you can avoid sucking the heated exhaust air from one device into another.

Some organizations get around this problem by staggering the racks, while others simply turn the racks at 90-degree angles. Whichever approach you use, keep in mind that you need to leave enough room around the rack to allow you to perform any necessary maintenance on the units within it. In the case of switches, you must also ensure that the layout that you use does not interfere with your cable management technique.

Power management is only one of the issues that you need to consider when designing your data center network. Another important consideration is how your floor space will be used. In Part 2, I will show you some techniques for saving both space and energy.
Building the network infrastructure in your data center

The network architect must help contribute to an energy-efficient and cost-effective data center network design -- without sacrificing performance. This can be accomplished by choosing optimal networking equipment. This tip will discuss some considerations for choosing energy- and space-saving routing and switching technology that can help cut power consumption and reduce your total number of switches.

Get the most out of your rack space

It almost goes without saying that using rack-mount equipment is essential if you want to maximize the floor space in your data center. Even racks have their limits, though. There is only so much rack space available, so it is important to make the most of it. This means selecting network hardware that will maximize your rackspace.

No matter what you are shopping for, it is hard to ignore the "green" trend. Whether you are talking about networking hardware or something completely unrelated, all of the manufacturers seem to want to promote their products as being good for the environment.

As an IT professional, I’m not really all that concerned whether or not my network switches are green. That isn't to say that I don't care about the environment; I do. It’s just that if I had to choose between energy efficiency and performance, I would choose performance every time. Even so, I believe that there is a way to have the best of both worlds and get energy efficiency, performance and a space-saving design all at the same time.

In my opinion, the best way to get a space-saving design and energy efficiency is to purchase network switches that have the highest number of ports possible. This approach makes sense from an environmental standpoint because each switch is going to have its own power supply built in. Generally speaking, one big switch is going to consume less electricity than two smaller switches, although there are exceptions. Fewer power supplies generally also mean that less heat is being produced. This in turn means that the air conditioners don't end up having to work as hard, which is also good for the environment.

Using switches with large numbers of ports typically ends up consuming less rack space than using a bunch of smaller switches. This can help you to get the most out of your available rack space.

Purchasing large switches: Some issues to consider

Purchasing a few large switches instead of a bunch of smaller ones generally makes sense. Even so, there are a few issues that you need to consider.

The first issue is price. It is sometimes less expensive to purchase several smaller switches than one big one. Sometimes the opposite is true, though. It just depends on what you are shopping for. If your budget is an issue, however, it pays to shop around.

The second issue with using large switches is that you are putting all of your eggs in one basket. In my experience, switch failures are rare, but they do happen. If an outage does occur, then the outage will affect more people if you
are using larger switches. Whether you use switches with lots of ports or something a bit more modest, it is important to keep a spare switch on hand just in case a switch should fail.

The last issue that I want to talk about is switch throughput. Some lower-end switches do not offer enough total bandwidth to simultaneously service all of the switch's ports. As a general guideline, a switch's total bandwidth should be double the amount that each individual port is rated for, plus the amount of bandwidth that is dedicated to the uplink ports.

For example, suppose that you are considering purchasing a gigabit (Gb) switch with 24 ports. The first thing you should do is to make sure that each port can run at Gb speeds. I have seen some lower-end switches that claim to be Gb but that support Gb speeds on only a few ports. It is also important that the ports be auto-sensing and that they support lower speeds as well, because some network devices (such as printers) still use lower port speeds. At any rate, although each of the ports is 1 Gb, the ports are all full duplex. This means that the ports can transmit and receive at the same time. On a 24-port switch, the total switch bandwidth would therefore need to be 48 Gb, not counting what the uplink ports are capable of delivering. Otherwise, network traffic will tend to get bogged down.

The uplink ports are also a very important consideration. The more ports you are using on a switch, the more uplink bandwidth you are going to need. Look for switches that offer dial uplink channels and that support 10 Gb uplink speeds. While you are at it, be sure to find out the total number of switches that can be linked together. It is important that the combined number of ports on each switch meet your current needs and allow plenty of room for growth.
How to monitor and manage your data center network

One of the most critical tasks in any data center is that of monitoring the networking equipment, the servers, and the data center itself. There is quite a bit of planning that goes into choosing an effective monitoring solution and into the ongoing management of the equipment within the data center network.

An effective monitoring solution is important in maintaining your data center network, in part because the data center often goes unattended for long periods of time. I have worked in a number of data centers over the years, and my experience has been that it is almost unheard of to have someone whose job it is to hang out in the data center and watch for problems. In fact, there may not be anyone at all in the data center most of the time. After all, data centers tend to be cold and loud, so often network administrators prefer to spend the bulk of their time elsewhere. Sometimes administrators may not even be located in the same building as the data center. Early in my career, I worked for a large insurance company whose data center resembled an underground bunker. In spite of the elaborate nature of the data center, only the security guards worked there regularly. Everyone else worked in another building that was a few miles away.

Whether administrators are across the hall or miles away from a data center, there needs to be an effective alerting mechanism in place. You can’t just assume that someone is going to walk into the data center and notice the console screen that indicates an imminent failure. This is why it is so important to make sure that you have a good network management and monitoring solution in place. Without it, you may never even know about problems until the phones start ringing.

What do you need to monitor?

A lot of planning needs to go into monitoring a data center because there are so many different things that need to be monitored. It’s easy to think of data center monitoring as keeping tabs on the servers, but there is really a lot more to it than that. For example, Microsoft’s System Center Operations Manager does a great job of monitoring Windows Servers and can be deployed with minimal planning. Even so, it doesn’t really help you if you have servers that are running non-Windows operating systems.

There are other factors that you need to monitor, though, besides just server operating systems and applications. For example, it is important to keep tabs on the temperature within the data center. Most servers have a built-in safety mechanism that will cause the server to shut down before damage can occur if the server’s temperature exceeds a certain threshold value. A good monitoring solution should be able to tell you the data center’s ambient temperature, but it should also be able to alert you if the temperature in any given server begins to approach a critical level.

The same thing goes for power management. If a power failure occurs, backup batteries will typically keep the servers online for a predetermined length of time. More elaborate data centers may also rely on backup generators. In any case, you need to be alerted to power failures, and you also need a way of knowing how much reserve power is available at any given time.
A good monitoring solution needs to be able to alert you to issues with server hardware, operating system errors, application errors, networking hardware issues, and environmental issues. This is a tall order, to say the least, and that is a big part of why proper planning is so important. To the best of my knowledge, there is no single monitoring solution that can perform all of these functions. Typically, network architects will need to invest in several monitoring solutions and set them all up to deliver alerts in a uniform way. This alert might come in the form of a text message to an administrator’s mobile device or an email message sent to the help desk, or some other type of alert. The important thing is that all of the alerts come to one place.

**Virtualization complicates data center network monitoring**

As you shop for a monitoring solution, it is important to remember that there are factors, such as virtualization, that can complicate the monitoring process. For instance, there are various monitoring applications on the market that can monitor a server’s hardware for signs of a failure. Such an application might look for excessive server temperatures, SMART disk warnings, or even the failure of one of the cooling fans within the server. The problem is that if a monitoring solution is not aware that it is monitoring a virtual server, it may not be aware of hardware issues that could potentially affect the server’s availability.

The monitoring software should pick up on problems with the host server’s hardware. But if the host is at risk, so are any virtual machines running on the host. Therefore, if your organization is going to be making use of virtual machines, you will need a way of differentiating between physical servers and virtual servers and of knowing which virtual machines are running on which host servers. You will also need to have the ability to move the guest machines quickly to a different host server in the event that hardware problems occur.

Finally, management and monitoring go hand in hand. Monitoring is no good unless you also have good management capabilities in place. This is especially true in situations in which the staff is located off-site. For instance, what good does it do to have your monitoring software tell you that a critical failure is about to occur if the administrative staff has no way of getting to the ailing server in time to prevent the failure? This is why it is so important to be able to monitor and remotely interact with every server and every major piece of hardware in the data center.

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