Principal Asset Management℠

BEHIND THE GATE:

The anatomy of a data center

Society relies on digital applications for work, education, transportation, entertainment, healthcare, and just about every other aspect of our modern lives. Through these digital applications, we create and consume massive amounts of data (three times as much in 2022 than just four years earlier). All that data—even data 'in the cloud'—is processed and stored inside a data center.

Indeed, data centers are the cornerstones of our digital world. And yet few people have ever been inside one. Most data centers don't have signs advertising them. You might drive by one on your daily commute and not even know it. You can't walk up to the lobby and ask for a look around. But in this short paper, we'll give you a peek inside.

The site

It's a well-worn adage in real estate: location, location, location. True for homes and shops, and true for data centers. That's why leading data center developers have location strategy teams to find the right sites that meet tenant-specific needs.

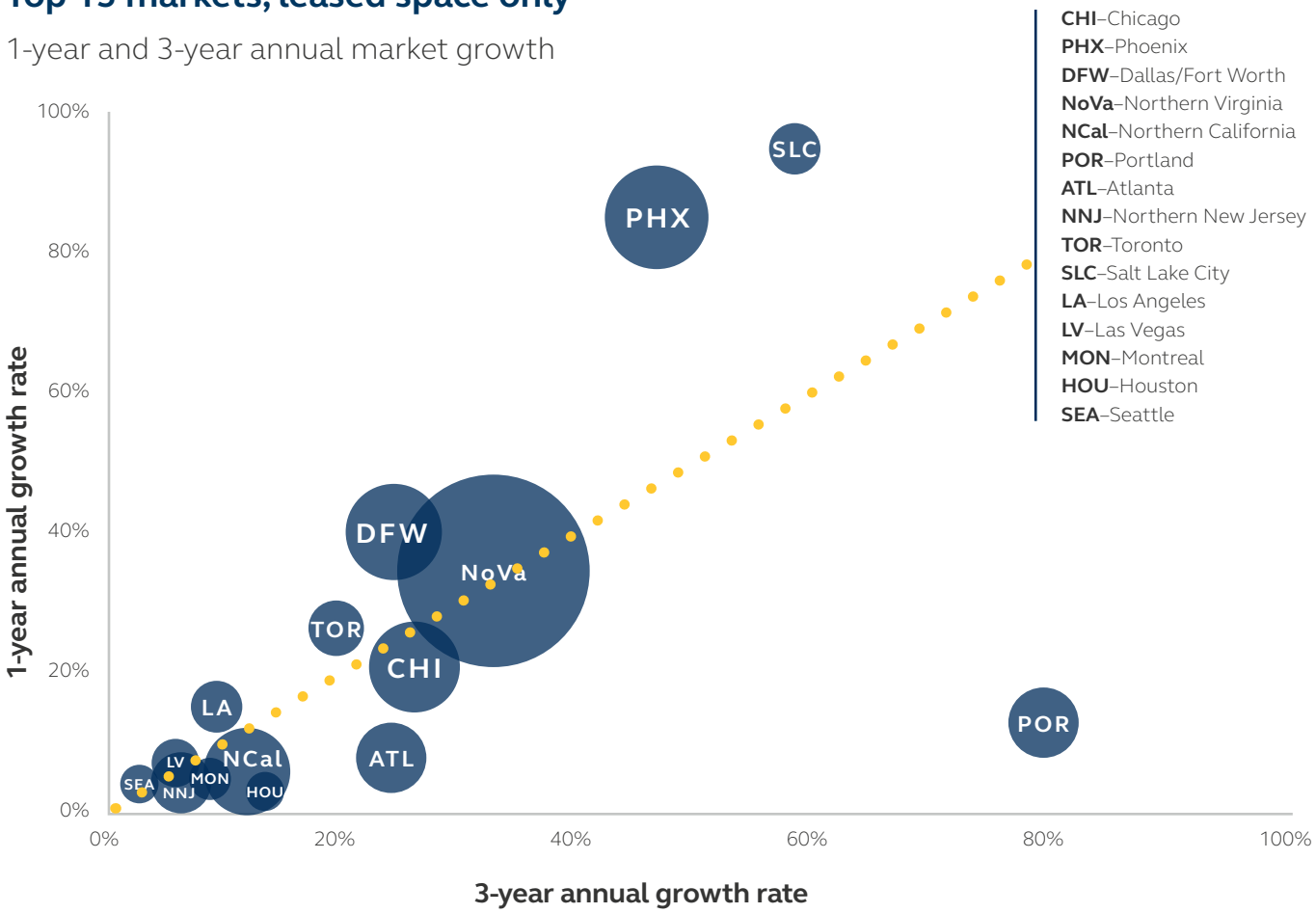
Both the market (city or region) and the specific site matter. Dallas, for example, is one of the world's top data center markets, with high marks on factors like power cost and network connectivity. But within the metro region, sites in the Eastern District of Texas are widely considered to be higher risk than sites in South Dallas.

SITE SELECTION FACTORS

- Low cost, high reliability power
- Low risk of natural disaster
- Strong network connectivity
- Favorable tax laws
- Renewable energy availability
- Access to technical talent
- Outside the FEMA 500-year floodplain

Top 15 markets, leased space only

1-year and 3-year annual market growth



As of 31 March, 2023. Source: datacenterHawk. The bubbles represent the size of the markets.

The building

Looking at a data center from the outside, you'll likely be struck by its resemblance to an enormous high-tech fortress. Indeed, hyperscale data centers are huge (one campus in Goodyear, Arizona, will be the size of 35 football fields). Many are designed to withstand or avoid natural forces like tornadoes and floods as well as human-caused risks such as a semitruck or an airplane crash.

BUILDING SPECIFICATIONS

- Concurrently maintainable or designed to "Tier III" standards means there are no single points of failure, the data center can remain online while equipment is being maintained or replaced, and can continue operating even in the event of a prolonged grid power failure.
- Secure yet accessible. Data centers must be secure enough to protect billions of dollars of tenants' IT equipment and the data on that equipment, while allowing 24x7 access to support, for example, large-scale deliveries by tractor-trailers.
- Resiliency to withstand natural forces. Data centers must meet International Building Code (IBC) 'importance factors' to help ensure continuous availability.
- Reduced risk via physical separation. Many data centers have setbacks from the property line to the data halls to help ensure protection of the data center even if the perimeter were breached.

Security

As you approach the data center, you'll encounter the first layer of security. Leading data center operators use a 'concentric rings' methodology with a number of barriers between the outside of the data center and tenants' IT equipment at its core. Between barriers, intervention zones allow for threat detection and response to stop the attack.

SECURITY LAYERS

- **Perimeter security** – Secure fencing (which can withstand vehicle impacts) and perimeter monitoring devices help ensure only authorized personnel are allowed within the 'security envelope' of the data center campus.
- **Exterior security** – A staffed perimeter security center helps ensure only authorized people can access the data center grounds and that authorized visitors (such as a tractor-trailer making a mission critical delivery) have clear direction on how to safely navigate the campus. Always-on video surveillance ensures a record of all activity outside the facility.
- **Interior security** – A main lobby security booth is staffed 24x7x365 with at least two guards who help ensure only individuals who have been thoroughly vetted and approved are allowed into the facility.
- **Restricted area security** – Dual authentication (biometric and color-coded key card) helps ensure only authorized personnel may enter into high-security areas. Security vestibules (sometimes called mantraps) help prevent 'piggybacking' by non-authorized individuals.
- **IT equipment** – A single tenant could have hundreds of millions of dollars in IT equipment in the data center (plus the company's most valuable asset of all: its data). Access to the data hall is restricted to individuals approved by the tenant. In shared data halls, suites or cages provide barriers between tenants' equipment and access into them is similarly restricted.

As important as the physical layers of protection is the data center's security personnel. Trained security professionals are critical as are rigorous continuous training programs that include security awareness, vendor management, and penetration testing to help ensure the team is ready to address developing threats.

Operations center

The ‘brain’ of the data center is often referred to as the Facility Operations Center or Network Operations Center (often referred to simply as the NOC). This is where technicians with various areas of expertise monitor the data center’s mission-critical systems—power, cooling, and network. They’re on the lookout for issues that could cause disruptions and are responsible for identifying and investigating any issues that arise.

Comparable to how you might imagine an air traffic control center or a crisis management room, NOCs are often outfitted with several rows of desks facing multiple screens displaying details about significant alarms, ongoing incidents, and general performance of the data center. The goal is to ensure that all team members have access to necessary information at the same time and can collaboratively solve problems when they arise.

THE PEOPLE OF THE DATA CENTER

Unlike with other forms of real estate (such as office buildings), in a data center the people who design, build, and operate the facility typically interface deeply with tenants’ technical and operations teams. These real estate professionals and technical experts with deep experience building and operating data centers are dedicated to providing the outstanding customer service that drives tenant satisfaction. And they have processes, honed over time, with a goal of ensuring optimal performance, cost containment and risk mitigation.

Mission-critical equipment

The mission of a data center is to ensure tenants can get data to and from their servers and storage devices and their end users. Delivering on that mission requires three components: network equipment, which manages the data flowing through the 'pipes' of the data center; power infrastructure to keep the network, cooling, and IT equipment on; and cooling infrastructure to remove the heat that IT equipment generates.

In a concurrently maintainable data center (designed to "Tier III" standards) mission-critical equipment is redundant. Essentially that means there are two of each of the critical components, with sufficient spares to keep the network, power, and cooling systems running even if one component is offline due to maintenance or failure.

Network redundancy means at least two different cable entry points, at least two different meet-me rooms, and at least two sets of cable distribution systems. It's critical to ensure physical network elements (such as a 'pair' of dark fibers) enter the data center diversely to avoid single points of failure upstream of the data center. Redundant power infrastructure means two diverse utility feeds, two sets of Uninterruptible power supply (UPS) equipment, and two sets of distribution systems. Cooling infrastructure like air handlers, chillers, and pumps likewise need to be redundant.

Network

Data comes in and out of the data center via fiber-optic cables operated by a network provider ('carrier') such as AT&T or Comcast or via 'dark fiber' dedicated to and operated by one tenant. Most data centers are 'carrier neutral' meaning they allow any carrier to deploy their network infrastructure and/or run fiber-optic cables into the data center.

Once inside the data center, network cables are diversely routed to a 'meet-me' room or directly to tenant-directed demarcation points in the facility. From here data center tenants run diverse, dedicated cables to their servers. The meet-me room also offers a secure location for tenants to economically 'cross connect' data from one carrier to another and to other tenants and service providers on a campus, or to networks providing access to major cloud providers.

Power

A hyperscale data center with 40 megawatts of IT capacity uses about the same amount of power in a year as 36,000 homes. That is a lot of power, but leading data center providers have implemented strategies to dramatically reduce power consumption; between 2010 and 2018 data centers globally did 550% more work with only a 6% increase in power.[1] In addition to efficiency measures, leading data centers now offer tenants the option to use renewable energy from sources such as wind and solar.

POWER INFRASTRUCTURE

- **Utility yard** – Like an engine room on a ship, the utility yard is a secure area outside of the data center building where diverse utility feeds deliver power from the utility. Here the utility power is transformed and prepared for distribution within the data center. Some data centers have on-site substations which enable faster time to deploy and give the operator more control, flexibility, and scalability.
- **On-site generators** – A concurrently maintainable data center (designed to "Tier III" standards) must be able to continue operating for at least 12 hours if utility power goes out. That requires on-site generating capabilities such as diesel generators and enough fuel stored on site to power them.
- **Uninterruptable Power Supply** – Instead of going directly to tenants' IT equipment, the power passes through a UPS system that protects the IT gear against disruptions like power surges and also provides temporary emergency power in the case of a utility outage, to keep the data center running.
- **Distribution** – After passing through the UPS, power is distributed directly to the data halls and the tenants' IT equipment.

[1] "Recalibrating global data center energy-use estimates" February 2020. https://www.science.org/doi/10.1126/science.aba3758

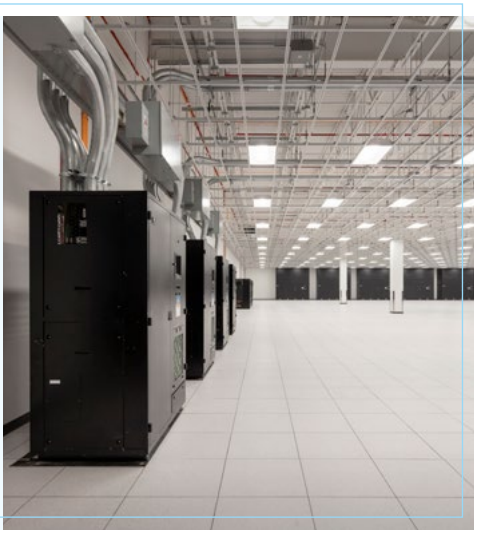
Cooling

Imagine bringing enough power for 36,000 homes into a single building. The IT equipment using all this electrical capacity generates a lot of heat—it's hard work processing quintillions of bytes of data every day! That heat has to get out of the data center somehow, and for that there is a range of cooling infrastructure technologies on the market. The 'best' depends on the type of work the IT equipment is doing (high density deployments like those used for AI applications, for example, create more heat per square foot and require more effort to cool), on the climate of the particular location, and on tradeoffs between energy efficiency and water efficiency—both of which are good for the business and the planet.

All else equal, closed-loop air-cooled chillers use less water but more energy than water-based evaporative cooling systems. In water-constrained markets and markets where renewable energy is readily available, leading data center developers are increasingly relying on air-cooled chillers. These systems use water pumped through a closed loop of pipes to extract the heat from the data hall and reject it into the outside air.

COOLING INFRASTRUCTURE

- **Computer room air handlers** – Fans distribute cold air into the data hall to remove the heat from the IT equipment. The hot exhaust air from the IT equipment goes back into the air handler where the heat is transferred from the air to the chilled water system via an air-to-liquid heat exchanger. A car radiator works essentially the same way, in reverse.
- **Chiller** – The chillers use a refrigeration cycle to transfer heat from the warm water leaving the air handlers to the atmosphere. The chillers are located outside of the data center building in the utility yard.
- **Pump room** – Located inside the data center building, pumps are used to move the chilled water in the chilled water loop from the chillers outside to the air handlers and the hot water from the data hall back outside to the chiller.



IT equipment

A large-scale data center houses hundreds of millions of dollars of IT equipment and—even more valuable—the IT systems and proprietary data that are the beating hearts of most companies. It all lives in the data hall. If you're standing just inside a data hall, you'll see a large room with rows and rows of servers stacked in racks. You may see network and power cables running overhead and connecting down into each rack of servers; or these cables may be hidden under access panels in the floor.

You may see the rows of server racks configured in sets of two facing each other with a door in between. This provides the opportunity for efficiency by installing hot or cold aisle containment, an airflow management strategy designed to optimize cooling efficiency by not allowing chilled supply air and hot exhaust air to mix. Chilled supply air can be delivered to the server racks in many ways, including through a raised floor plenum, through ductwork above the racks, or through rows of fans lining the data hall, aptly referred to as 'fan walls.' As densities within the data halls increase, tenants may look to other techniques to cool their equipment including using liquid cooling in addition to or instead of forced air. Oftentimes liquid cooling using equipment such as rear-door heat exchangers or even direct-to-chip cooling can be incorporated into traditional forced air data halls. Additional efficiencies can also be achieved by data center users through liquid immersion cooling, but that has yet to achieve widespread adoption due to requirements for specialized servers and cooling equipment, and proprietary (and costly) dielectric fluid.

How a particular data hall is configured depends on the particular needs of the tenant. Hyperscale companies that operate gigawatts of data center capacity around the world typically prefer standardized deployments across their portfolio—but the configuration of one company's data hall may be quite different from its competitors'. It requires a lot of experience and deep relationships for data center operators to ensure their data hall designs support the broadest set of tenants and allow for configuration without requiring one-off customization.

Conclusion

Now that you've taken a look behind the gates of a modern data center, the next time you stream a movie, bank online, post a video on social media, or have a video conference while working from home, you have some idea about the complex and vital digital infrastructure that makes that possible. In fact, the next time someone asks, 'But really, where is the cloud?' you can confidently answer that it's in a data center.

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