Data Centric City

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Abstract
New York is one of the four biggest data center markets, alongside San Francisco, London, and Tokyo. The city's infrastructure for connectivity, especially in Manhattan, is world class due to the data requirements of the area's large companies. Along with the growing amount of data usage and smart city development, more data centers are expected to be built in the urban area to meet the demand of even higher connectivity and lower latency brought up by the advance technology. Data centers have long been an infrastructural typology that prioritizes machinery functionality over humanity. Urbanization of data centers means more urban space will be taken up by inaccessible data centers that are designed purely for servers, which harms our livability. As data usage is growing exponentially every year, it is imperative for the city to design a way that situate data centers more harmoniously into the city fabric that bring positive impact to the social context and the neighboring environment.

Data-Driven World
Improvement of living quality in the information eras cannot usually carry out without an involvement of digital technology. Many aspects in our lives are becoming more data dependent: For the ways we transit we have the new mobility modality such as uber and e-bike; with digitalization of knowledge we could acquire knowledge online through internet or e-book; e-commerce and social media allow us to shop and communicate without constraint of physical distance. Our lives therefore immerse more and more into this intangible control of digitalization. Every activity and decision in our lives involve algorithms underlined in the device which served us the purpose.

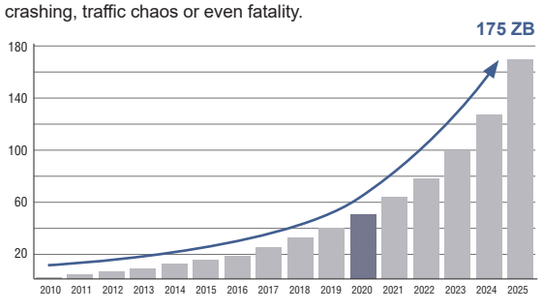
Along with the fact that data has become an essential to daily life, the need for data storage space grows exponentially. According to a report by International Data Corporation for EMC, it is estimated the worldwide digital information will grow from 1.8 zettabytes in 2011, 40 zettabytes of data in 2020, and could amount to nearly 175 zettabytes by 2025. North American contributes to the largest portion of data usage among the world, who creates 2000 terabytes of data every second as stated in the report EQUINIX Global Interconnection Index 2019. The data created every minute includes 60 thousand of Google searches queries, 1.2 hours of YouTube uploaded footage, as well as 3.4 million sent emails[1].

We are getting used to immerse into digital activities which build up our social lives and provide us entertainment. Even though the hardware of data storage is constantly getting smaller, faster and more powerful, it is still at the edge of fulfilling our data demand. The growing demand of data mean more data centers are expected in the future for data storage.

NYC- The Smartest City in the World
"A smart city harnesses the power of its data to run more efficiently. Every company and every city are now data-centric."
Melvin Greer, Chief Data Scientist at Intel Corp.

Awarded the smartest city in 2016 and 2017, New York is recognized as a city of innovation[2] for it to have devoted to excessive use of information and data communication technology for real-time city management. The smart controls implemented in the city include densification of free wifi network and real time control sensor for traffic light, which keep track of instant traffic condition and calculate the ultimate signal pattern to alleviate its serious congestion problem. Big tech companies distributed around Flat Iron building and midtown have constituted a tech community known as Silicon Alley, which is recognized to have competitive force with Silicon Valley in San Francisco. Other than those big brands, tech startups in New York are also major contributors to the smart city achievement, who continuously collaborate with the government to develop new applications and AI programme which digitalize current governmental service to improve efficiency in communicating with its people.

The New York City is also the leader of future technology. The establishment of 5G network has brought about a wave of real-time applications such as autonomous vehicles, remote surgery and drone delivery. No latency will be allowed when these new technologies and city-managing system are implemented in the future. Any delay in data transmission may result in serious consequence such as car crashing, traffic chaos or even fatality.



7.4.1 Demand of data storage per year

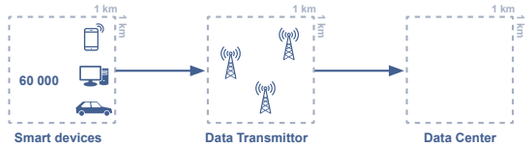
1 Real Time Statistics Project. internet live stats. http://www.internetlivestats.com/one-second/ (accessed April 10, 2016).
2 IESE Cities in Motion Index 2017

Data, Time and Distance

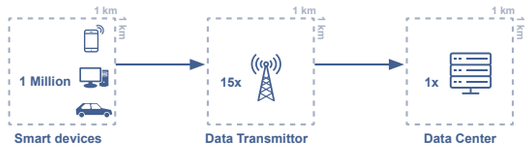
To ensure real-time data transmission, the distance from data center becomes a critical factor. The closer the data center to a device, the faster the device could receive a response signal. Data centers, as the core of these technologies, are expected to distribute in the city more densely to support the need of real-time response and possess the skyrocketed amount of data generated from the whole system of operation of the city. To put it into actual number, currently data centers in suburban can already cater the speed for 4G connectivity. Data center experts predict that, when 5G network is implemented, there should be at least one data center every one square kilometer to support real-time communication.

The Physical Form of Data

A data center consists of numerous rows of networked computer servers that runs 24/7 for remote storage, processing, or distributing large amounts of data. These servers are stored in standardized racks that are placed in a climate-controlled room. The whole system is protected by layers of room with different security access control, and safeguarded by a monolith, impermeable building envelope. Although technology advancement allowed the size of one server to shrink, the technological capacity is not able to catch up our growing demand of data, which ends up with a need of even larger physical space for data storage compared to the past[1]. Currently there are two major types of data center, namely colocation and hyperscale. The size of a colocation data center could range from 2200 square meter to 6000 square meters. A hyperscale data center could have size ranged from 40 thousand square meters to 60 thousand square meters. The thesis will focus on data centers in urban environment, which means in the scale of a colocation data center.



7.4.2 Number of devices for 4G Connectivity



7.4.3 Expected number of devices needed for 5G Connectivity

7.4.4 Urban data center, Titanpointe Manhattan

Potential and challenge for Midtown NE

Despite the need of data center for implementing smart city technology, there is no data center in Midtown NE at the moment. Midtown NE is used to be a corporate center in New York City that houses many offices of large local brand such as FACEBOOK at 335 Madison Ave, TWITTER at 340 Madison Ave, Black Rock at 40&55 East 52nd Street and IBM at 590 Madison Ave, which are all data demanding businesses. Big companies are moving out of midtown NE to Hudson yard and downtown for new expansion and closer data infrastructure. The Midtown NE area will then face the threat of losing gravity and its position as central business district, which consequently leads to large amount of office vacancy and loss of liveliness.

The department of city planning anticipates that, without taking any proactive action, the area's premier business district status could diminish and the large investments in transit infrastructure could not live up to their full potential, in terms of bringing jobs and tax revenue for the city and region. The city council has therefore announced a new rezoning plan in 2017 to provide incentives for development within the rezoned midtown subdistrict bounded by Fifth Avenue, Third Avenue, East 39th Street and East 57th Street. This area is anchored by Grand Central Terminal, one of the city's major transportation hubs and most significant civic spaces. The plan includes allowing additional floor area for new development, making the allowed FAR to increase from 12 to between 18 and 27. It aims to attract new development of tall buildings and position the district as a world-class business district and a major job generator.

According to a Bloomberg report, over half of the new business that planned to move into Midtown NE is data-demanding industries such as finance and technology sector. The existing big tech community in midtown and the rezoned development also allured 9000 tech startups to enter midtown Manhattan. The number of start-ups is expected to keep growing and looking for place in midtown Manhattan. Although a lack of centralized data center create no problem for big companies since they have their own in-house data infrastructure, it is an obstacle for smaller businesses to develop and implement their innovation because they cannot afford to build their own. Besides, high office rental price in midtown also make small businesses difficult to sustain in this expensive land, which restricted new tech businesses from joining the tech community. Last but not least, since 83% of the buildings in Midtown NE are over 60-year-old[2], the existing office space in Midtown NE is obsolete for creative industries, who need more innovative space to spark new ideas. The district is therefore in need of a design to renew its architecture to fit its upcoming change in business landscape.

A data center within a business center is indeed ideal for both internet users and businesses to test out their smart city innovation due to the low latency it provides. Data centers are anchoring infrastructure that can potentially act as a centralizing force to construct a technology and media community, which incubate small businesses and develop them into world class businesses in accordance to the vision of midtown subdistrict rezoning. Investment in these data facilities can also bring considerable tax revenue and promote further economic development to Midtown NE by attracting new businesses and providing job opportunities.

7.4.5 Existing colocation data center location in Manhattan

1 Joseph Lauro, interview by Clog. An Interview With Gensler (2012).
2 Gottscho,S. (1931). Manhattan Skyline 1931. Achieved in October 2019.

Data center- a threat to urban life

Architecture is used to be designed for the human bodies. However, data centers are typology that usually designed just for optimal performance of machines and therefore any humane features that may constraint the performance of machine are not considered in its design process[1]. It ends up with inhumane appearance that looks more or less like a monolith warehouse with no windows and limited spatial articulations. More than that, it does not contribute much to the “life” of any area. A 100,000 square foot facility might employ fewer than a dozen people. For example in Sarpy County, Switch will hire 65 people and Facebook expects to hire 100 for one million square foot facility they planned to build. The data facility was even designed as anonymous as possible and fenced with high security to keep people out of the building, which turns a place into a desert and lower the liveliness of the located district. The incentive provided for data center may also mean an additional economic burden to the residents as there may be higher taxes imposed on them or leading to rising housing and rental prices.

Other than a lack of ‘life’, a data center is inaccessible for most of the people. The whole mass of a data center is fortified with high fence for high security, which tend to be anonymous and hidden from the city[2]. Unauthorized people are kept out from its fence line and encourage no street life and human touch around its architecture. Paradoxically the data center is a key infrastructure to sustain the Internet which allows timeless communication and connects humans in a distance, our physical urban space is gradually taken up with the construction of more inaccessible data center in the city, which harms our physical social life and livability. The thesis will reexamine the conceptual boundaries between physical and digital, men and machines.

Despite a data-hoarding culture in our lives, many people have no ideas on the environmental ramification of their usage of data. Data centers create a lot of environmental problems including residual heat and noise. Running or idling servers could both generate waste heat that raise the room temperature 10°C more than its surrounding, which means cooling is critical in the smooth operation of computers and servers. According to the latest report, 40 percent of the total energy that data centers consumed goes to cooling IT equipment.

Other than the electricity needed for doing the computation work, consulting firm McKinsey & Company found that the average data center wasted around 88 percent of its power for idling while waiting for the next surge of traffic. It results in an unimaginably high power consumption for just one data center. Peter Gross, who is expert of designing data centers mentioned, “A single data center can take more power than a medium-size town.” Reports show that data centers across the globe consume thirty billion watts of power, which is comparable to that outputted from thirty nuclear power plants. Data centers located in the United States accounts for 25-34% of this load and 90% of worldwide data center server space is owned by American companies. Construction of even one data center would create enormous environmental burden from its excessive energy consumption to the pollution it brings about. It is imperative to come up with a sustainable data center design which could fulfill our growing demand of data storage without create much harm to nature.

Conclusion

Data centers have long been an infrastructural typology that are designed for the sake of operation of IT equipment. As it used to be located in deserted suburban area, its socio-environmental impact to the its surrounded neighborhood is not always taken into account in its design. When we are more immersed into the advanced lifestyle provided in the information era and depend more on data, it becomes imperative to think about the possibility to introduce data center to the city in a more human-oriented and environmentally friendly way.

Research Question

Seeing urbanization of data center as a future trend, what extra values could data center contribute to the people and the urban environment of midtown Manhattan?

1. What is the current trend of data usage? What will be the new typology of data center in the future?

2. How does the digital landscape change people’s perception of the physical world? Will it change the meaning of architecture?

3. How could digital infrastructure and humanity intermingle to create a more humane space for the neighborhood?

4. How can architecture be relevant across time in the ever-changing digital world?

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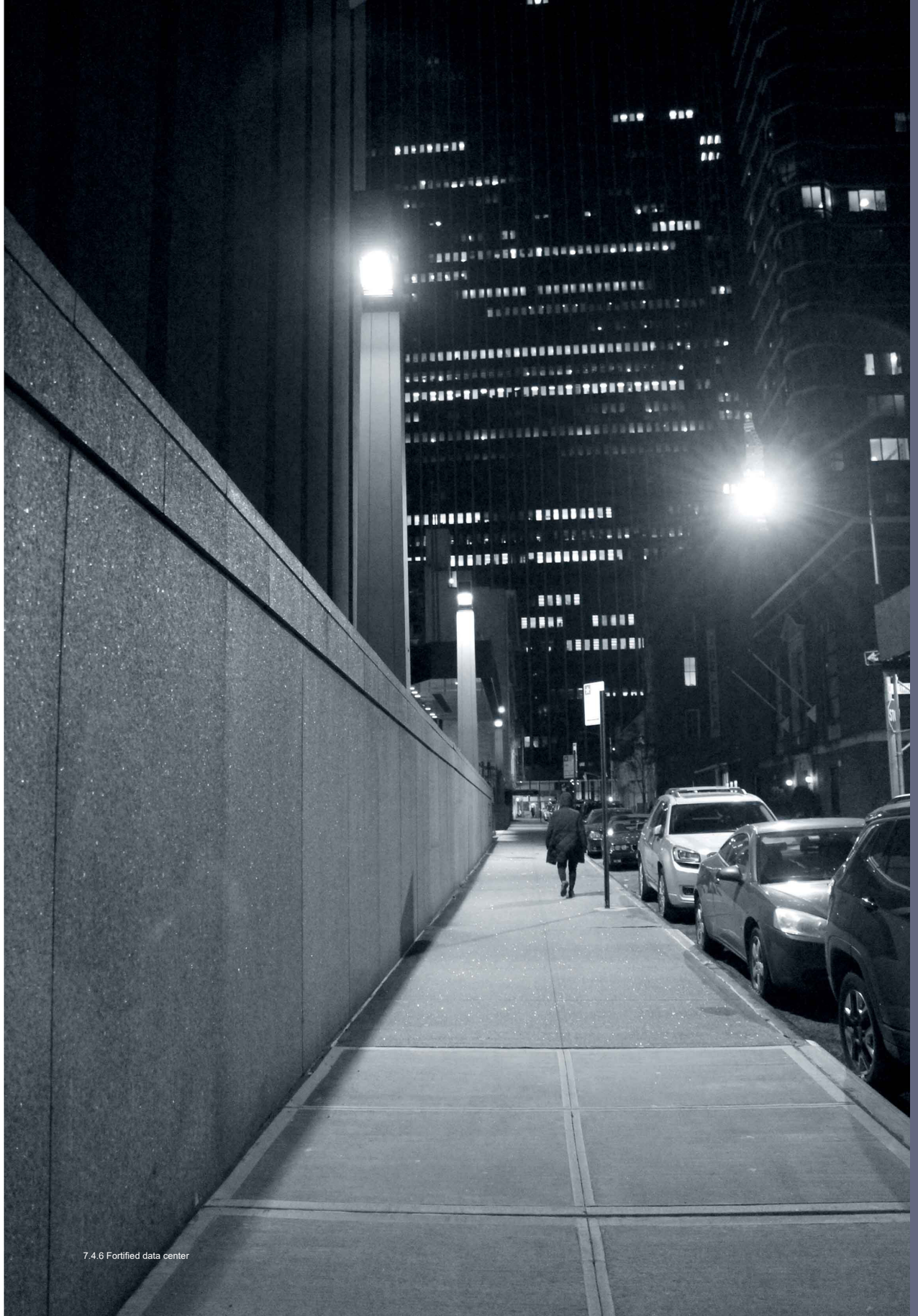
1 Graham McKay, misfits’ architecture: neither art nor artifice. October 19, 2013.
2 Garner, Dwight. He Has Seen the Internet, and It Is Us. June 19, 2012.



7.4.6 Fortified data center

A New Data Hub for Urban Regeneration

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Abstract

The design will focus on developing a new data center typology which could at the same time fulfill the growing demand of data infrastructure in Manhattan central business center and provide positive impact to social life and the environment. Looking into situation in Northeast Midtown Manhattan, an adaptive reuse proposal is adopted to redesign an existing 50-years old office tower, which is 40 stories high and fully vacant at the moment, into a new data center that fit contemporary need. The result will be a future-proof integrated complex with gross floor area of 70 000m² which incorporates function of a data center, office and recreational center. The design aims to position data centers in midtown Manhattan as anchors of smart city developments and harnesses its waste energy to empower social gathering places and creative work environment.

Client

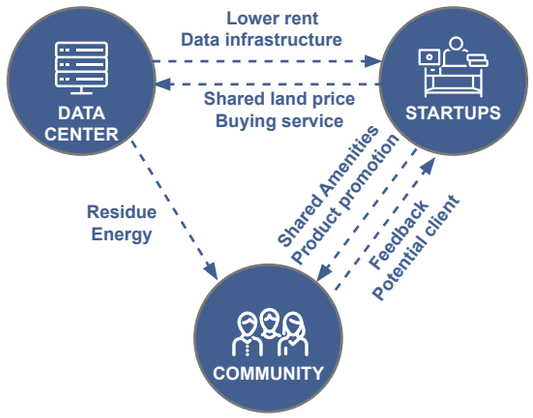
It is common practice for a colocation data center to provide only a rentable secure server space, whereas servers are provided by tenants themselves who need to visit the data center regularly for management and maintenance. Running a data center business alone in a building is not financially sustainable due to high cost of power and high land price especially in midtown Manhattan. On the one hand a data center needs to have extra spare space ready for future expansion, and sufficient tenants to cover its astronomical operation cost on the other, which made the data center business difficult to survive. The monotonous function as a server storage also makes data center a typology for machine that segregates from any human touch and social context. For the project to be viable, economical and public-friendly, mixed-function is proposed to introduce startups office and public amenities into the building on top of the data center.

New York City is renowned to be the Silicon Alley second to the Silicon Valley in San Francisco and such high-tech workforce is concentrated around Midtown NE. This big tech community has attracted 9000 startups in New York City to look for a place to enter midtown. The opportunity now comes since big company is moving out to Hudson yards and downtown for expansion and closer data infrastructure, which leaves space for startups to move in. The challenges for startups to stay in midtown are high office rent and high construction and operation cost for an in-house data facility, which is necessary to support their business's intervention. Contrary to a data center, startups need more interaction with the community to spark innovation and receive feedback, and contrary to the dull public space that are usually found in midtown NE, startups office consists of abundant amenities to boost creativity.

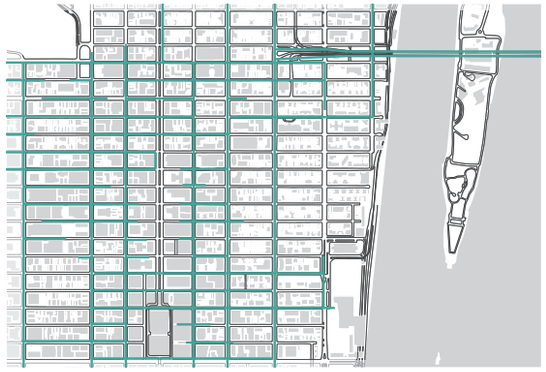
Introducing startups into the building allows a reciprocal relationship to be formed, in which data center provides data infrastructure and low rent office space for multi-tenant startups, and startups office could share the land price and ensure enough clients for the data infrastructure to run. Startups in the data center also complement the segregation of data center from the urban context by fostering dialogue with the community. They could have closer and harmonious relationship with their potential clients if they share amenities with the public. To go one step further data centers can provide residual energy for the neighborhood to benefit.

The project ends up adopting a design that composes of data center, creative office and recreational center.

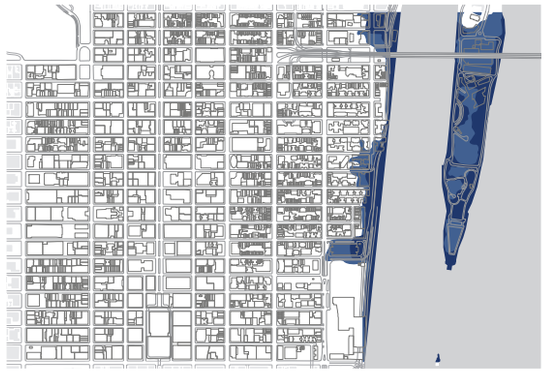
7.4.7 Proposed functions



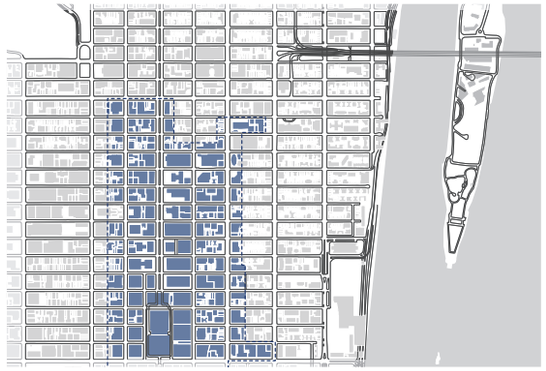
7.4.8 Correlation between clients



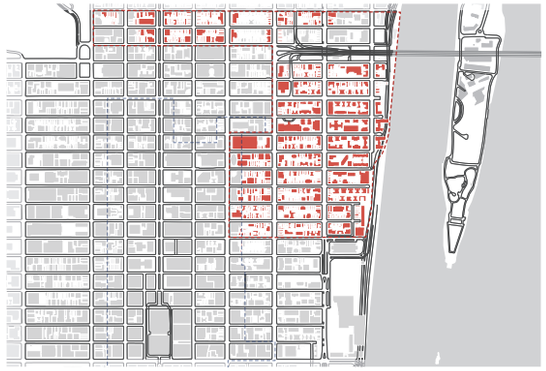
7.4.9 Underground optic fiber network



7.4.10 Flooding zone



7.4.11 Rezoned commerical area



7.4.12 Residential area

Site Location

The project is located at 825 third avenue, which currently consists of a fully vacant office tower and a few low-rise buildings. The site is selected in prior consideration to fulfill all basic criteria for data center location, including high connectivity, low risk of natural disasters, as well as proximity to business and end users. Midtown NE is one of the two areas in Manhattan that consist of the densest optic fiber network underground, whereas low risk of flooding in Midtown NE made it a more favorable place for the next data center in Manhattan. The chosen site is within the new rezoning area, which is envisioned to be a world-class business center and job generator in the future. To serve both business and individual users, the project is with location sandwiched between this rezoned area and the residential district. Although there are other vacant lands and almost-empty buildings within this in-between area, 825 third avenue remains as the most appropriate lot for redevelopment since it is the only empty building that has footprint larger than 1500 m², a minimum area for a server room to be power-efficient according to data center construction standard.

7.4.13 Existing building in the site

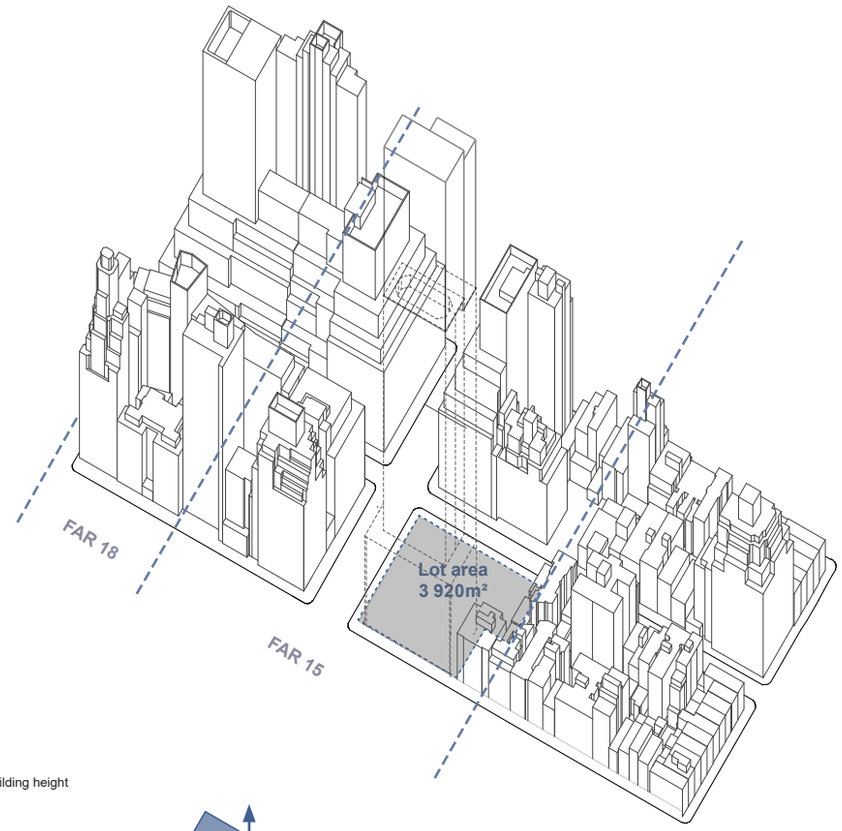
Site Analysis

The existing building in the site is a 40-stories high office building built in 1969. It has been fully vacant since the long-term tenant Advance Publications ended its lease. The design project aims to take this opportunity to renew this old tower with new function to cater the growing need of data infrastructure and serve the community. The existing building consists of a concrete core and floor plates supported by steel columns. Whereas the core will be kept, the floor will be partially removed to allow higher ceiling height for specific new functions and daylight to enter the inner part of the building. The site boundary is extended to include neighboring 4-stories buildings which were built in 1900 and 1926 respectively. They are under city's vision to be demolished and redeveloped into high-rise commercial buildings. The resulting site is with ground area 3920 m². Benefit from the 2017 rezoning plan, the available FAR for the site has increased from 15 to 18, which mean extra floors could be added on the existing building in the site, reaching a maximum of gross floor area 70560 m².

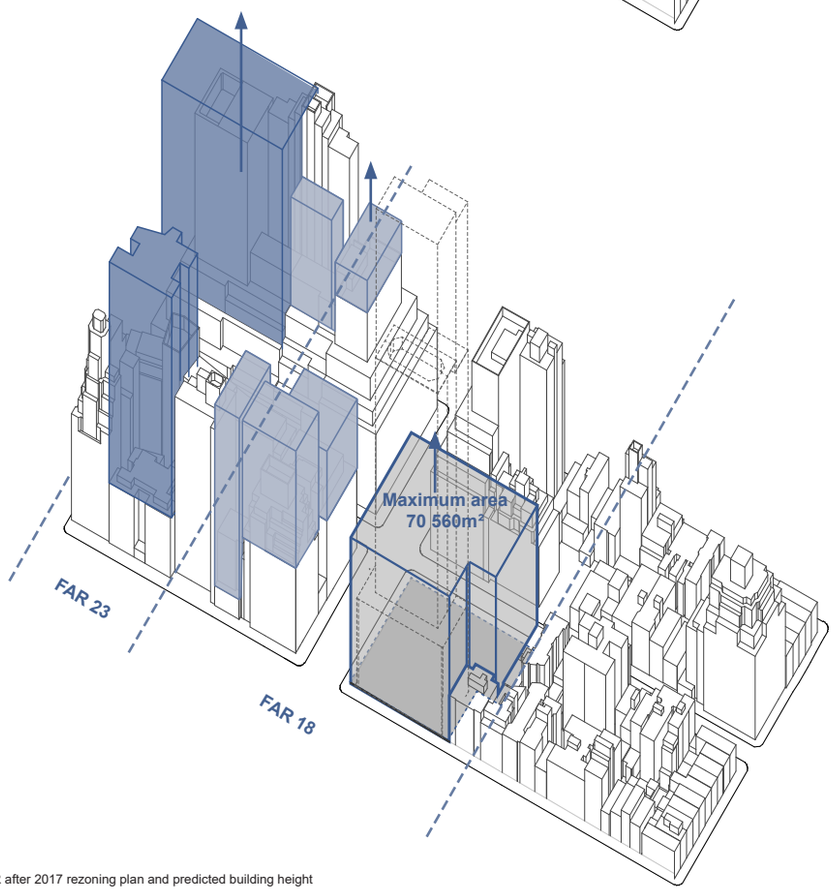
Other than being a favorable location for data infrastructure, the site has several potentials which make it an ideal place for social gathering and recreational use. First it has good public transport network. Within 5 mins walk there are bus stops for East West transits, two subway stations for North-South transits, and within 10 mins walk there is Grand Central Terminal for cross borough transit. Whereas heavy car traffic in north-east direction, pedestrians mostly transits east-west to the subway. Most of the residents in midtown NE work in the central business center. Lying at the intersection between commercial and residential district, 825 third avenue will be an important pit stop for working classes, residents as well as visitors from the nearby subway and train stations.

Across from the site there are two quality privately owned public space. One on the North is an outdoor plaza, Greenacre Park, which was listed in the National Register of Historic Places in 2018. Another one on the South is a covered pedestrian space on the concourse level of 805 Third Avenue. Existed as a pocket park between densely packed buildings and an underground pavilion, these two public spaces are usually unrevealed. The proposed design suggests a set-back and a publicly accessible connection across the lot to link up these two public spaces and make these historical entities more visible from their hidden positions.

7.4.14 Neighboring functions



7.4.15 Existing building height



7.4.16 Allowed FAR after 2017 rezoning plan and predicted building height

General Design Requirement

The data center is composed of complex combination of facility systems and IT systems which require a comprehensive spatial design to cope with its operational requirement. Since data stored in the server are important resource which involve privacy of billions of people and confidential businesses information such as transaction record, it is of first priority for data center to provide a secure server storage environment. As a data center is also a core to possess internet and business activities around the world, it needs to run 24/7 to support worldwide internet activities. There is strict standard and guideline for data center design to achieve high security and power efficiency.

From the entrance behind the fence, there are double access controls to prevent any unauthorized access. It is usually mean a double gate which open one by one to make sure every time there is only one single authorized person could pass through. Another gate is accessed with password or fingerprint scanner before entering server hall, which is the most secure and climate-controlled room. The designed space should be open and unobstructed to facilitate video surveillance over every corner.

For the server hall, the power density and efficiency would be of prior consideration in arranging standard server rack with size 600mmW x 600mmL in 2m high. The standard arrangement is rows of 14 racks, separating alternatively with at least 600mm wide hot and cold aisles. The size of the server hall is suggested to be a multiple of 8m x 10m ideally. Other than packing all space with server racks, spare space should be provided in the data center to support future expansion without reducing the level of redundancy of the critical systems. The server room need to have at least 3 meters ceiling-to-floor height to house the server rack and 1 meter raised floor for putting cooling and power network underneath. Besides, the entrance should be with a 1:12 ramp to facilitate the transportation of heavy equipment or computer when replacement is needed.

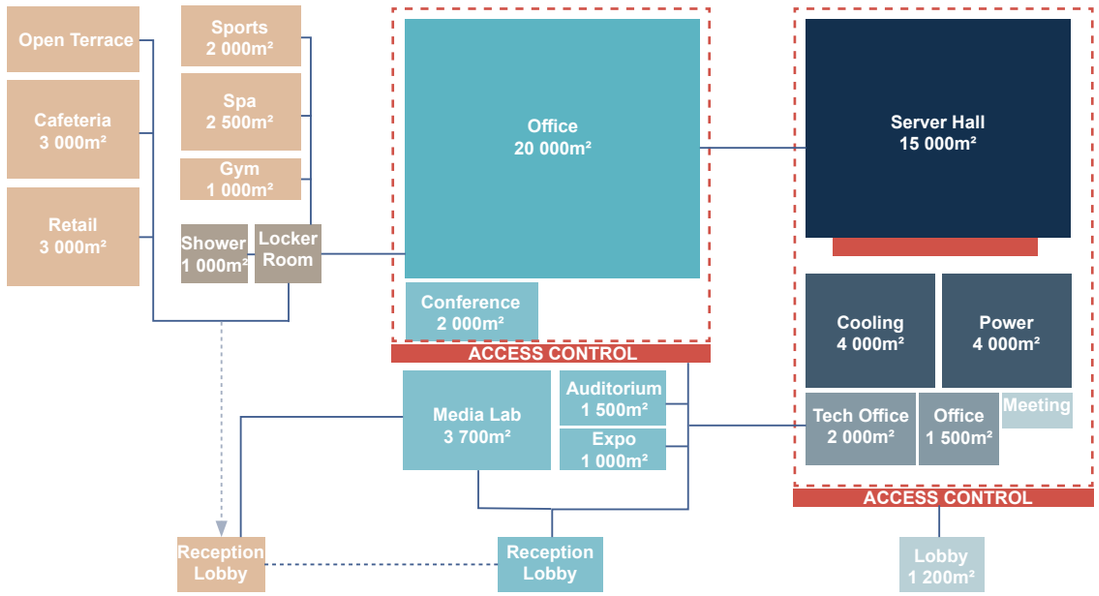
The project targeted startups and medium-size enterprises with employee under 250 people. It aims to act as an incubator for these enterprises to grow and move out when it expands beyond 250 employees, which forms a sustainable ecosystem for newcomers. Taking 7 m² as the standard office space per person, the minimum office space in my building will be ranged from 350 to 1750 m² per company.

Programmatic Organization

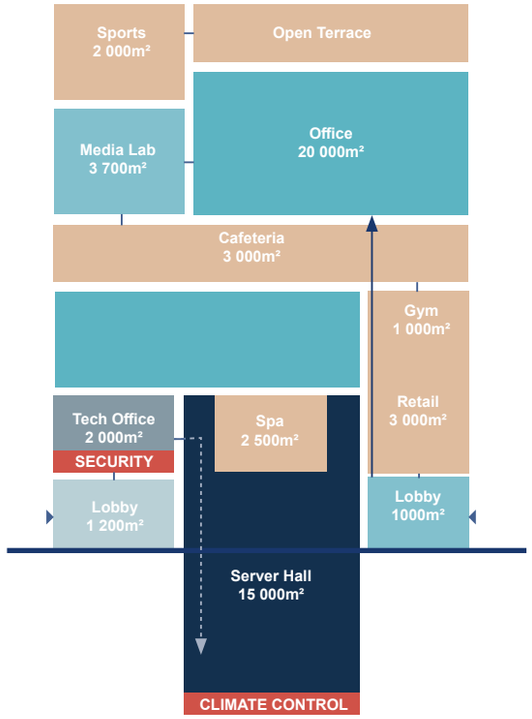
Looking into current data center examples from Manhattan, Sweden, Swiss and China. A trend is concluded that new data centers tend to have less proportioned space for server hall, from 50% of the its total floor area in 2007 to 26% in 2016. More space is allocated for other functions such as communal space and office. Case studies of new tech and co-work office shows that office and communal space is in the ratio of around 2:1. Deduced from the analysis my design adopt a ratio of 40% data center, 40% office for startups and 20% public amenities. It includes office and technical space in data center, communal space within office, and public wellness facility shared among. A detailed breakdown is shown in figure 2, server hall and startup office will occupy the largest portion space. The data center function will be distributed around the core so that residual heat could be used extensively for other functions in the whole building. Since public amenities are shared among with employees from the startup office and data center office, an intertwined programmatic distribution is adopted. Not only the ground floor is opened for public, part of the upper floor is also publicly accessible to introduce high quality public space to the city. Separate entrance and circulation with access controls will be designed respectively for data center officers and the public to ensure the security requirement of the data center could be met within such open and accessible building.

		Area (m²)
DATA CENTER 40%	**Data Center**	**28200**
	Server Hall	15000
	Cooling Equipment	4000
	Power Generator	4000
	Technical Office	2000
	General Office	1500
	Meeting Room	500
	Lobby/ Visitor Center	1200
CREATIVE OFFICE 40%	**Office**	**28200**
	Office space	20000
	Multimedia Lab	3700
	Conference Room	2000
	Auditorium	1500
	Expo/ Workshop	1000
RECREATION 20%	**Recreation**	**14100**
	Cafeteria	3000
	Gym	1000
	Sportsgroud/ Playground	2000
	Spa	2500
	Open Terrace	2000
	Retail	3000
	Lobby	600

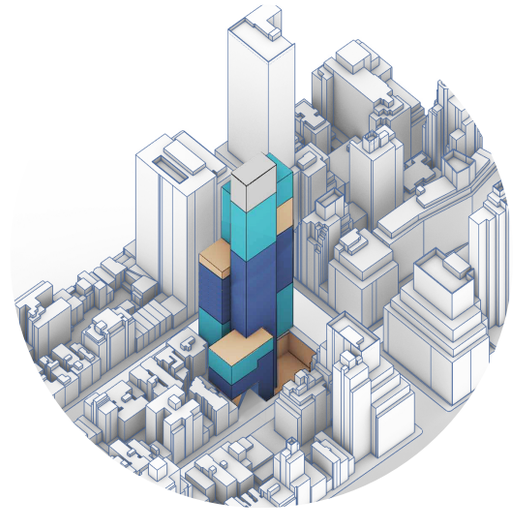
7.4.17 Table of proposed programme area



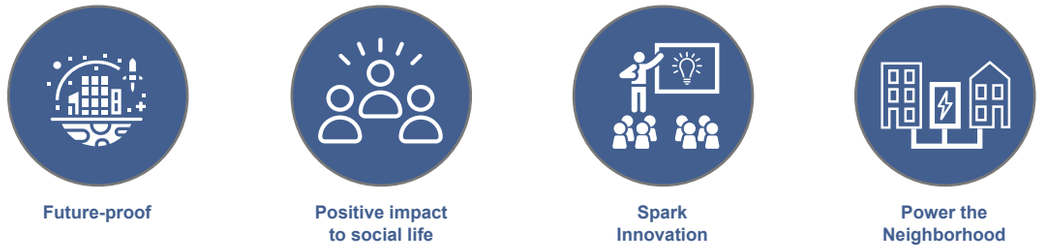
7.4.18 Programmatic organization



7.4.19 Programmatic organization in section



7.4.20 Programmatic distribution



7.4.21 Project goal

Ambition

Different from typical data center design which free itself from constraints of aesthetics and relation with surrounding social context to optimize efficiency in machinery performance, the thesis envisions a new data center typology that caters future need of data infrastructure and at the same time contributes to society through its architecture. The design should position aesthetic and users' experience as equal importance as the utilitarian performance in the data center. As a data center situated in an urban environment, the resulted design will not only be a secure, flexible and scalable data infrastructure that support the smart city development, but also appealing, perforated and welcoming for public use through its mixed-program strategy.

The ambition of the design falls into different aspects. For architecture aspect, the design seeks an innovative solution of adaptive reuse to give the old high-rise building a new life and act as an example for future urban data center design. For social aspect, the design provides critical data infrastructure for tech startups to grow and develop a smart city. It aims also to raise awareness of the physical ramification of our highly connected data-centric lives and reintroduce a human touch back into our digitalized lives. For the environment, the design should harness residual energy to power the community and explore possibility to turn this high energy-consuming typology into an energy-producing resource.

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7.4.22 Conceptual collage