

# I o S<sup>3</sup> : T h e I n t e r n e t O f S p a c e s

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exploration of the human-centered spatial configuration responding to the living changes by the emerging “smart” technology, the internet of things.

By

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## **Abstract**

As the smart era coming along with the pervasive IoT, AI and other smart technologies in the next decade. Society will confront a revolution on the space people live in, the way they are socializing and the way they perceive their living environment, even themselves. Smart space is not merely being intelligentized, but ought to become an interface where the cyberspace and the physical world are merged in to one reality.

Smart Spaces is the agency for occupants to interact with their environment and for them to better understand themselves. By embracing smart technologies in architecture, this thesis explores the possibilities of how people perceive and interact with their living the environment in the Smart Era through three different scales – Solo, Social and Spiritual



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Thank you all.





## 1.1 Timeline of the Smart Technology

*The technologies (includes physical and logical applications in all formats) that are capable to adapt automatically and modify behavior to fit environment, senses things with technology sensors, this providing data to analyze and infer from, drawing conclusions from rules. It also is capable of learning that is using experience to improve performance, anticipating, thinking and reasoning about what to do next, with the ability to self-generate and self-sustain.*

—Smart Technology Definition from

**Regional Development Getting Smarter with ICT**

With the development of computer science from 1980 to 1990, some systems called "intelligent environment" (IE) attempted to create a human being that can interact with each other by embedding sensors and actuators at objects and humans and the physical environment.<sup>5</sup> Enhance everyday activities seamlessly with computing. His goal is to allow computers to participate in people's lives and allow people to interact with computers through gestures, sounds, actions, and more.<sup>6</sup> This is also the source of modern technological ideas such as AI, IoT, neural networks, machine learning, autonomous agents, and human-computer interaction.

Tim Berners-Lee paid attention to the experiment of hyperlink information on a global scale and began to explore the establishment of a network-like system.<sup>7</sup> In 1990 he developed the World Wide Web, extending connectivity from hypertext to hypermedia. In 1991, Mark Weiser introduced ubiquitous computing technology to cybernetic systems, where people can learn beyond the reach of a typical machine using only a keyboard and screen. The first study on smart spaces was conducted in Hashimoto's laboratory in 1996. Lee and H. Hashimoto equipped their rooms with home-made 3D tracking sensors and mobile robots, all of which were connected via a network.<sup>8</sup>

Soon, the system, which consists of the internet and sensors, had broader use in our lives. In 1993, the US government established a GPS through satellite tracking and monitoring of geographic information. More business applications have also seized new possibilities by emerging technology to provide services such as e-commerce sites, search engines and the online auction site eBay. Sergey Brin and Larry Page, the search engine innovators, founded Google to retrieve large amounts of digital data in 1998. In the following year, the phrase "internet of things" was carried out by Kevin Ashton from MIT to describe

A timeline of the confluence and mutual influence between the development of architecture and digi-tech.

MASDAR  
Norman Foster  
2008



DDS (Virtual Amstrad)  
1994



NEUROMANCER  
William Gibson

SUSTAINABLE  
1970S



POPULAR SCIENCE



UNIVERSAL UNITY

1940 Swiss and the Modernist Movement

pleasing  
describes  
to suit h

After emailing, e-commerce, social media and cloud computing, the next generation of the internet is creating a connection among different things and devices- It's called internet of things

proportions devised by the  
 or. Le Corbusier developed the  
 works like the Vitruvian man  
 proportions in the human body  
 ons. To create architectural  
 etically pleasing and also  
 described it as a "range of  
 le-scale-to-human-scale"  
 architecture and its mechanical

of proportions devised by the  
Léonard da Vinci developed  
of works like the  
of mathematical proportions in  
use these proportions he  
as that are both aesthetically  
in well. Léonard da Vinci  
of harmonious measurements  
universally applicable to

the body of the subject that  
and architecture when  
resistant

Architecture evolution always occurs along with the development of technology. Within the digital-era, technologies like communication and digitalization play a vital role in reshaping architecture in terms of form, material, spatial organization, etc. In addition, such technologies render resources structure, capital, channel, labor, distribution, and the way people capture and utilize public space, etc. In this class, therefore, we will discuss how the digital era, as a container of our lives is imperative to respond to the changes in how we live and perform physically, socially, and culturally. The design objectives accordingly are according to the new understanding with the changing people and their behavior. For the human body as an instrument in the Renaissance time, to body as a standard for mass-producing in the modern period, to design for the architecture, emerging technologies, and the digital era, we will inspect and reconsider what we could better design for. If data was the next design objective to fulfill both children's preference and the parents' desire, what would be the next design objective of structure and management of digital tools, how to bring culture and morality into the system? Is nationalism or community identity still necessary?

When speaking to smart architecture, it is commonly thinking of interactive or adaptive architecture which is equipped with various digital sensors and able to respond to its clients and the environment to a certain degree. It appears plausible that the building becomes smart. However, the smartness only attributes to the device, not architecture itself, that doesn't authentically reflect the ongoing changes of our lives. Even though architecture couldn't get away from its materiality, there still may possibilities worthy to explore enabling architecture essentially evolve according to this new digital era and become real "smart".

Figure 1.1 Timeline of Smart Technologies and Changing Notion on Living Environment

a device with an on-off switch that's connected to the internet. The invention of Wi-Fi by Apple Inc. facilitates access to the internet. More and more daily items were connected with the network from the first connected refrigerator by LG Corporation in 2000 to a flurry of smart devices since 2007. For the storage and process of such massive data, Amazon and Google launched their Cloud platform successively in 2006. In 2008, the statistics from Cisco, Inc. indicated the number of connected devices surpasses the number of people. The smart technologies referred at present are a confluence of various techniques based on data storage, transfer, analysis and use, including AI, communication technology (5G,6G), cloud computing, IoT, etc. The world of smart technology is full of imagination, and many objects will become "human."

## Terminology

<b>5G:</b>	the 5th generation mobile network. It will not only interconnect people, but also interconnect and control machines, objects, and devices. It will deliver new levels of performance and efficiency that will empower new user experiences and connect new industries.
<b>IoT:</b>	a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.
<b>AI:</b>	the study of "intelligent agents": any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals.
<b>Cloud Computing:</b>	the on-demand availability of computer system resources, especially data storage and computing power, without direct active management by the user. It is generally used to describe data centers available to many users over the Internet.
<b>Fog Computing:</b>	an architecture that uses edge devices to carry out a substantial amount of computation, storage, communication locally and routed over the internet backbone.
<b>Block Chain:</b>	A blockchain is a decentralized, distributed, and oftentimes public, digital ledger that is used to record transactions across many computers so that any involved record cannot be altered retroactively, without the alteration of all subsequent blocks.

## SMART Architecture

Containing aspects of automation and similarly intelligence is an important aspect of Smart Buildings. Automation in buildings requires "a lot of 'intelligent' devices" and Intelligent Buildings are increasingly using a number of smart devices, materials and sensors.

A dynamic and responsive architecture that provides every occupant with productive, cost effective and environmentally approved conditions through continuous interaction and the interrelation between them.

An Intelligent Building is one that is responsive to the requirements of occupants, organizations and society. It is sustainable and healthy in terms of well-being for the people living and working within it, and functional according to the user.

to be smart is treated as a system of systems, or a set of heterogeneous systems, they each have their autonomous systemic dynamic, but are in dynamic interaction with one another to create a meta-system.

"A subset of smart environments" where smart environments are "able to acquire and apply knowledge about the environment and its inhabitants in order to improve their experience in that environment".

clean, tidy, and well dressed  
(neat, fresh, bright, stylish)  
having or showing a quick-witted intelligence (quick, brisk)  
programmed so as to be capable of some independent action  
informal intelligence/acumen  
liveliness and eagerness

**SMART**

a well-integrated, uniformed space; relieved from objects and multiple furniture and device  
responsive, real-time interactive  
independent, case-to-case, customized  
adaptable, resilient, temporary  
liveable, initiative, participating

Software, IT components, Managing system

Besides environmental var residents should smart an

Environmental

Energy Efficiency, Sustainability and Pollution

.Green

## 1.2 Emergence of Smart City and Architecture

Revolutions in science and technology often lead to a new understanding of our living environment. Urban expands from static to dynamic with the convenience of the internet, IoT, Cloud Computing and Big Data. The concept of a smart city originates from the smart earth officially proposed by IBM in 2008 at the Foreign Relations Council in New York.<sup>9</sup> Its essence is to use modern information technology to promote the inter-connection, efficiency and intelligence of urban operating systems, thereby creating a better life from six different spheres: mobility, governance, economy, environment, living and people.

The emergence of smart cities has quickly aroused a global trend. In 2006, the European Union established a living lab organization that uses advanced information and communication technologies to mobilize "collective intelligence and creativity" in all aspects. In 2009, Dubuque partnered with IBM to become the world's first smart city. More countries such as South Korea, Finland, Canada, China, Sweden, Denmark, and so on are committed to developing smart cities that are more livable, energy saving, environmental protection and efficient management.<sup>10</sup>

The initial application of smart architecture promoted the formation of communication networks so that occupants can interact with the system with a simple interface. Smart buildings use technological way to improve building conditions and functions, thereby improving the living environment and monitoring costs. Early smart building concepts meant automation rather than intelligence. With the rise of smart technology, people hope that smart buildings can provide more humanized services and turn optimized environmental data into living data and psychological data that satisfy residents.

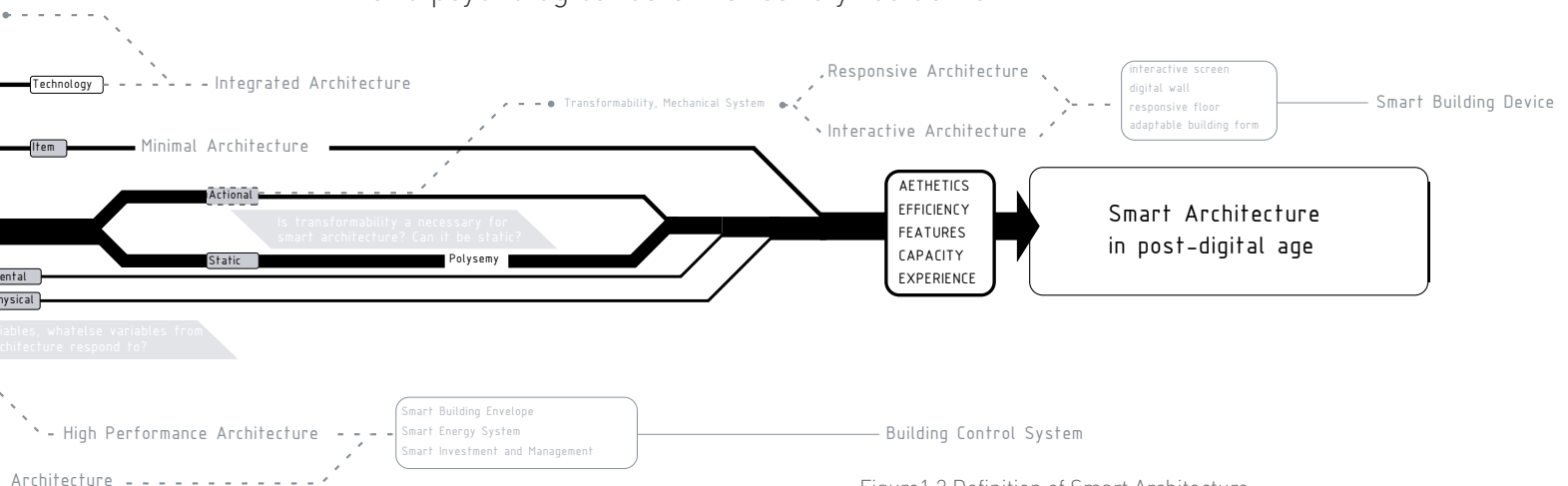


Figure1.2 Definition of Smart Architecture

### 1.3 Smart Life and Urban Scenes

According to the infographics, It is marvellous to realize that 90% of data throughout the entire human history were generated over the last two years. The digital device has become indispensable in post-modern life, helping people to receive and generate numerous data through the internet.

- **Extensive Information**

One obvious symbol of the digital era is that the internet connects human lives with the interaction of digital information, eliminating the constraints of time and space. Instant messenger has improved the efficiency of communication, allowing people to instantly share and comment moments or collaborate remotely for work or study. Undeniably, extensive digitalization has brought benefits in education, business, governing, global cooperation, etc. It is like a flattened world where all sorts of information can be undifferentiated accessed.<sup>12</sup> Initially, the perceived smart life means each individual could gain more knowledge than ever, regardless of his background or social position.

- **Effective Information**

Data scientists have deepened the understanding of smart life recently, which concentrates on the extraction and utilization of useful information rather than merely the quantity of data. With the maturity of AI technologies and big database, sophisticated algorithms can also be leveraged to analyze user data and predict user preference. For instance, Amazon and YouTube apply AI models to calculate user recommendations based on collected user data. Another example is Tiktok, a smartphone application providing short videos made by its amateur users, which has rapidly become popular among teens all over the world by circulating videos to each accordingly. People called this the second phase of the digital age.<sup>13</sup>

- **Digital vs. Real**

As it comes close to the limits of Moore's Law and new computation methods emerges, smart technology is then reaching deeper into every aspect of people's lives.<sup>14</sup> Gradually the boundary between the cyber world and reality is blurred. The virtual information network is like another invisible layer juxtaposition on our living space. Through GoogleMap, people can optimize their travel routes with fewer shifts and fast arrivals. The launch of PokemonGo in 2016 immediately caused a global



phenomenon that an incredible amount of people surged onto the street to catch their pokemon, changing the way we perceive our surroundings and enriching our entertainment. Technology like virtual reality and augmented reality strengthen the connection between virtuality and physicality. The implementation of smart technologies does not change the built structure of the city, but the human topography shifted dramatically based on the added “invisible” layers on the city.<sup>15</sup>

- **Shared Lifestyle**

The reliance upon the internet substitutes the dependence on physical objects. Digital books, online music are exact pieces of evidence of this transformation. Also, the popularity of electronic currency facilitates this trend. Another example would be the emerging shared lifestyle. Car2go, shared bikes are commonly seen in modern cities. People also share their houses through Airbnb, Booking. This shared mode is based on cloud platforms where information is highly integrated and intelligently distributed among users. The notion of using specific services rather than possessing corresponding objects has been widely accepted by the public.

- **IoT Phenomenon**

Along with the development of smartphones, smart devices such as glasses, speakers, users are able to manage their belongings without physical contact. This demonstrates a direct effect from the mobile network to the physical world. IoT is regarded as the third phase of the digital era. The connected objects record the information and habits of the users through sensors and transmit the data through network sharing. And then this data is analyzed and processed by artificial intelligence algorithm before being fed back to related devices. Whether in the NBA or Manchester United, players will wear smart belts to record body functions to improve training efficiency. In cities of China, neighbourhood committees use smart furniture to prevent indoor risks of single elders of amnesia such as gas leaks and unlocked doors. In fact, the impact that IoT brings to life is more than this. When the ubiquitous smart era of the IoT arrives, there must appear a revolutionary cityscape beyond we can predict today.

- **Information Safety**

The function of the IoT depends on the collection and transfer of data. But now people are getting uneasy about sharing private information. Security concern has become one of the biggest problems for the development of smart cities and

buildings. The anxiety mainly comes from the distrusted data collection of third parties, fears of severe outflows and illegal exploitation. Again, the modern society is in a sensitive period of transition from post-industrial society to the information society. It is crucial for people to be able to value personal data in the information age, which will help introduce new management policies regarding the collection and use of information. But it is also important that excessive resistance to the collection of information which is not conducive to social development and civilization. It should be known that there is no essential difference between invisible information data and visible biological information. It is worth noticing that Information such as expressions, heights are also exposed without reservation. In addition, when everyone's living habits, and other information are collected in the form of data, then usually these are only considered as a cluster of data rather than individual's feature. In order to avoid leakage and abuse of big data, the government should establish a collective database to prevent most personal data from being monopolized by a company, or restrict technology companies to read metadata directly and only indirectly use the results of calculation and analysis to characterize minimized aggression against a person. Indeed, respect and protection of each individual require the concerted efforts of all parties in the society. At the same time, users also need to gradually get used to the exchange and circulation of data. It is important to remember that people have the right to choose whether to get the services they need by providing their own data, whether now or in the future.

From interconnection to digitalization and then to effectively integrate and utilize digital information, smart life has also evolved from time to time. The goal of smart living is to be efficient, instant, and convenience in terms of satisfying emerging desires, multi-aspects management and energy saving. . When every person generates uncountable data according to their unpredictable needs, how does our living environment accommodate to these emerging needs is the essence of how we think of smartness.

- Quayside Toronto, by Sidewalk Labs

The Sidewalk Toronto is an experimental proposal for a smart community led by Sidewalk Labs(a Google affiliate) partnering with Waterfront Toronto on a 12-acre site east of downtown. It entitled as "the first neighbourhood built from the internet up." The embedded model is an interactive platform, including a suite of proprietary products: Waymo (autonomous vehicles), Flow (transportation planning), Waze (traffic data), Cityblock(social-service delivery), LinkNYC (public Wi-Fi), and Nest (thermostats, outdoor security cameras).<sup>16</sup> The envisioned neighbourhood be populated by a cluster of passive buildings

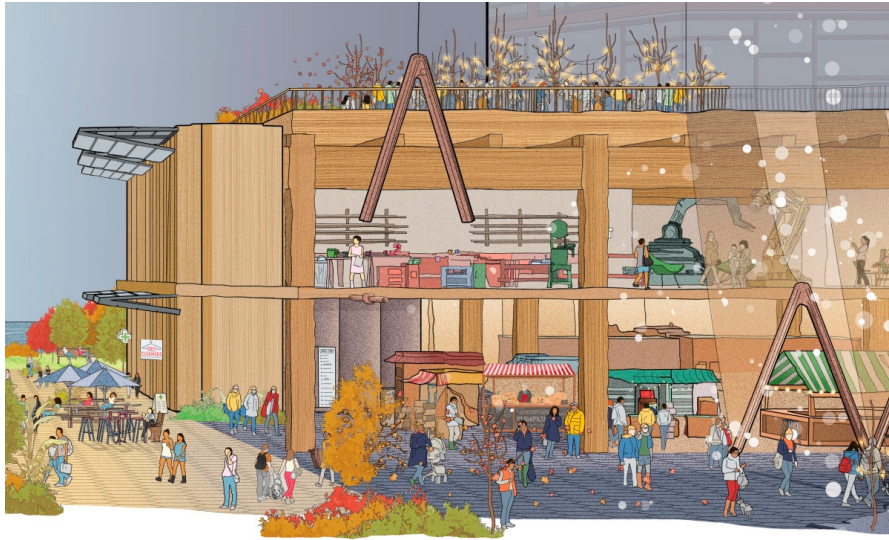


Figure 1.3.1 A scenario of the flexible "Loft" building type. from Sidewalk Labs Toronto

with each member being monitored digitally for their misfunction and durability, and a modular tower. A "Loft" building with ultra flexibility for accommodating changeable programs within.

Besides, this project would be plugged into a "microgrid" for fueling electric vehicles. The application of photovoltaic roof and façade coverings would result in a reduction in load on the Toronto Hydro electric grid by 75% per capita versus existing conditions. This microgrid system would be joined by a thermal grid that can turn surplus energy into heat and cooling power. For the extreme weather in Toronto, heated paths for bike and pedestrian could be used to melt snow in winter. New material like ethylene tetrafluoroethylene (ETFE) plastics along with traditional canopies would be used for sheltering public spaces. As a result, the combined weather mitigation methods could create an additional 2,767 hours of comfortable outdoor conditions on Toronto's waterfront per year.<sup>17</sup>

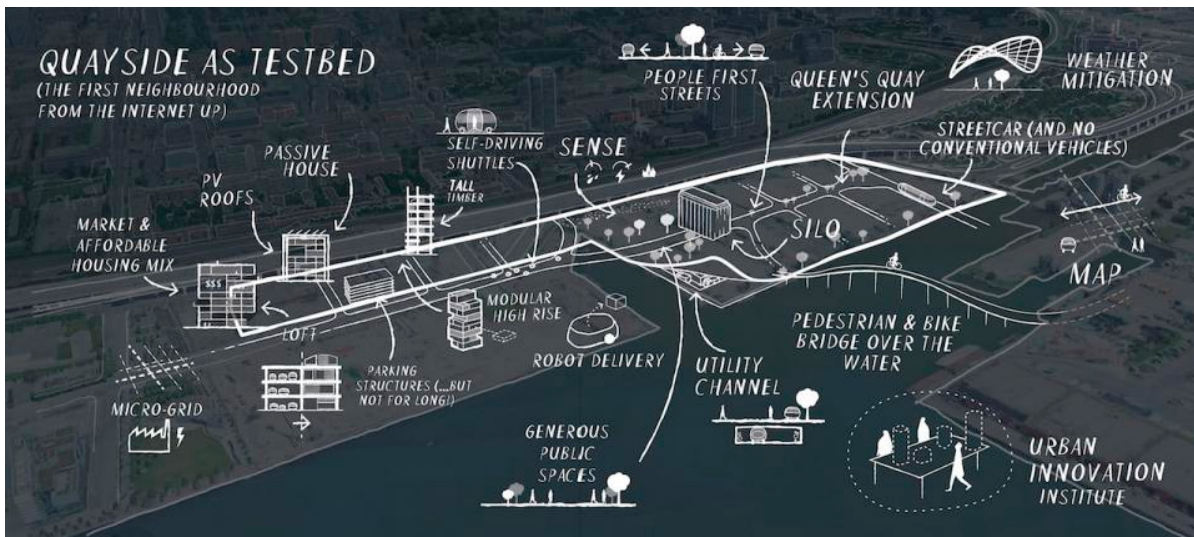


Figure 1.3.2 A notional map of the Quayside neighbourhood, from Sidewalk Labs Toronto

Dan Doctoroff, chief executive of Sidewalk Labs, made an analogy between a mobile phone and a smart city, saying “What made ultimately magical is that it (smartphone) enabled millions of people around the world to use their imagination and skills to create apps that, in most cases, no one ever dreamed the platform would be used for and keep it fresh, changing, useful, and current.” It is a promising model for a smart community. However, concerns about the privacy of residents' data and regulation policies aroused a hot debate. In 2018, a privacy expert resigned as an advisor of Sidewalk Labs, worrying about the reliability of data collection and storage. “It is clear evidence that we don't have the proper regulatory infrastructure to deal with these new smart city initiatives.” said by Fenwick McKelvey, associate professor in communication studies.<sup>18</sup> Nevertheless, Sidewalk Labs announced an expedient that ‘urban data’ should be under the control of an independent civic data trust. And it will completely remove personal identifiers from all data.

•Beijing Daxing International Airport, Zaha Hadid Architects, ADPI, BIAD

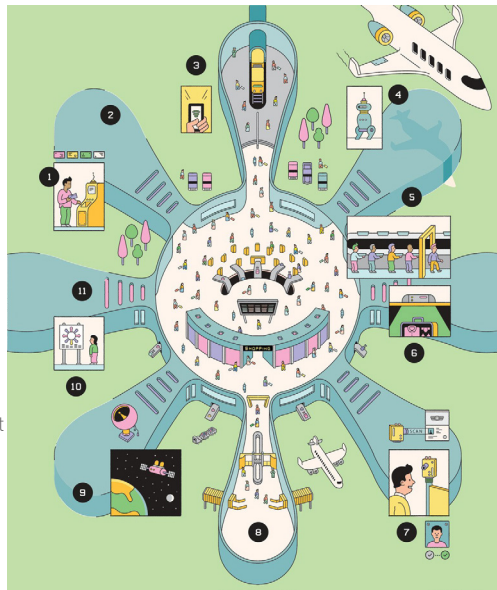


Figure 1.3.3 Follow the Robot in the Airport of the Future, WIRED (Left);

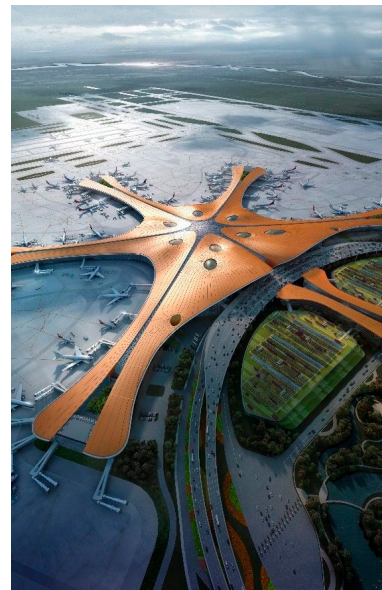


Figure 1.3.4 Daxing Airport top rendering, Zaha Hadid Architects (Right)

Currently, as the world's largest airport designed in 2014 and put in to use in 2019, this epoch-making airport integrated various emerging smart technologies, including self-service check-in kiosks, biometric scanners, luggage tracking, smart security checks to streamline the process of boarding with 40% faster than traditional way. Luggage information will be electronically stored in the tags which allows the passengers to track or transfer their luggages through apps on a smartphone. 5G and interactive LED art screens are embedded inside, providing instantaneous access to the digital world. It also incorporates five traditional Chinese gardens with interactive seating to enrich the experience of staying at an airport.<sup>19</sup> Artificial intelligence-powered smart robots work along with



airport workers and accumulate learning experience with data collecting. Robots in combination of Smart Parking system will also be used for automatic parking and vehicle pick-up which operating as an app with real-time mapping and traffic information for drivers.<sup>20</sup>

Sustainable design strategies such as passive design and active control system are the foremost approach for architecture design. Monolithic interior space and cut-through skylights provide natural light and ventilation everywhere inside. Besides, Daxing Airport has planned a synthesized smart traffic system of the subway, shuttle bus, private cars to enhance the accessibility and speed from Beijing city. The Airport Expressway pavement has used a compound of "anti-icing" materials and asphalt to ensure vehicles run at high speed with high security all year round.<sup>21</sup>

A smart management system (comprehensive monitoring system, big data intelligent analysis, simulation deduction, and electronic sandboxes) and Internet Charging system are the innovative smart technologies applied on the Expressway. Also, a smart streetlight system was set along the road, that each light enables to adjust its illuminance according to the environment.<sup>22</sup>

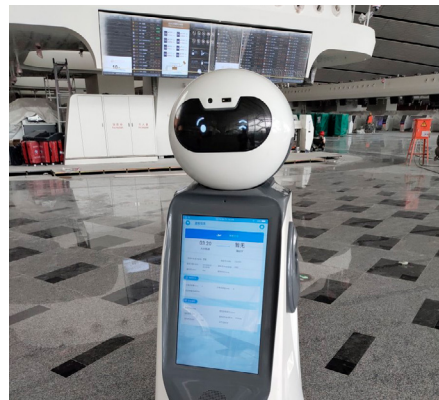


Figure 1.3.5 Daxing Airport interior rendering, by Zaha Hadid Architects

Figure 1.3.6 Self-check in, from ChinaDaily

Figure 1.3.7 Robot in service, from the Beijinger

## 1.4 Design Objectives

Talking about smart city projects, Green Field complaint that developers tend to focus more on the requirements from companies, public authorities, regulators, and a few NOGs as the major stakeholders. However, the actual needs of the residents are absent. Same misconception can be found in modern smart architecture projects where techniques and cost efficiency are the dominating aspects throughout the design phase. According to Stevan Dedidjer, residents are the producers and receivers of information. They are also the ones that choose which equipment to use in the smart architecture. Hence, prioritizing residents as the core of smart cities plays a critical role in the success of modeling.

- **Residents**

Architecture, essentially, is the container of people's lives. Meeting the needs of its residents is the foremost objective of architecture. However, lacking concerns about the residents' lives in most architecture projects in modern times results in many complaints from the irreconcilable contradictions of residents' living habits and the behavior patterns preset by the architects. Smart architecture should induce people to naturally integrate into the space rather than deliberately ask them to adapt to rigid spaces with embedded smart devices. In the theory of a post-humanist subject, individuals are believed to be influenced by objects such as space, architecture and art. The object and subject are no longer separate entities. Blindly applying cloud computing and electronic Internet of Things (IoT) technologies while constructing smart architecture might end up being a burden of all residents. Therefore, it is smart and necessary to create a more harmonious relationship between the space and residents and to promote a constant dialogue between life and architecture. In order to fulfill the needs of residents, the current spatial organization needs to be optimized and resilient enough to support further integration with smart appliances and their emerging living patterns.

- **Cyborg**

It is also important to note that the residents as the objective for smart architecture are not the exact term of "resident" in tradition. As W.Mitchell stated in 2003, "we are all Cyborgs now," indicating the fact that smart technologies have become part of our physical body. The most obvious instance is the smartphone, which can be treated as an extended human

capacity with implanted mechanical devices in one's body. Along with face recognition, sound control, body presence detection, these technologies become part of our own capacity, and also being regarded as the extension of our own biological feature. The smart technology generates new collective physical couplings and a reciprocal projection of one's subjectivity between the digital and physical world. "Architects and urbanists must begin by re-theorizing the body in space" reminded by Mitchell. For acknowledging the cyborg condition of most residents, it realizes the borders between part animal and human, human beings and machine, nature and artificial, physical and immaterial are dissolving.

## 1.5 Summary

A broad connection is a hallmark of smart living. IoT, which adds the 3rd dimension to the internet, projects an extensive network from virtual space into the physical world through intelligentized objects. It enhances the interoperability between humans, humans and objects, and even between objects in the real world. By then, everyone can access a more comprehensive network of information, a broader social network, and can also establish long-term connections with cultures and elusive emotions.

The extensive connection will blur the boundaries of living, socializing, work, and entertainment of modern life, and will allow activities to take place beyond the constraints of time and place. The location and method of organizing a specific event are no longer sole but diverse, which leads to more possibilities and interestingness. However, in 2015, Eric Schmidt, the director of Google, stated: "technologies with far-reaching effects are those that have disappeared." -When people criticized smart technology, it shows a split and opposite relationship between people and technology, technology and the. Therefore, in the smart era, intelligent devices will further be integrated into our cities. People will use their functions and services without consciousness.



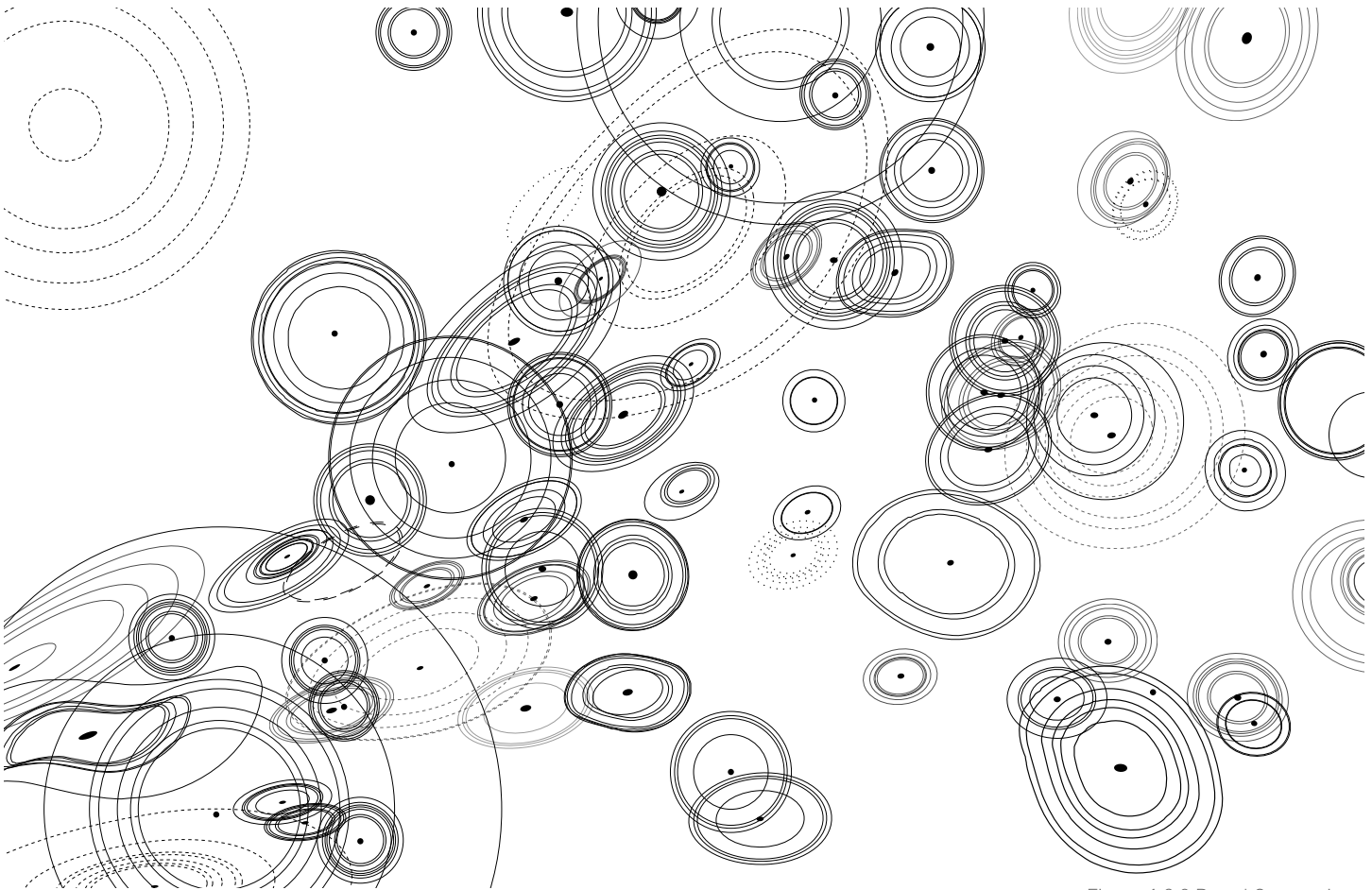


Figure 1.3.8 Broad Connection

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## 2.1 Future Scenes

With the rapid development of technology, our lives are changing at an alarming rate. Although smart furniture, smart room, smart transportation and other products have come out, it is still the beginning of what ubiquitous "smart". When the application of the IoT and AI has covered all aspects of life, there must be more essential changes in our lives. Now it is possible to envision how to live in the smart era through the analysis of scientific and technological theories and empirical reflection on the current social development.

- Post-digital Era

With advanced AI research, the application of the IoT and 5G technologies, it is not difficult to foresee a comprehensive smart living environment. It is speculated that in 2020, the use of AI will change the livelihood of people and bring stunning changes in economic structure. In 2025, AI will be widely popularized to drive industrial upgrading. The city will achieve the intelligence of the entire life cycle from planning, construction, management, and operation in 2030.<sup>1</sup> With a large number of data statistics, the perception and collection of ground information, the centralized processing of various information and rapid semantic analysis, an extensive shared database will be formed in the city. Meanwhile, multimedia will also be used more in-depth due to the abundance of data. Shortly, it will undoubtedly be an era featured by the coexistence of personal computers and intelligence. Technology perception, rational learning, AI and human experience judgments will form a brand new decision system to achieve a consistent and reasonable optimal combination of decisions. Reality and imagination will be more deeply intertwined in this digital age.<sup>3</sup>

- Work in the Future

The pessimist believes that smart technologies will eventually cause large numbers of unemployment. The society will be unstable with a larger gap between the rich and the poor. But the impact of the traditional social structure caused by a new city model is inevitable. New work systems, labor redistribution, and extensive coverage of social welfare will follow. In the next 30 years, the labor-based work industry will indeed be replaced by machinery and equipment, and the basic service industry will be provided by the IoT and AI.<sup>8</sup> The exploration and application of new technologies will continue to require more outstanding talents; education and creativity will become more

diverse and popular in terms of content and communication forms; culture and entertainment will become industries that require a large number of people to participate. Not to mention that these smart technologies and the new urban environment will bring more unpredictable job types and needs.<sup>9</sup> The obvious trend is the emerging Vlogger and Youtuber, who use the online platform to earn money by creating and sharing their own content. In the future, the types and methods of work will become very flexible, and people's ability to work will become more adaptive than ever. In addition, when the extensive use of intelligence makes social resources excessive, it is no longer important to work or not. If everyone needs to work less time and engage in more effective work content, then there will be more time to rest and entertain and enjoy their lives.

- AV and Integrated Transportation

AV (automatic vehicle) is one of the most prominent features of future cities. The high permeability rate of AV will increase the utilization of roads, thereby solving traffic congestion. This will further reduce the width and numbers of the streets in general. Apart from that, the high utilization rate of the network formed by people, vehicles, urban facilities and energy resource will eliminate the insatiable need for parking lots, bus stops and dispatch centers. At the same time, passengers can use AI to analyze real-time data and allocate vehicles to achieve boarding at any time and place, and smoothly transfer among a variety of transportation modes. This also illustrates that future cities are full of dynamic vehicles and people moving all the time. In addition to efficiency, IoT can also provide sufficient safety for pedestrians. All transportation can be tracked in real-time so that citizens can use not only common AVs, subways, bicycles, but also a high-speed rail, maglev trains and unmanned aerial vehicles in the city.

- Instant Consumption

Another feature of future cities is that the consumption pattern will be fully electronic. Even at present, all payments can be made through smartphones regardless of the products. Also, the rise of second-hand trading platforms indicates that someone has entered a new period of fast and instant consumption. If all goods can be connected to the Internet and personal identity, then the transaction behavior does not need to be so concrete and obvious. In the future, the consumption pattern may be that customers can directly take away the products

may be that customers can directly take away the products they want, and the cost is calculated based on the number of uses and the time they own them. This type of pay-as-you-use model ends after a certain period of time, or after products are deemed to be purchased or replaced by the users. One principle of this model is that second-hand users will be charged at a lower cost, which is equivalent to using second-hand products in the current consumption model. This demonstrates the association of commodity interconnection to people's consumption behavior under the sharing model. Eventually, the consumption relationship between people is no longer simply customer and supplier. The reliance on substance will become further reduced, and newly generated desire can be satisfied instantly.



Figure 2.1.1 Amazon Go Self-Checkout Scene, Shara Tibken/CNET

- Wall-less City

With the Internet of Everything(IoE), fingerprint recognition, face scanning, voice recognition and other technologies will eventually replace the importance of mobile phones. Private information such as human identity, credit history, funds and additional information can be collected with their biological information instead of bulky devices. Stores no longer need glass windows to secure the merchandise against non-buyers. Likewise, house owners also do not need to have physical access controls to manage occupants. Specifically, people without the right of access will not be physically blocked. However, their information will be tracked, and they will potentially be dismissed by security guards. When the access management facilities are digitized, the urban space will be significantly opened. It is not hard to predict that future cities will have a broader vision and a freer scene. In general, smart technology will increase the utilization of urban space and equipment. As a result, there will be a lot of excess metropolitan areas in the future. High-rise apartments may occupy these spaces to accommodate the

growing urban population, or they may become places for residents, children to socialize, watch, play, or add more natural spaces for future cities to promote humanity and nature.

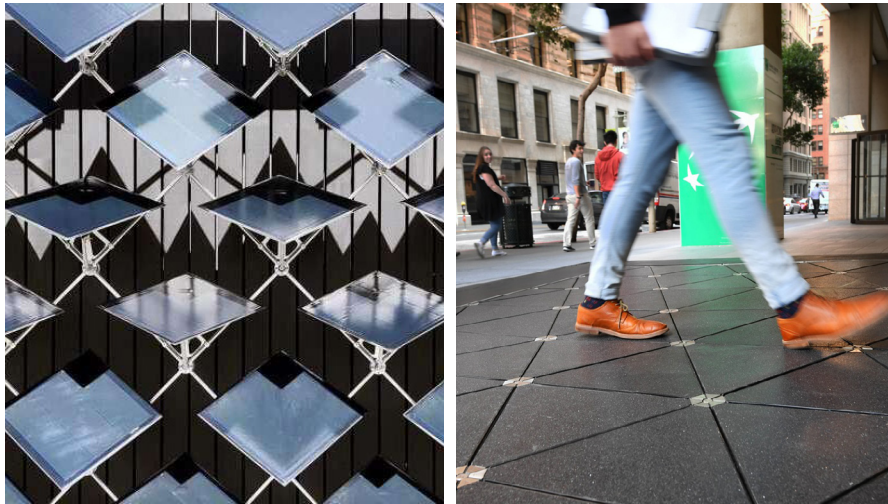
- Overcapacity

On the other hand, smart cities must also be sustainable and wise in their energy use and pollution emission control. In addition to the IoT and the storage of environmental data, the energy consumption of urban equipment can be adjusted instantly according to the environment and needs, and the comprehensive networking of the infrastructure can also enable each device to regenerate energy. For example, pavement that converts road vibrations into electricity, or every building skins that collect rain and solar energy.

Figure 2.1.2 & 2.1.3,

(left) A solar façade developed at ETH Zurich, / ETH Zurich

(right) Sidewalk generates energy when people step on, by Laurence Kemball-Cook, UK, photo/ Cortesia de Pavegen



Smart cities are based on the Internet and the IoT. One of the main characteristics of the experience is the spread of digital network in urban spaces. In the technology saturated daily lives, the way of human existence and social interaction are transformed at the junction of electronic communication and material interaction. This creates certain fluidity, which does not belong to any space, institution or group. And it is perceived as a "liminal condition," which is ambiguous and uncertain. When new possibilities in the cities of the future bring us an imagination of endlessly beautiful lives, there will also be as many social problems emerging.<sup>11</sup> Concerns about the security of network information, the anxiety of personal privacy, and higher-technology crimes all require more comprehensive collaboration between technologies and policies to prevent. It takes time for our society to resolve the tension brought by emerging technologies which always challenge the existing condition.

## 2.2 Domestic Life

For domestic life, the most intuitive manifestation of intelligence is that the needs of daily life can be satisfied instantly, and the flow of different indoor activities is smoothed to improve comfort and efficiency. The current popular smart home devices are optimized for smooth and coherent use of features. For example, with the opening of the smart door, the lights, heating, and audio in the room will be automatically turned on with the arrival of the occupants. In the future, users can also set different function modes to enable different home devices to serve specific scenarios. Nakajima et al. also says people will change the way they live with those attractive smart surroundings.<sup>12</sup>

- Customization

With the ability to download new data and information through the Internet at high speed to meet the different needs of residents, smart devices make indoor space more personalized and customized in terms of atmosphere, visuals, and functions. Just like smart lights can adjust the color according to the mood of people, smart speakers such as Hompot can change the type of music with instructions. As shown in the black mirror and white Christmas episodes, the resident will wake up with the alarm clock, and the bathroom will adjust the mirror lights, water temperature, bread toast, and the electronic calendar will report the schedule of the day. These customized arrangements can be set according to different households and habits to diversify and customize domestic life.



Figure 2.2.1 Smart Home Scene, screenshot/ Black Mirror

- Liberation from Objects

If the Internet of Things links every household item, their functions are highly integrated. The number of devices people need to meet a particular function is drastically reduced.



For example, smart audio integrates functions such as radio, thermometer, calendar, cd player, etc. Smart dining tables can also integrate refrigerators, dishwashers, microwaves, stoves, etc. into one. In the future, more and more residents' functional needs will be met through the linkage of a few smart objects. In the end, the indoor space is no longer a place to store household items that have to be used for functional needs, but to give more space to the residents. Residents will also be freed from the rule of objects, so as to truly enjoy a better family life.

- Integrated Indoor Space

According to the above speculation, the future indoor space will become more uncomplicated but more comfortable. Minimalism and flexibility will be a prerequisite for future space. Only an unpreset space can return more possibility of space shaping to the residents themselves. This user-centred indoor space makes people more actively participate in domestic life, which will largely solve the dissatisfaction of their living area among residents.

- Function Redivision between Domesticity and City

Future domestic life also reflects the trend of overall smart living. The concept of shared life and electronic consumer platforms allow for better integration of functions throughout the city. The trend of takeaways and light meals heralds structural changes in people's diets in the future. Therefore, citizens will be less and less willing to spend time on diet. When the city's catering services can quickly spread to the surrounding residents, the indoor kitchen can be minimized. Similarly, urban laundry, urban library, and community activity centers can replace many indoor spaces such as bathrooms, study rooms, and entertainment rooms. Smart cities can more intensively integrate resources and energy to provide better services to more residents.

- Pluralism

Although electronics and IoT can greatly reduce people's reliance on objects, it does not mean that humans will completely get rid of materiality in future life. As long as human beings still physically occupy time and space, the object is the essential substance that we can manipulate. In fact, apart from materials that cannot be reduced, such as food, clothing, and transportation, human beings have a deep emotional attachment to objects. Although books are widely digitized, paper books are still the choice of many readers. Likewise, painting

can also be presented through projection, but real paintings can bring deeper emotional connections.<sup>13</sup> Therefore, in the future home, there is a scene where virtual and reality coexist, electronics and physical coexist, and high technology and unsophistication coexist. The smart home space can be seen as an externalization of the resident's inner world. Space reveals the resident's hobbies, interests and personal experiences. Overall, home is the place to accommodate and cultivate oneself. Smart technology brings more possibilities for people to live, rather than an imperative replacement. In the future, people will also live in diversified lifestyles. Some people like to pursue a more advanced living experience, while others prefer the traditional simple living mode. The smart era is all about satisfying different people's pursuit of different needs.<sup>14</sup> In domestic life, return the imagination of residence to the residents.



Figure 2.2.2 An illustration of smart domestic life

## 2.3 Social Life

Social life is an essential part of urban life in the near future. Both technologists and urbanists emphasize a lot on the connection between different social groups. The goal is to promote social exchanges and social integration so that the overall satisfaction of residents will be improved. Social communication is not just a relaxing way of entertainment, and it also covers work, study, innovation, culture, business activities, and so on. Frequent and diverse communication is essential for the formation of a positive, open and equal civilized society.<sup>15</sup>

- Transformation of Online Social

Some scholars believe that in the post-digital era, humans are becoming no longer social animals, but animal of multi-task. Meanwhile, the objectives of online social have become more utilitarian than before. Tweets and online opinions have become an addictive tool that can satisfy gossip, vanity, and voyeurism.<sup>16</sup> Although We-media allows everyone to express online, the quality of information has dropped significantly. The indicators that measure the quality of the content become page views, and the quantity of likes and comments. Honestly, this shows that online social is getting more and more superficial.<sup>17</sup> However, with the advancement of communication technology, online social content is transforming from text to pictures, video and even multimedia projection in the future. This allows future online social to promote and encourage the release and circulation of media with high-quality content and will eventually improve the online platform.

- Increased Real-Confrontation

Although through the Internet and smartphones, social interaction with family and friends can happen regardless of the occasion. This kind of socialization is mostly among acquaintances or people with a certain level of mutual trust.<sup>18</sup> However, in a broad sense of social intercourse, random communication with strangers is a must-have. For instance, greeting with unfamiliar passers-by on a roadside seat or social interaction at these unpredictable times, places, and objects can build trust in the community and the city, resulting in a sense of belonging and happiness. Many mobile applications also consider the virtual information exchange with strangers, but it is difficult for people to have trust and synaesthesia without judging and preliminary understanding of each other through biological

characteristics, expressions and tone.<sup>19</sup> Also, there are psychological studies which show that this "non-embedded" social activities would likely make people feel more lonely while staying in touch with others.<sup>20</sup> Evidence suggests that a large amount of loneliness comes from the long-term social and physical isolation, thereby exacerbating the social isolation effect.<sup>21</sup> No matter now or in the future, the real world social interactions are indispensable, and the desire of having these kinds of communication will greatly increase.

- The Liminal Condition

The diversification of social methods reflects the fact that it can occur in any place and through various methods, including direct interaction and electronic communication. Nowadays, daily verbal social communication sometimes comes with a certain piece of music or picture through a mobile phone or tablet. In the future, smart devices are not only used to assist daily communication but also promote comprehensive communication between people to people, people to devices and devices to devices. In addition to the metaphysics of "existence," the function of the media in the construction of the public social interaction form rethinks the complex intertwined relationship between "media" and "immediateness." This is a "betwixt-and-between" liminal idea, which contrasts sharply with the common triad structure of human versus technical, media versus physical spaces and self versus the other.<sup>22</sup> Specifically, this human versus technical liminal thinking changes urban public space, social form and spatial vitality. For example, the time limit of games or business will trigger different people to gather in a specific urban area, and the purpose of their gathering exceeds the use served by the space. As a result, public spaces will become more ambiguous and flexible. Also, some social activities are no longer understood at a glance. For people without any context, inexplicable behaviors performed by small groups will also become the norm in future cities. In addition, social not only affects current participants and events, but it can also often trigger the extension of the event and subsequent activities, thus linking different places and functions. Geomedia is a description of the concept of liminal, which is embodied in the connection between the concept of "ubiquitous, convergence, enhanced positioning function and real-time feedback."<sup>23</sup>

- Uncertainty

Future urban space should supply the dual demands of both social life and technology requirement from cyborgs. For liminal space, the multidimensional complexity and potential of change provide exactly this opportunity. First of all, it can not only intensify online communication, but also attract individuals to return to reality. This allows people to realize and re-interact

the links between others and life. Secondly, with the combination of digital technology and reality, liminal space emphasizes the uncertainty in the relationship between distance, proximity, urban space and social activities. In contrast, the specific implementation tendency and obvious prescriptive tendency towards urban space have restricted the potential of residents to misappropriate the environment. McCall claimed that with the context of social interaction becoming a technological event, the contradiction between prescriptive design and urban spontaneity is particularly prominent in the "smart city" under systematic control.<sup>24</sup> This is because urban planning does not attach importance to the value of incompleteness so that it incorrectly sets the possibility of spaces from top to bottom repeatedly. Overall, future city design will focus more on liberating the purpose of space utilization. By taking uniqueness and difference as the basis of publicity, future cities can enhance their adaptability with the content of social activities and the number of participants.



Figure 2.3 An illustration of smart social life

## 2.4 Spiritual Life

Philosophers such as Marx and Baudrillard talked about alienation and materialization of human beings came with the early technological revolution very early on.<sup>25</sup> In this digital age, with the spread of mechanization and digitization, human alienation is manifested in continuous adaptation to machine language and digital language. It is worth mentioning that human communication has become digitized, exaggeratingly speaking, just like programs that can only operate based on user inputs. This will eventually resulting in human beings being mechanized. Just like humans are now controlled by clocks or mobile phones. In the post-information era, smart technology is no different from real life. Once human increasingly rely on technology, the significance of spiritual life is to set humans apart from machines.

- Symbolic Thinking

Scientists propose that the real threat of AI is to subtly change "symbolic thinking" into "machine thinking".<sup>26</sup> Since ancient times, people's values had been judged by unique symbols, such as rituals, festivals, customs and so on. In practice, these behaviors are not significant, but they all define a certain psychological need of the people, reflect their imagination and sustenance above themselves. Yet, these value judgments are completely useless to AI, because AI is ultimately controlled by machine language, it will only have "mechanical thinking". Symbols are the connections generated by different collective consciousness of human society in the long-term interaction with the environment. Anthropologist Clifford Geertz also emphasizes that human beings live in a network of cultural meanings that they have woven. Although at present, the general trend is that convenient and content-rich networks are eating away the respect and heritage of modern citizens towards customs and traditional festivals. Reflection on this phenomenon is exactly a correction of future development. In the near future, symbolic thinking needs to be considered as the core of spiritual life, and it needs to spread to all aspects of human lives just like smart technology.

- Spirit of Place

It is symbolic thinking that endows the spirit of place. The spirit of place is the bond between the person and the space created by projecting human culture, art, feelings and emotions in a specific space through materials, activities, and forms.<sup>27</sup> It

skillfully merges the material and the spiritual, the physical and the metaphysical. In addition, it unites the past, the present and the future, results in a state of equilibrium between nature and culture. With the informatization, architecture is frantically pursuing temporariness and flexibility, leading to the loss of the spirit of the place that is attached to eternity and materiality. Therefore, future architecture should explore new ways to reshape the emotional connection between people and places.

- Ritual

In order to enhance symbolic thinking, local customs and traditional festivals should enrich their contents and forms through smart technology in the future. For example, using specific media such as holographic projection and VR to promote festivals and encourage people to participate in live interaction. Simultaneously, smart technology can also strengthen the realistic scenes for weddings and ancestor worship. Furthermore, modern cultural festivals are generated by adopting new technologies and cultural patterns, such festivals include Amazon Prime Day, Super Bowl, Oscar and Grammy award.

Spiritual life is not completely incompatible with technology. Technology is always neutral and invented to improve people's living conditions. So in the future, smart technology should aim at strengthening spiritual life and serving symbolic thinking.

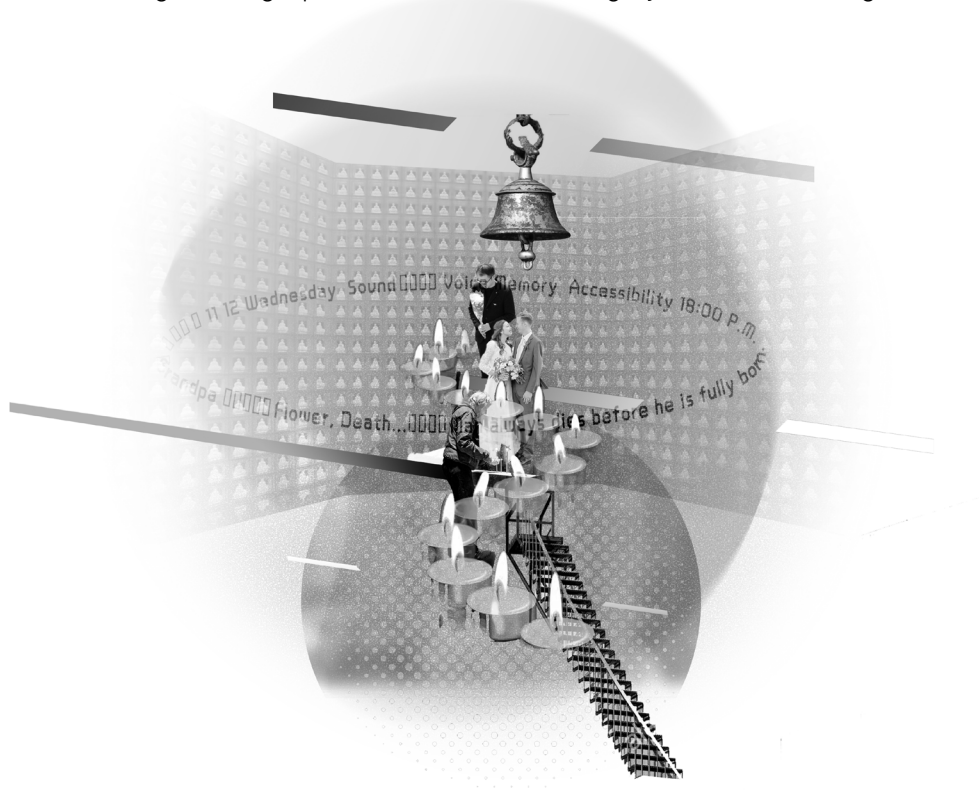
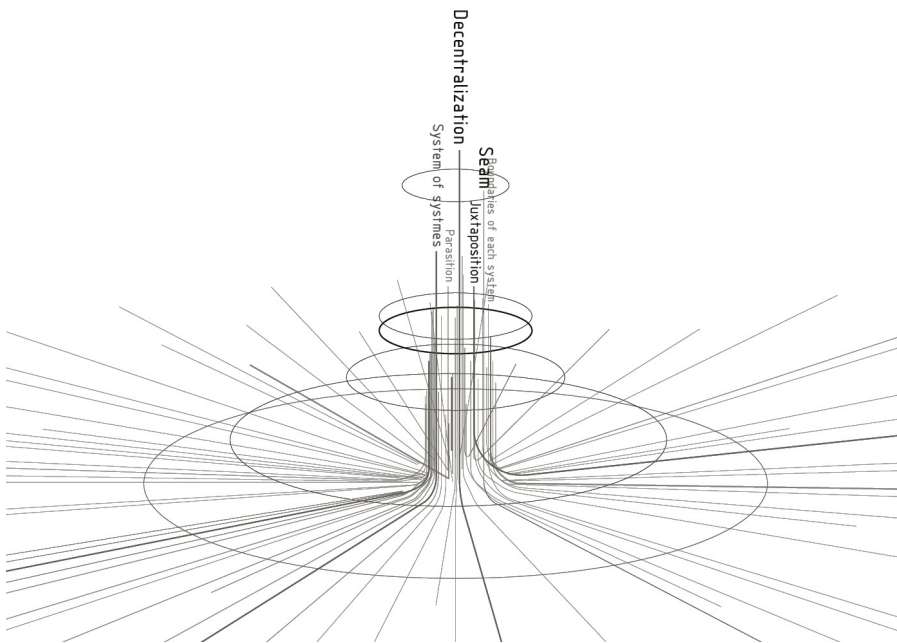


Figure 2.4 An illustration of smart spiritual life

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## Chapter 3

A proposal of generic spatial features results from new technological properties and programmatic demand analysis with spatial case studies.

### 3.1 Minimalism, Flexibility, Humane

Instead of being considered separately, space and digital life should be interacted and designed together. Within three decades, the smart life will not only put forward new requirements on the function, aesthetics, comfort, efficiency and sustainability of the space in different living scenes, it will also need evolved space organization to guarantee the correlation between different smart devices.

- Minimalism

The modern architectural movement elaborated that the development of science and technology is gradually becoming simple and minimal. From a technical perspective, the objective is to satisfy user preference by highly integrated functions with the simplest appearance and structure. Mies van der Rohe's signature style "less is more" is to design a comfortable space suitable for people's living with minimal architectural elements.<sup>1</sup> In the dialectical relationship of less and more, simple and complex, expressing more functions and possibilities with fewer elements is the core spirit of minimalism. From this point of view, the wireless connection between smart devices will not cause extra clutter to the space. Further, the linkage of various objects requires a simpler space design in order to retain efficiency. In addition, minimalism is an aesthetic demand for smart life. When the IoT becomes ubiquitous, the functionality and space of the building will be further integrated to present a minimalist scene with advanced feature support. When the redundant components are muted, the purity of space and beauty of life can be better presented.

- Flexibility

Flexibility is an essential ability derived from adapting to changes, diversity and evolution for internal consciousness and external factors. In traditional buildings, it is difficult to rearrange the spatial organization due to the preset structure. On the contrary, the merging and apposition of functions allow space to achieve different levels of proportions. This will further unblock the chance of having multiple usages and transformations. Also, variations of some non-load-bearing components have also allowed space facilities to reach maximum flexibility. Examples could be movable roofs, mobile walls and foldable furniture. As understood by modernism, free space and open plan can enhance flexibility by providing great inclusiveness. Postmodernism also emphasizes the variety and plurality of

functions while criticizing modern architecture. Charles Jencks introduced diversity and change as one of the key characteristics of ideal contemporary architecture (Jencks, 1987).<sup>2</sup> This trend of thought is a cult of seamless, continuous processes and optimization. However, the truth is that life is seamed. Everything can not normally work without friction, and seams can also ensure the confidentiality of the data and isolate some disturbing processes.<sup>3</sup> Not all systems are mechanical, so there needs to be some gray space to correct uncertainty. It's worth noting that when flexibility allows multiple users and space configurations, it can also lead to overly generic and indeterminate results that make specific demands difficult to satisfy. This also means that these systems cannot adjust themselves to provide adaptability for all kinds of changes. There needs to be a seam between each system to ensure continuous and uninterrupted delivery of services. Therefore, designers must pay attention to the mutable and immutable parts over time in the space design.

- Humane Space

The post-digital era places human back at the core of data services while promoting humanized smart services and smart spaces.<sup>4</sup> Thus, in the future, human demands rather than high tech, energy consumption and commercial value must be considered as a prerequisite in the design of smart buildings. In modern time, architects use human scales, collective memories and context as norms for humanized cities and spaces. But in postmodernity, the first requirement of humanized space is not to treat people as a collective, which can void ignoring the specificity and preferences of each person. Therefore, space needs to be customized and personalized according to different people, in order to meet the aesthetic and functional requirements of different environments.<sup>5</sup> From comfortable spaces, services, sound policies to long-term sustainable living, architects need to balance the differences and commonalities between collectives and individuals, and design in more delicate ways. The concept of humanization is propagated to every individual by smart technology and the instant feedback capability of big data.<sup>6</sup> This has to be said to be a big expectation of people's future smart life.

### 3.2 Decentralization

Decentralization is the most outstanding feature of the smart technology structure. For instance, the decentralized fog computing makes up the shortcoming at the execution level of cloud computing. By removing the direct data transfer towards the "cloud" center, fog computing uses scattered "fog" in the "ground layer" for faster data exchange.<sup>7</sup> The decentralized structure not only greatly increases the speed of data transmission and storage security, but also improves the scalability of the network structure. Decentralization is an optimization broadly applied in IoT and blockchain. If space organization is decentralized, it will also get similar benefits, such as optimizing the comfort and energy consumption of space for different users at different time periods.

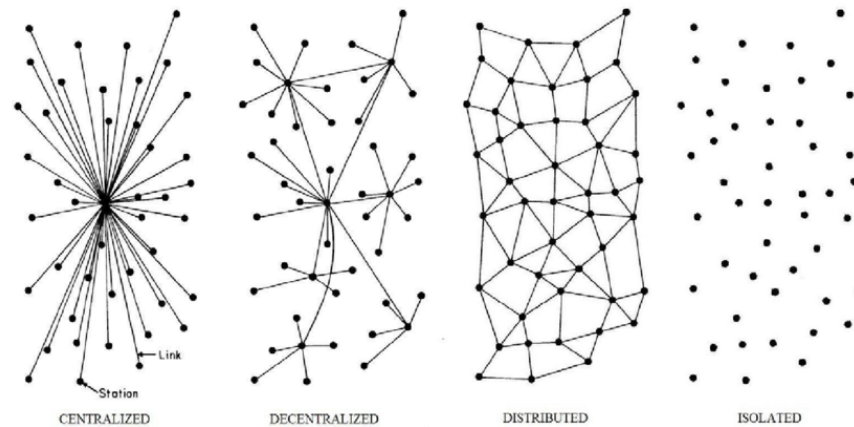


Figure 3.2.1 A diagram of different network structures, / Wysieńska, 2012, p. 5

#### • System of systems

Modern architects unconsciously embody the top-down centralization of power when designing residential or commercial spaces.<sup>8</sup> This is reflected in the fact that architects are arranging the life trajectory of the residents. As discussed in the previous chapters, when people need to customize their space, removing this centralization of power allows the interior space to break the predetermined relationship without the dependency of the technologist who designed it. The space in each part of the building is a subsystem that serves the entire residential unit.<sup>9</sup> In terms of the whole building as a unit, the unit element will be each subsystem. In the same way, each resident as a single unit is also subordinate to the residential unit and the entire building. Again, decentralization is conducive to the effective operation of this system.

#### • Increased Correlation

Decentralization enhances the linkage between each part of

the building. Centralized space, each part is hierarchical, with the strongest function, the largest scale, and the most frequently used space as the center. The other secondary spaces are activated through the connection with the central space. Its function and scale and frequency of use also gradually decrease. Some spaces and forms are over-emphasized and used, while others are restricted or experience differences occur, which are not conducive to people's long-term flow and coherent feeling in the space. And decentralization can remove the centralization of space, so that each part can be used

- No-Stop City, ARCHIZOOM

In the 60s, Archizoom realized the rising preeminence of networks overbuilt structures of architecture influenced by the microcomputer, telecommunications, and pervasive computing combine with the bureaucratic landscape to shape a formless and immaterial world.<sup>10</sup> Architects' traditional design tactic that defines plan-specific or hybrid- through preliminary activities gradually fades in contemporary spaces, which are determined by programming codes instead of by architectural programs. "The programmatic indeterminacy of the generic, meanwhile, offers little more than a capitulation to this condition." Archizoom adopted an infinite grid system rather than a fixed structure or replaceable units based on flexibility, unit assembly and mass-production (Metabolism) to adapt to the transformative potential of computers and the expansion of the global telecommunications grid.

The model of No-stop City is built in a mirrored box with an unending grid of aluminum columns, depicting a monolithic but anonymous space with ultra flexibility. It neglected the quality of its exterior but concentrated on its horizontal, centerless configuration, criticizing traditional bounded where architecture and urbanity were demarcated. According to Andrea Branzi, the leader of Archizoom, the "total estrangement of the subject, who gradually lost control of his inhibitions in dance, moving towards a sort of psychomotor liberation."<sup>11</sup> This did not mean for us a passive surrender to the consumption of aural and visual stimuli, but a liberation of the full creative potential of the individual."

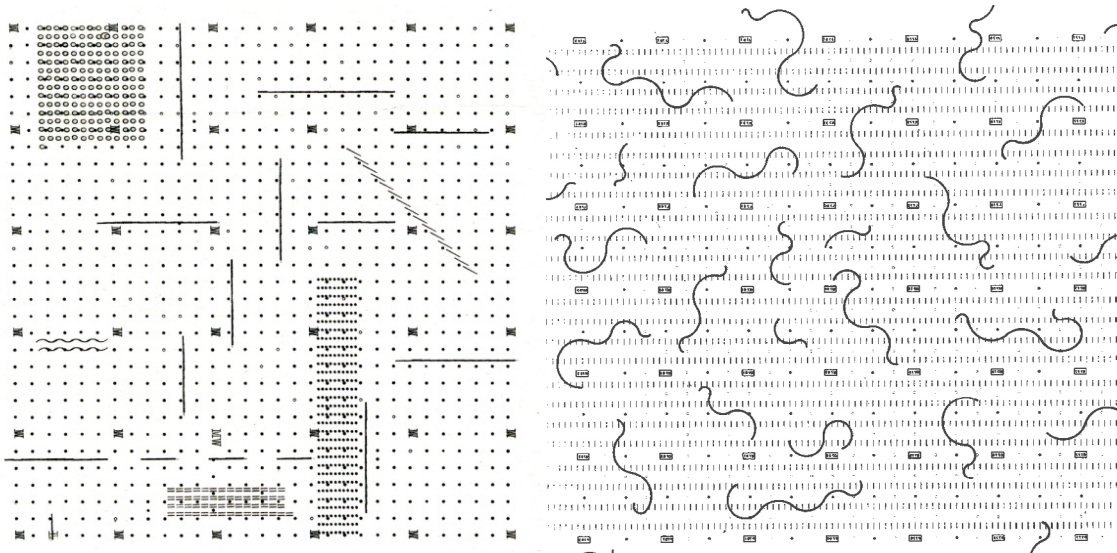


Figure 3.2.2 Drawings for No-stop City, 1970-1971 /Archizoom



Figure 3.2.3 Photo of No-stop City Model, 1970-1971 / Archizoom

The acknowledgement of the importance of the overlapped program highlighted the meaningless prescribed function for space; therefore the grid could continuous grow and absorb anythings of desires. The result of No-stop City has a very similar social structure with the future smart society where IoT and the internet integrate the action of production and consumption into a critique of the same system.

The infinite grid commendably removes the center of a space, thus bringing more flexibility, allowing the space to adapt to the changes of the program. In addition, it enables the space to instantaneous accommodate more desires without relying on addition and replacement of materials. But due to the infinite tolerance nature of this system, after eliminating all boundaries, the necessity for architecture also becomes a problem. In Control theory, the more the perimeter is open, the less the system is stable. Archizoom ignores the controllable boundaries of the system and allowing everything to return to the nothingness of desire, thus, a flexible but unstable system is formed. The purpose of systems of systems is that the system can be broken down into smaller independent systems that can run independently and develop in accordance with their own development.

- Farnsworth House

Architects: Ludwig Mies van der Rohe

Location: Springfield, Illinois, United States

Year: 1945-1951

Area: 140 m<sup>2</sup>

Program: Retreat House

Farnsworth House is one of Mies' masterpieces, from its material to space, fully reflecting the concept of "less is more."<sup>12</sup> Although negative effects like the omission of privacy and living habits had been brought on this masterpiece due to the contradiction between the highly emphasized fluidity of space, the continuity of program and its owner Farnsworth. By adopting the open plan concept to a residential house, Mies breaks the space division of the traditional residence whose space also centred with a living room or a hearth. The spatial layout reflects the minimalist and pure space aesthetics.

The glassed-in house consists of several raised rectangular planes supported by eight 1.5m high steel pillars.<sup>13</sup> The planes function as a platform, the floor and the roof with gradually changed height above the ground, giving a smooth transition between indoor space and outdoor space, nature and domesticity. The interior space was divided by function and scattered on a grid and permitted to expand or shrink according to the resident's desire. Without the presence of walls, space is seemingly decentralized. However, the primary service section becomes the center of Farnsworth House instead of the master living room. The service core enclosed by wooden panels is configured in a so-called "American Style" with a wardrobe separating two bathrooms in between, and a kitchen and closets at the periphery of the core.

Although the interior space still has a center, the continuity and relevance of the surrounding space is greatly enhanced. From a dialectical aspect, the centralized service functions is precisely the decentralization of other living areas. Every living space with the same hierarchy and the similar extensibility can be rearranged in terms of location and function. Theoretically, the way people access the next functional zone is no longer a single circulation, thus making the space more customized and effective.





Figure 3.2.4 & 3.2.5 Photo of Farnsworth House (exterior and bedroom), / <http://www.architecture.org>

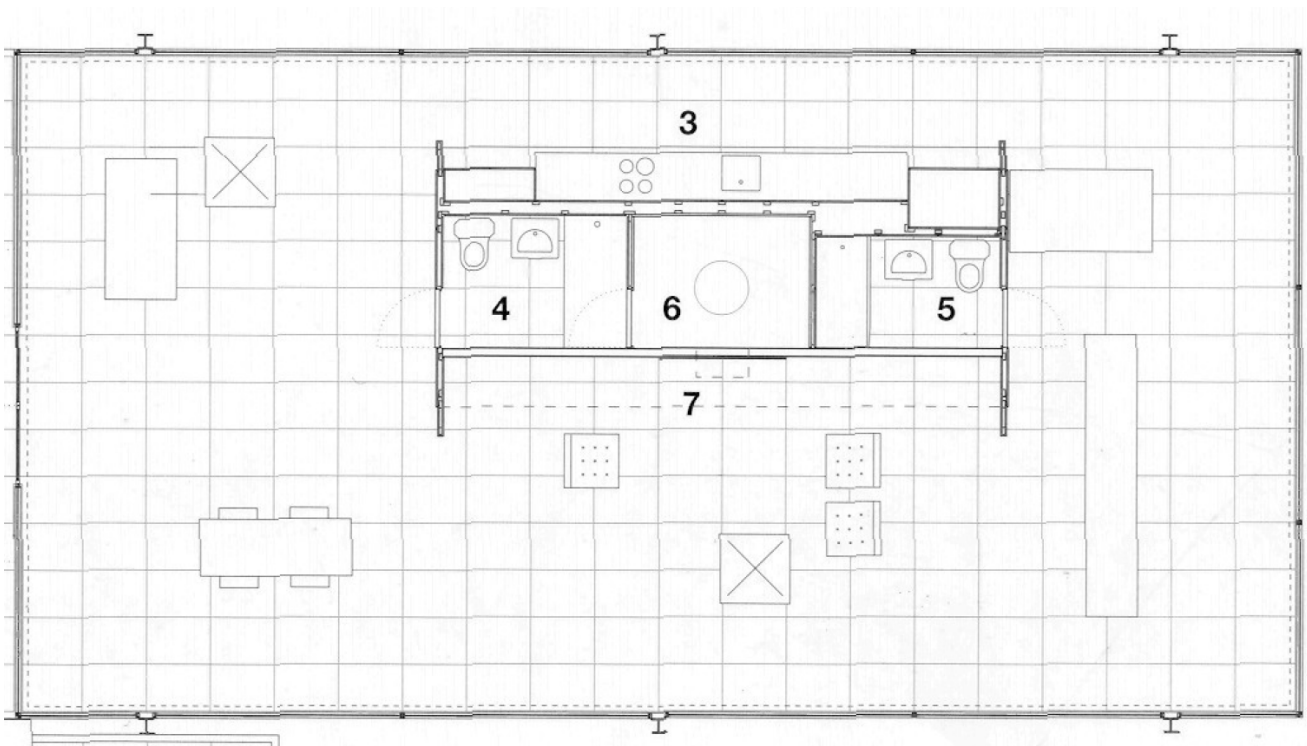


Figure 3.2.6 Farnsworth House Plan, / Mies van de Rohe

- Children's Center for Psychiatric Rehabilitation

Architects: Sou Fujimoto Architects

Year: 2006

Area: 14590m<sup>2</sup>

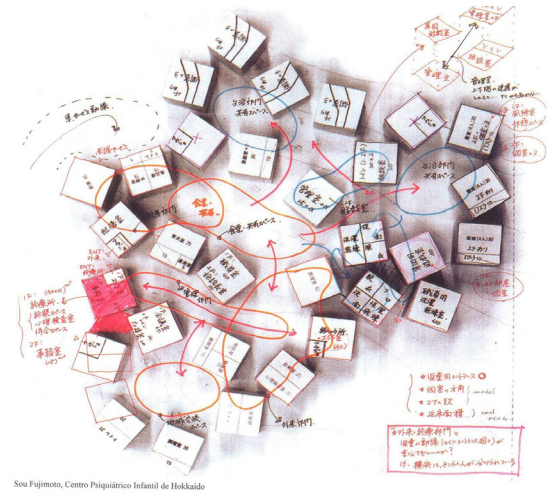
Program: treatment center

Sou Fujimoto wanted to bring intimacy to this children's rehabilitation center by creating a dreamlike town for them. He dissolved a massive volume into several cubic houses with a method of being random.<sup>17</sup> As a result, these randomly scattered cubic houses created a lively life scene which makes kids feel more homey than precisely planned one. Fixed programs were assigned to each small boxed while the irregular void outside the box appears dynamic and undefined. This configuration is decentralized with a series of different but nonhierarchical space. In fact, all cubic houses are "relative centers" depends on the condition of light or the consciousness of those who are there. The fluctuation of space eliminates the concept of absolute functional center in this place.



Figure 3.2.7 Plan. /Sou Fujimoto Architects





### 3.3 Multiaccess

Multi-Access is a term invented in computer science field. As it defined:

*Multi-Access Edge Computing (MEC) moves the computing of traffic and services from a centralized cloud to the edge of the network and closer to the customer. Instead of sending all data to a cloud for processing, the network edge analyzes, processes, and stores the data. Collecting and processing data closer to the customer reduces latency and brings real-time performance to high-bandwidth applications.*

--cite from Juniper Networks,

<https://www.juniper.net/us/en/products-services/what-is/multi-access-edge-computing/>

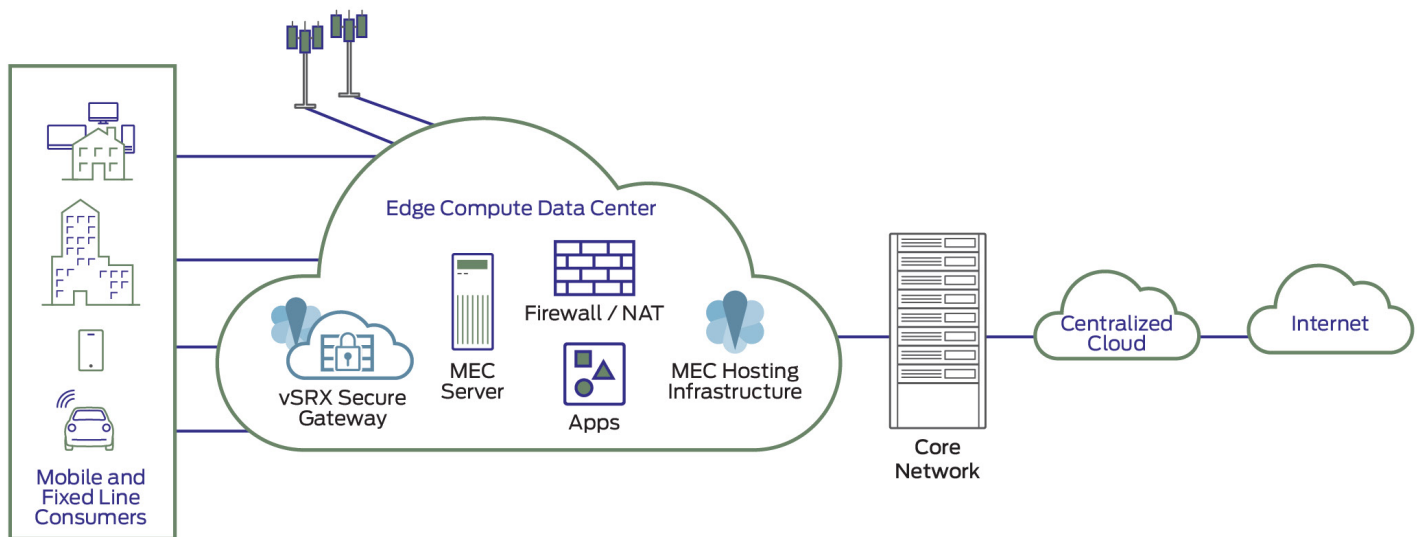


Figure 3.3 Multi-Access Diagram. /JUNIPER Networks

Multi-Access is a basic protocol for mobile communication networks and smart technology. It is a precondition for maintaining stable and fast network signals. It manifests itself in the way that each terminal device must accept multiple data broadcast from the signal transmitting source instead of single point-to-point data.<sup>18</sup> In order to reduce data loss and the collision caused by receiving data from different signal sources at the same time, each terminal device only accepts the broadcast signal of the signal source closest to itself. This is called the "proximity principle",<sup>19</sup> and it is also the principle of fog computing and IoT. The multi-entry reception of the device greatly increases the data exchange volume and speed of each device. This multi-passage is embodied in the building as multiple entrances and multiple streamlines.

- network of circulation

Multi-access is an inevitable result of decentralization. When the space has no absolute center, and the non-hierarchical

hierarchical are connected to each other, it will spontaneously form a variety of possibilities, which will cause the circulation of the network. If zoom out to the city scale, the accessibility between every two locations will become a road network similar to the urban texture. In reality, the efficiency of these routes does not necessarily depend on the shortest distance, but, as discussed earlier, depends on the coordination of multiple systems under real-time conditions. This is also the same in electronic networks. The principle of proximity is also constantly changing the reference frame. The received data usually comes from the relative transmitting source. Only with the help of smart technology can people find the most efficient path in this real-time data stream. Analogous to some route planning software such as google map, it can find the most effective way to meet the needs of users among the various possibilities of the transportation network. In contrast, when not pursuing high efficiency, multiple streamline options can make people feel roaming in the environment. Speed and efficiency are no longer the only goals pursued by people in the post-digital era. How to integrate efficiency and experience in a system is an issue that needs attention in the future.

- multiple entrances

Most of the existing building forms are a single way in and out. This is mainly because it is easy to manage access permissions, guarantee the hierarchical use of space, privacy and security. For example, a commercial house will be equipped with a security room or access control device at a single entrance. Public buildings will have a single door and monitoring facilities at the junction of different privacy levels. However, some buildings that encourage public participation and consumption, such as shopping malls and markets, have more than one entrance to facilitate people to gather from everywhere. Increasing the capacity of the building also improves the speed and efficiency of people entering and using building services. When face recognition and intelligent surveillance are more widely recognized and used, buildings also seem to become more porous, which enhances efficiency and enriches the experience while ensuring the privacy and security of the space. In addition, some shared IoT devices will also increase the demand for space entry. To know that the future system is a system of superimposed people and equipment, and to ensure that multiple systems work together and are independent of each other, multi-entrances seems inevitable.

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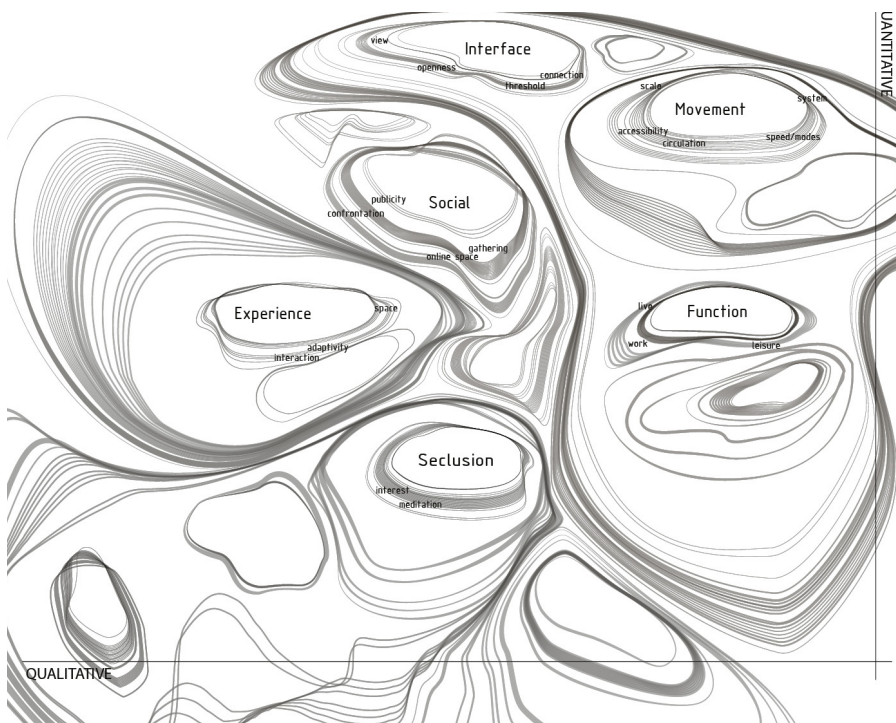






## **GP2 Design Intervention**





## Chapter 4

Design Framework

## 4.1 Design Framework

Smart technology has definitely strengthened the interconnectivity of the Internet, linking real-world objects with the awareness of people's needs. At the same time, the virtuality and physicality are also juxtaposed in the space by this multi-dimensional network. Based on different degrees and objectives of connection, the smart life can be divided into three main categories: solo (connection to objects), social (connection to people), spiritual (connection to metaphysics/ideology).

These three categories demonstrate different levels of connectivity that IoT can connect people with, and reflecting pivotal elements of smart living in the future from an individual, to interpersonal interaction and a mental, psychological realm. In addition, the three categories also lead the design to three different spaces, corresponding to domestic space, social public space, and spiritual-cultural space. In the future, these existing space typologies will also be difficult to meet people's new demands in a future smart life. The Internet of Things will eventually facilitate the evolution of these spaces.

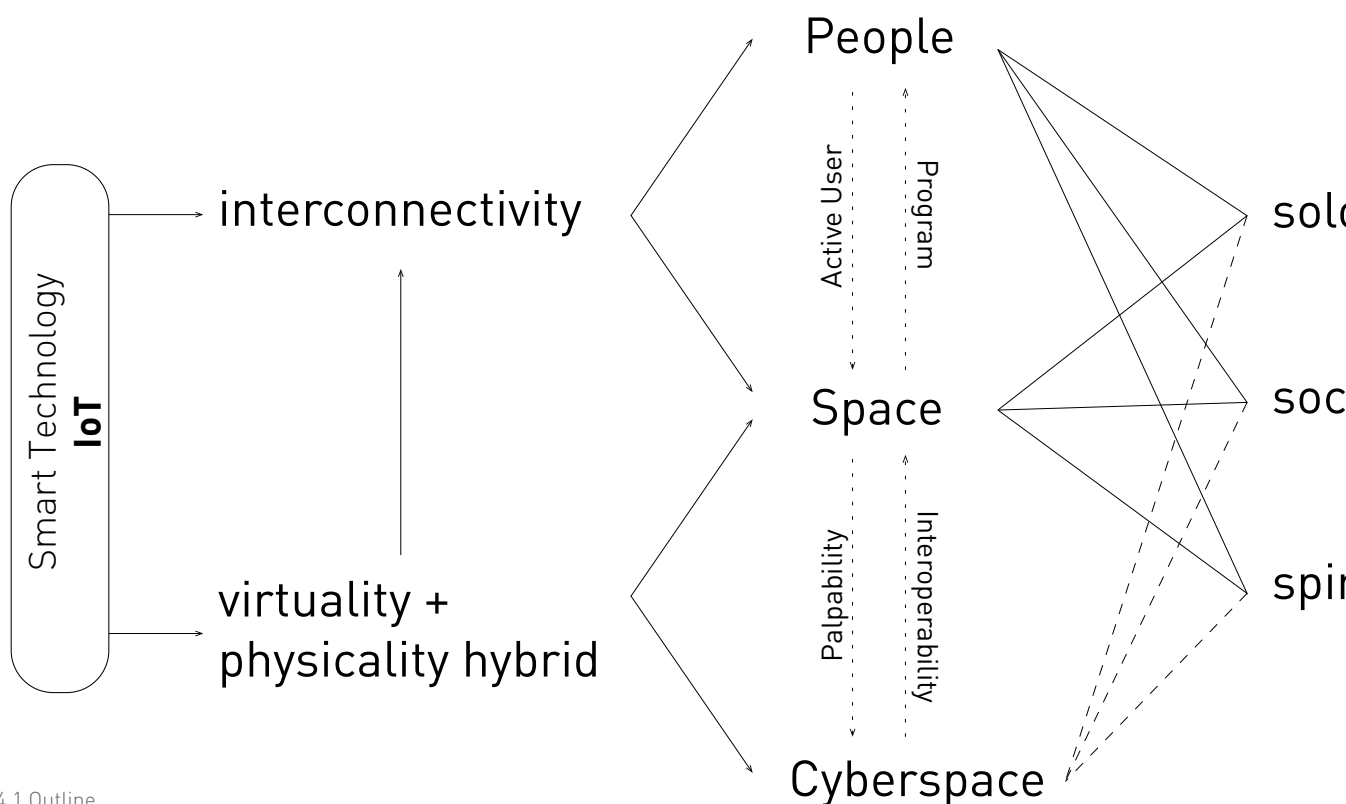
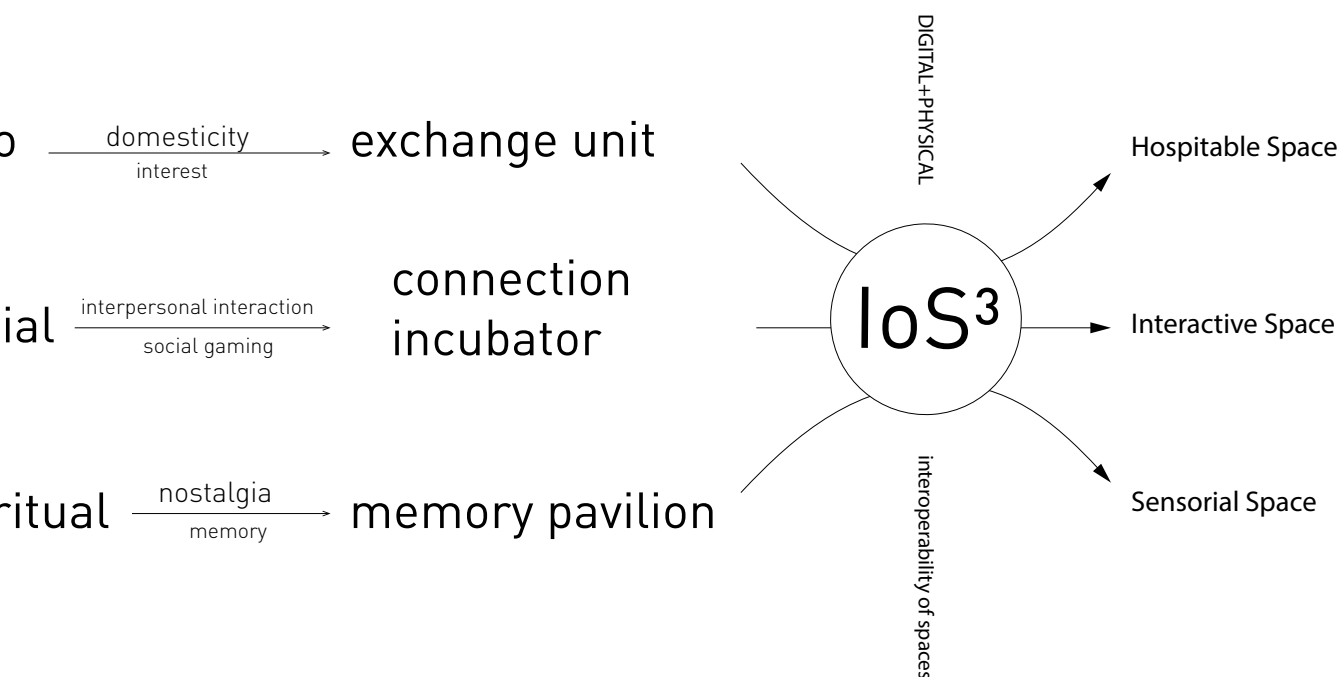


Figure 4.1 Outline

However, these spaces are still too general and vague. Here again, by referencing to current trends and changes towards the living condition, the thesis is using home, social gaming and memory as the index to further exploring the possibilities of spaces and speculate on how they are interoperating. Correspondingly, the successive spaces are exchange units, a connection incubator and a memory pavilion.

People's behaviour and living demands determine the function of spaces and the way they are organized. Within the spaces of each scale, the interconnectivity is achieved by seamless communication and analysis of different devices and fixtures. Besides, spaces of different scales also realize the data communication across spaces through this digital network to implement the interoperability of spaces, so that spaces are also connected to the network of people's consciousness.



## 4.2 Solo

Solo indicates a relationship between a person and connected objects. It is an extension and externalization of one's self in space. Usually, it refers to home or space with a sense of exclusivity. People either behave as their desires with less supervision or selectively expose one's interests and life section for entertaining and online social.

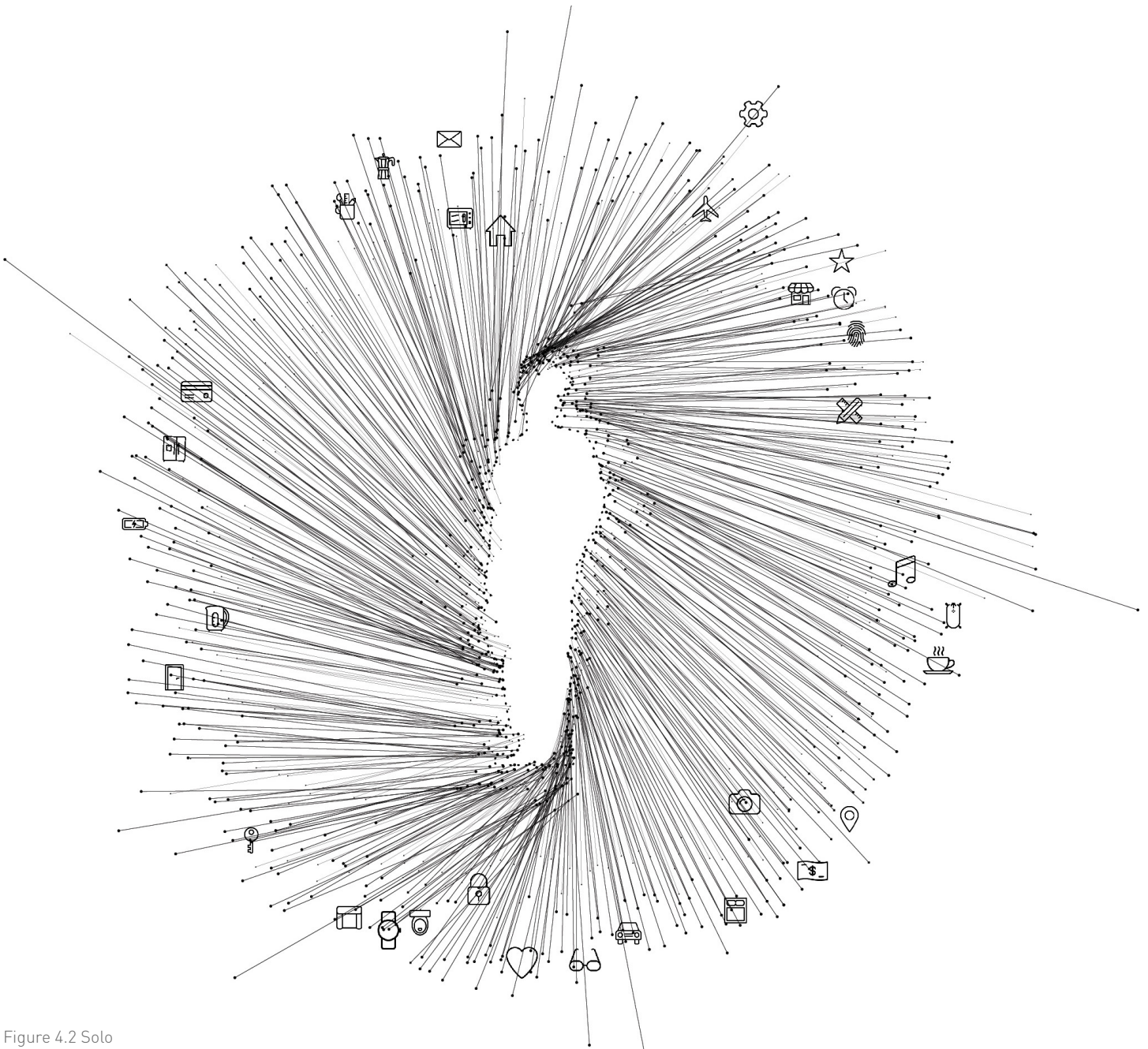


Figure 4.2 Solo



### 4.3 Social

Social life pays more attention to interpersonal connection and communication, referring to real, non-self-centered social activities and obligations. Even though online social media has enriched the way people socialize, however, real social connections are still an integral part of people's psychology about authenticity, sympathy and trust. (online social, acquaintance with a certain level of mutual trust. It is still an extension of self-relations, not real social relationships.)

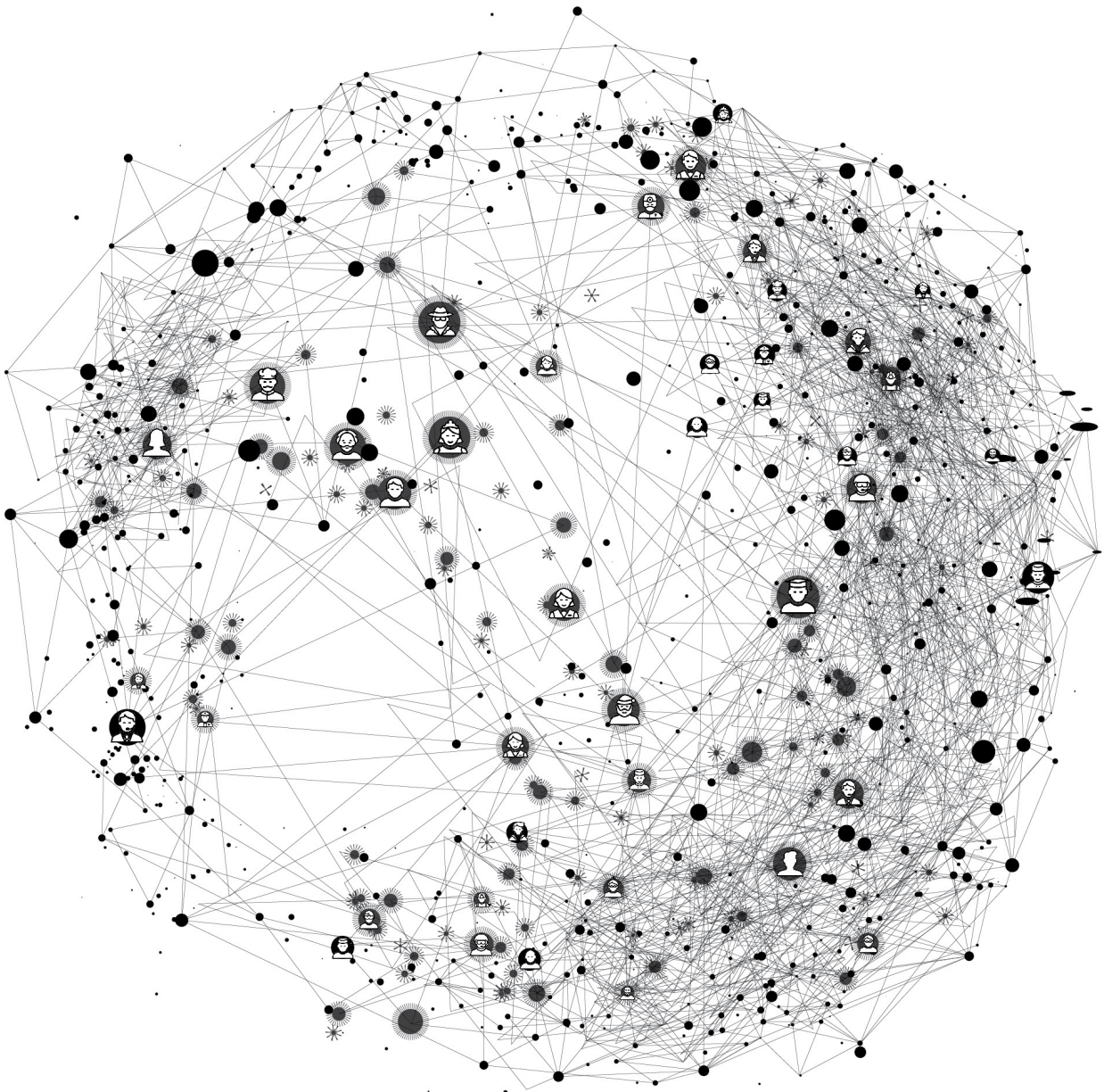


Figure 4.3 Social

#### 4.4 Spiritual

Spiritual refers to the part of life that is enhanced by technology or has the potential to be connected through technology. Anthropologist Clifford Geertz asserted that man is an animal suspended in webs of significance he himself has spun. It is a human-specific emotional connection or cultural appeal. It is an indispensable part of future smart life, and should be emphasized. It helps us to distinguish humans from machines and maintain humanity as well as symbolic thinking.

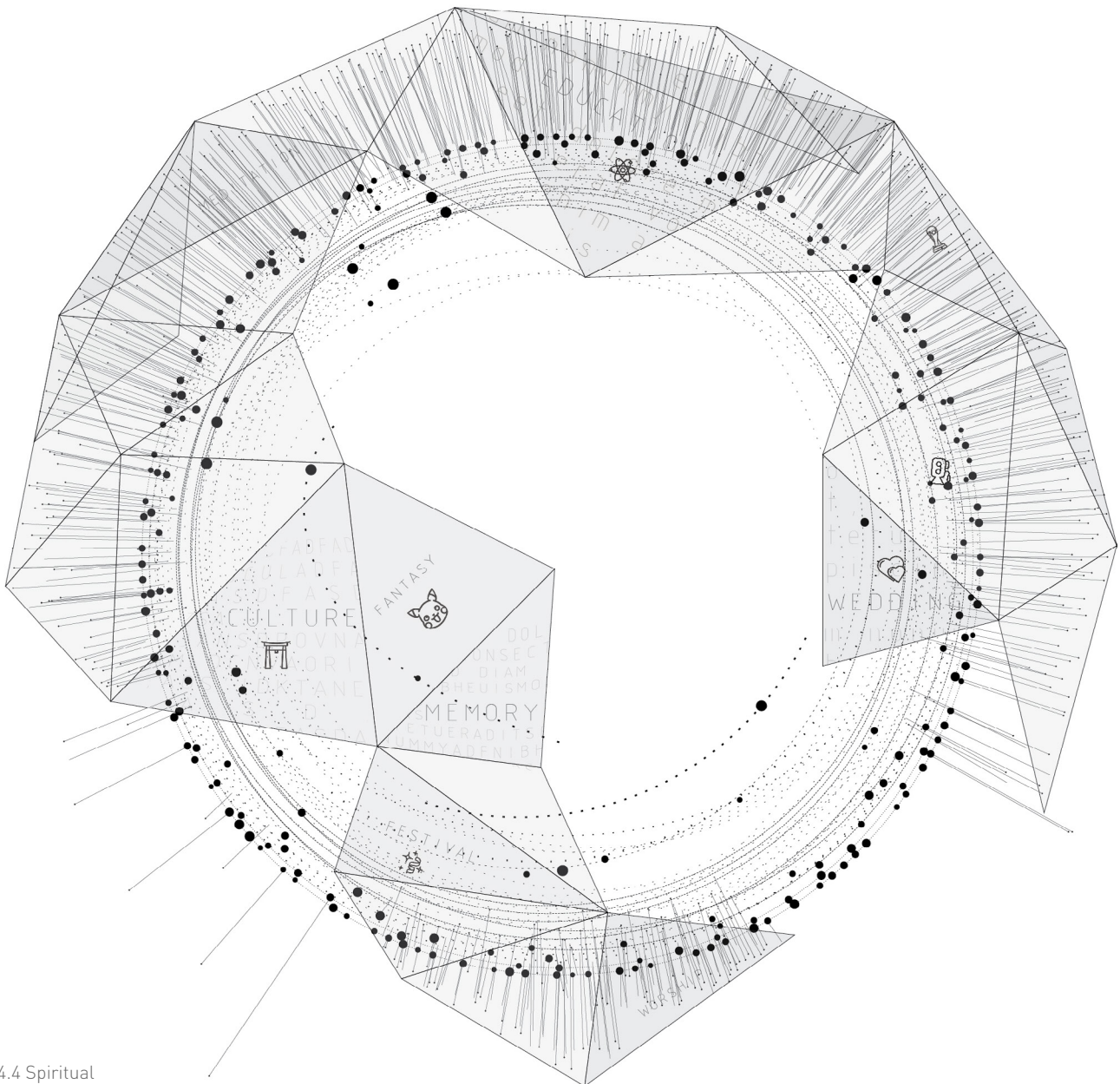


Figure 4.4 Spiritual



## 4.5 Potential Site



Figure 4.5 Application of Smart Technologies in Shenzhen

In 2019, the Bay Area of the Pearl River Delta was planned by the Chinese government to develop into one of the four greatest bay areas in the world by 2035. As an area of multi-urban cores, Shenzhen is undertaking the mission as a technological innovator. Shenzhen itself is also a new city with a history of only 40 years. It was known as the fastest growing city in the world in the 20th century. As an immigrant city, the average age of the population is less than 30. Hence, it has a huge potential to grow and a more open, diverse and inclusive attitude. Since 2017, the application of smart technology has begun to experiment in various areas of the city, such as automatic bus, AI restaurants. Big data and AI are extensively used in realms like public safety, senior's care, transportation analysis. Huawei's headquarters is also located in Shenzhen.

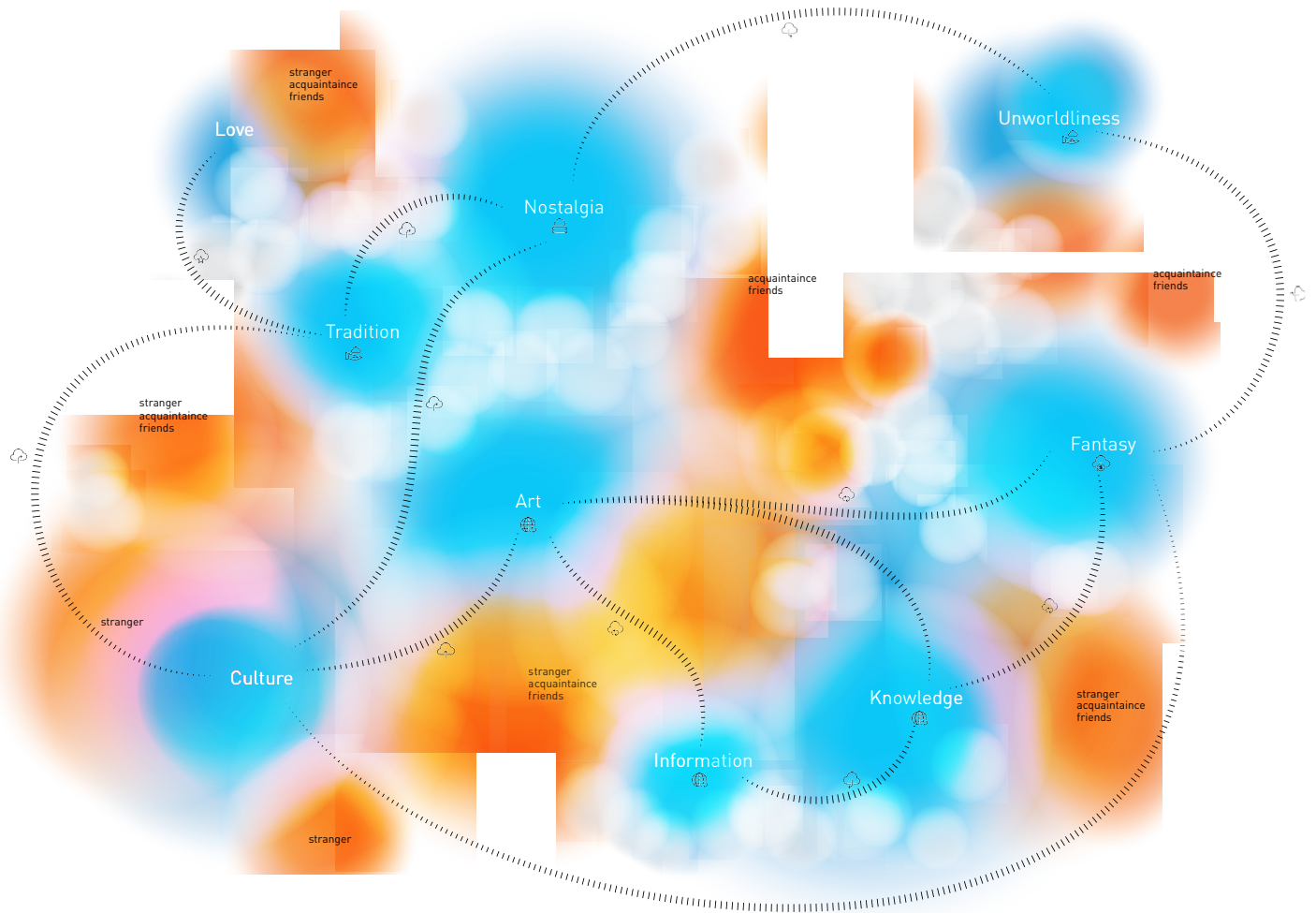


Figure 4.6.1 Infospheric Cloud

## 4.6 Community Envision

The space we live in has gradually been incorporated into this complex and massive information network. It is necessary to reconsider the building of a new IoT system architecture to achieve the integration of abstract mental and cyber-physical-social spaces to adapt for the future IoT. Smart architecture are not merely intelligentized buildings, but ought to provide customized living space and exclusive living experience for residents in this huge network, and to manage the system of multiple subsystems.



Figure 4.6.2 Evisoned Program

The conceptual cloud shows a network of various connected objectives and the flow of data on a community scale. The blue clusters represent spiritual life connecting people to fantasy, tradition, nostalgia etc. while the orange clusters showing the social life connecting people to others with different levels of intimacy. The grey ones indicate domestic lives. It also illustrates the distribution of high/low intensive programs.







## Chapter 5

## IoS: The Internet of Spaces

- exchange unit
- connection incubator
- memory pavilion

## 5.1 Exchange Unit

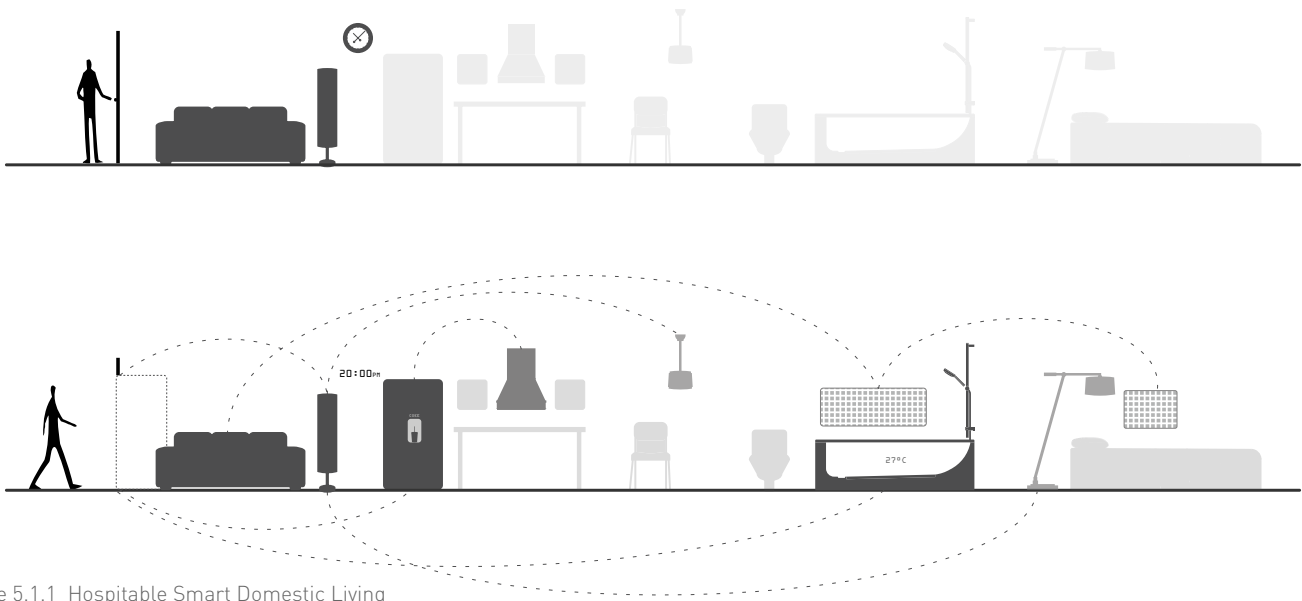


Figure 5.1.1 Hospitable Smart Domestic Living

The universal envision about future living is that all the furniture can communicate with each other in order to respond to the user's immediate needs seamlessly. This part of SOLO speculates on the domestic landscape from a technology point of view and explores the new definition of domesticity what may mean in the smart era.

At the domestic level, the IoT is achieved by connected devices that use the resident's data to remember their habits and preferences. The expectation of smart living seems to anthropomorphize domestic space into an invisible but hospitable role. "At home" is to be yourself. These hospitable domestic spaces reveal the "self" by realization the resident's living pattern.

In many cities of high density, such as Shenzhen, people's living space is compressed into a single unit with normalized architectural plans where rooms surround the living room as a centre. Clearly, Specific prospects of implementation limit the potential for residents to embody their identity through domestic environment. Therefore, the requirement of domestic space should be more ambiguous in function, simpler in form, and more flexible in organization. The free plan, which dissolved the separation of spaces reframed domestic space as a more fluid and open field. With tendency towards openness has moved from radical exception to ubiquity, living imploded into a single continuous space.

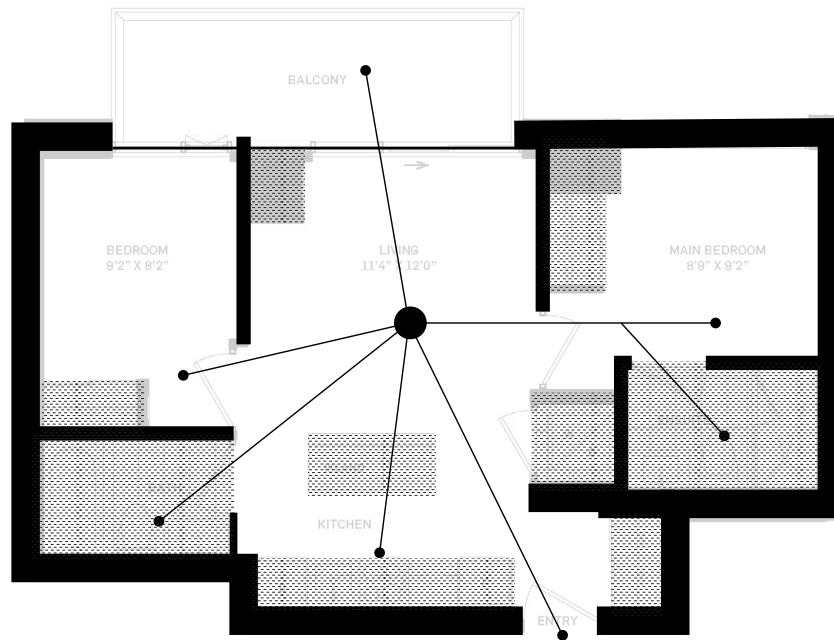


Figure 5.1.2 Centered Space Configuration

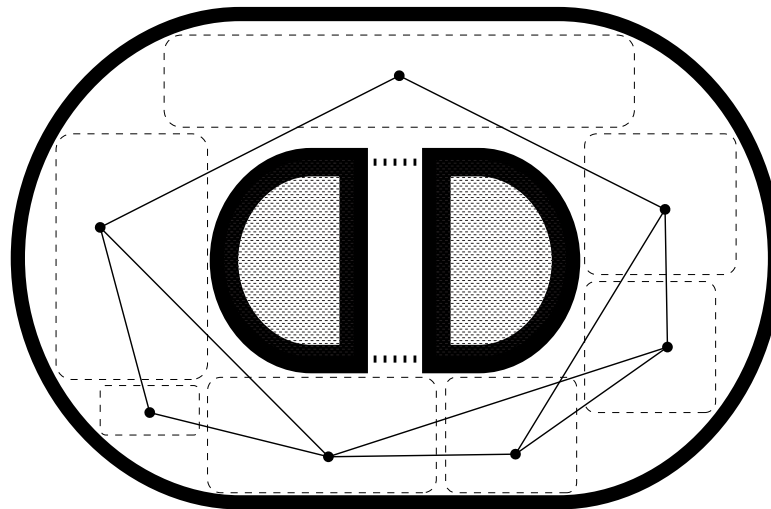


Figure 5.1.3 Decentralized Space Configuration

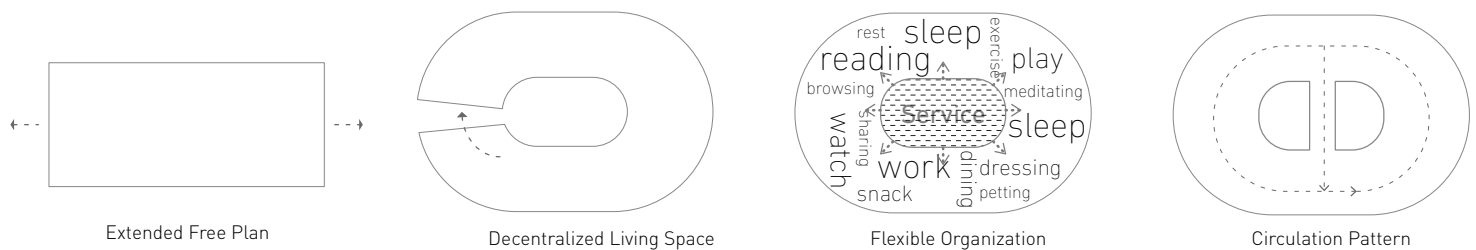


Figure 5.1.4 Plan Diagram

As a result, the double ring-shape residential unit centralizes the service, e.g. washroom and elevator at the center while decentralizing the living space in an egalitarian layout, resonating with a watch-anything- anywhere culture and communication technologies undermine the solidity of walls and borders. /The default setting of the unit appears in a “naked quality”. All the smart furniture and service are integrated into the wall of the inner ring. This wall becomes the interface between the resident and spaces of different functions. Only the desire for service determines a segmented space from the whole. In this way one could configure spaces in endless different arrangements for multiple uses. The outer ring is a curtain wall that can change its transparency and function as an interactive screen.

The pathway in the service core transforms the circulation into a  $\theta$  shape as a metaphor for the cyberspace, constantly changing between linear and nonlinear, and “endless like the human body- no beginning and no end.” In our domestic rituals, we can imagine an existence more fluidly located in time rather than statically marked out in space. Once we had a chance to reflect how we live, the sensorial and the ritualistic can come alive again— and we might discover that the question of who we really want to become can be rehearsed more consciously as part of the everyday.

The so called “exchange unit” is not only the program and space become a changeable network, but also the entire “unit” can be exchanged for emerging trend of nomadic lifestyle, enables an expanded definition of the domestic realm, such as Airbnb. Then what defines the sense of home is no longer the fixed place, but a portable, documentable, transplantable modality of belonging and familiarity—the living pattern that residents generated by their own data is a subjective consciousness recorded by IoT network. You can upload and download it onto your personal device and apply them to another unit somewhere else in the world. The unit will transform itself to adapt the living pattern from the new occupant.



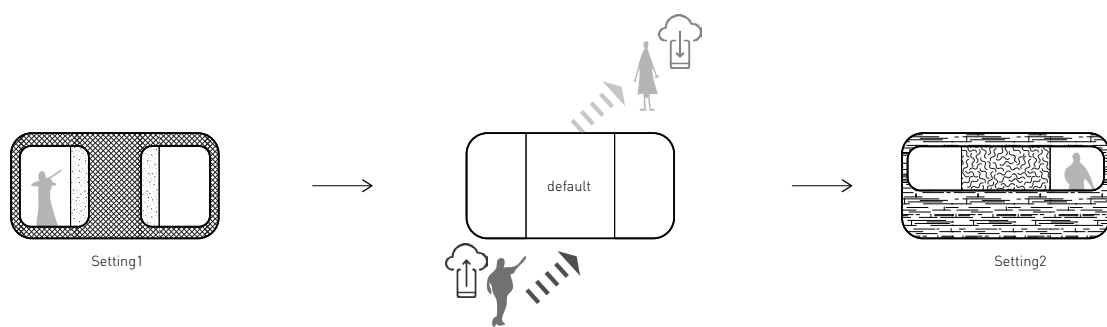
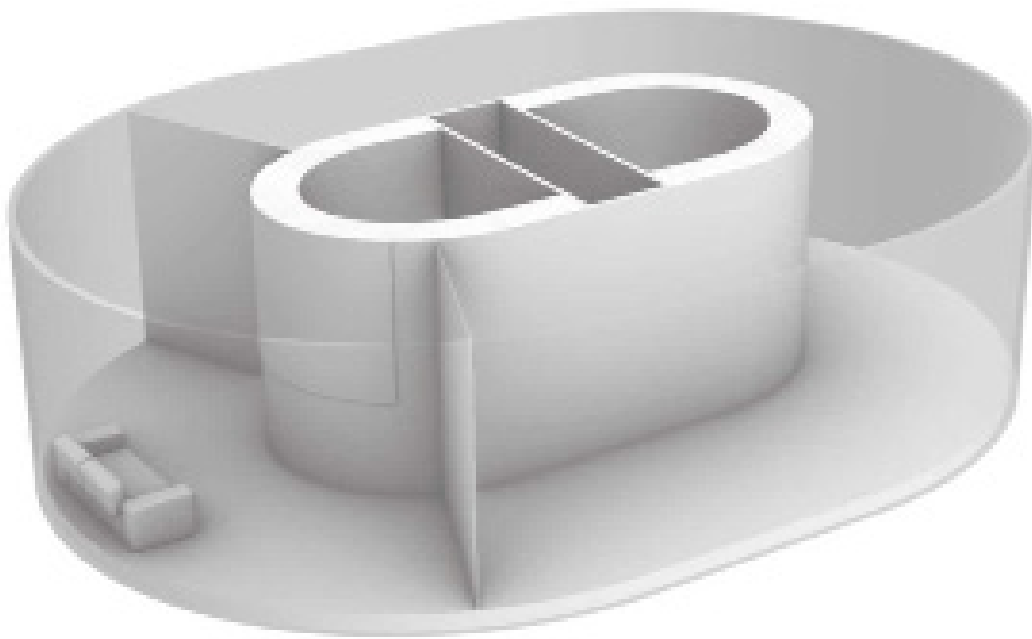
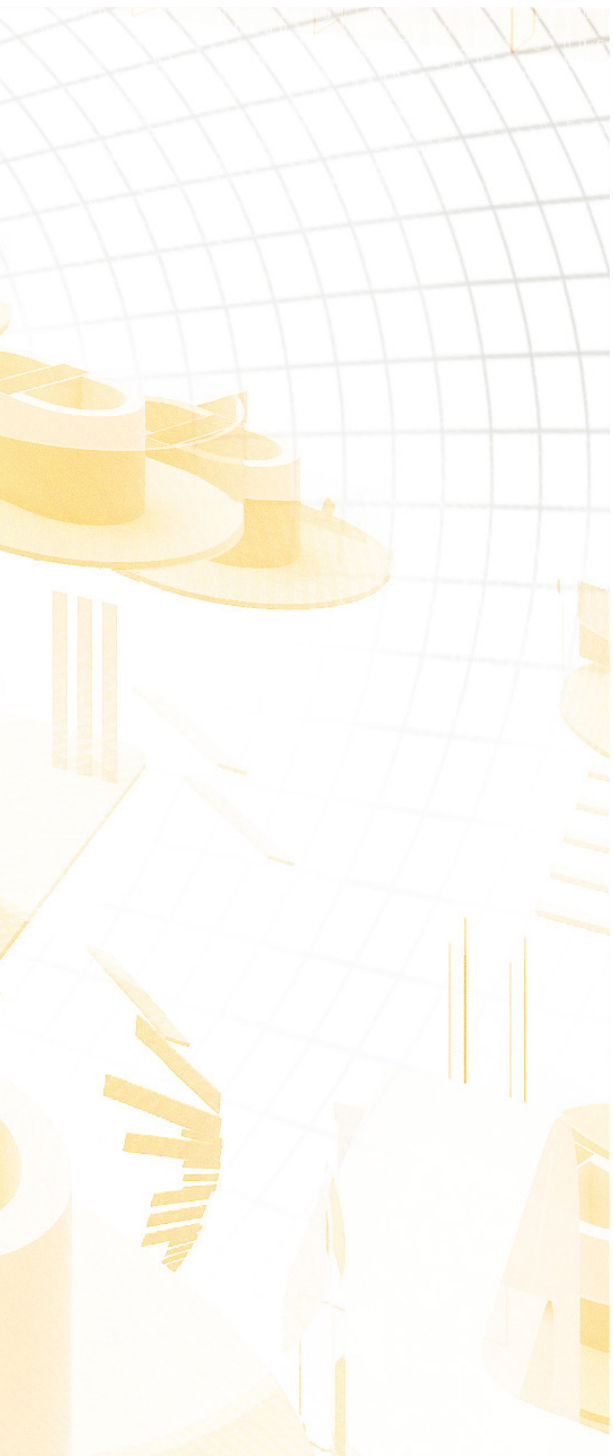


Figure 5.1.6 Exchange of Living Pattern and Residents



Figure 5.1.7 Exchange Unit



entertaining



cooking



sleeping

## 5.2 Connection Incubator

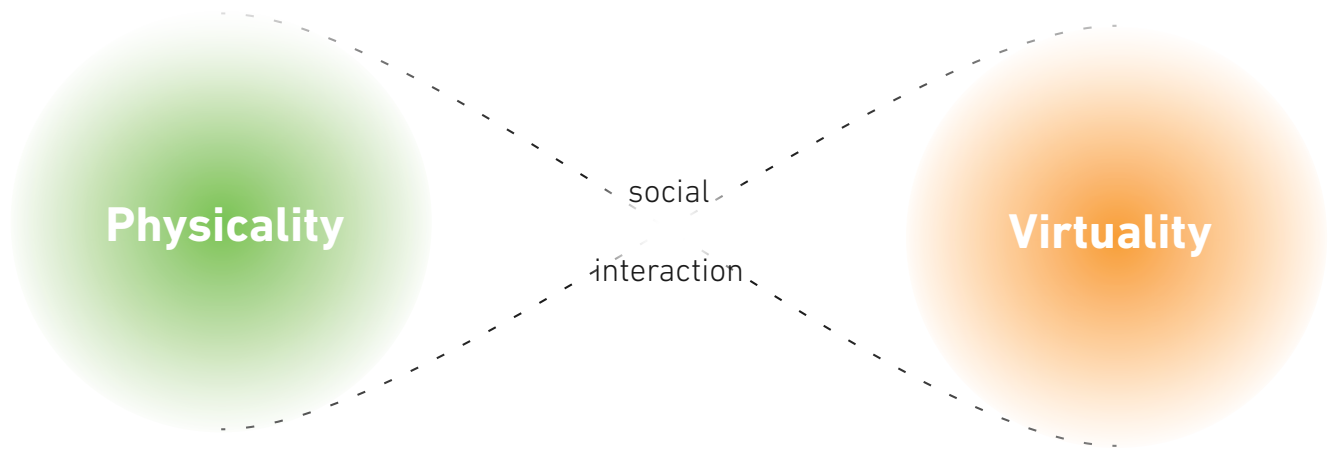


Figure 5.2.1 Hybrid Physicality and Virtuality

Growing virtual connectivity has certainly created a network of unlimited communication pathways to extend our social reach. to prevent loneliness and enhance interpersonal connection.

Yet while our social reach has extended, Yet relationships spawned by the web often remain confined to the digital space in which they were initiated. The phenomenal AR game PokémonGo attempts to lead people to explore our physical urban places and facilitate real social connection through trading or battling virtual characters with other players. More wearable game equipment is invented to enhance body engagement and immersive playing experience. The IoT is focusing on augmented reality, overlaying the virtual information on the physical environment so that the content in a screen can be experienced alongside others. Many recent games encourage people to create connection with other players and more actively engage their body to the space. All these shows that social in the smart era will become more gamified while the game is more socialized.

Therefore, the connection incubator, as a physical space for social gaming, provides a more comprehensive interaction between people and space to address the loneliness and social obstacles.





Figure 5.2.2 Degrees of Hybrid

What kind of space on the one hand can realize the overlapping of virtuality and reality with different degrees, and on the other hand, can provide the publicity and independence of space required by various gaming activities? First of all, the incubator should provides three basic experiences according to the degree of the combination of virtual and real:

- an enclosed space dominated by virtual scenes providing an immersive gaming experience,
- an open space emphasizing on the interactive interface where virtual and real hybrids,
- a P2P social space assisted by electronic devices . The three spatial attributes are naturally formed according to the distance from the digital interface.

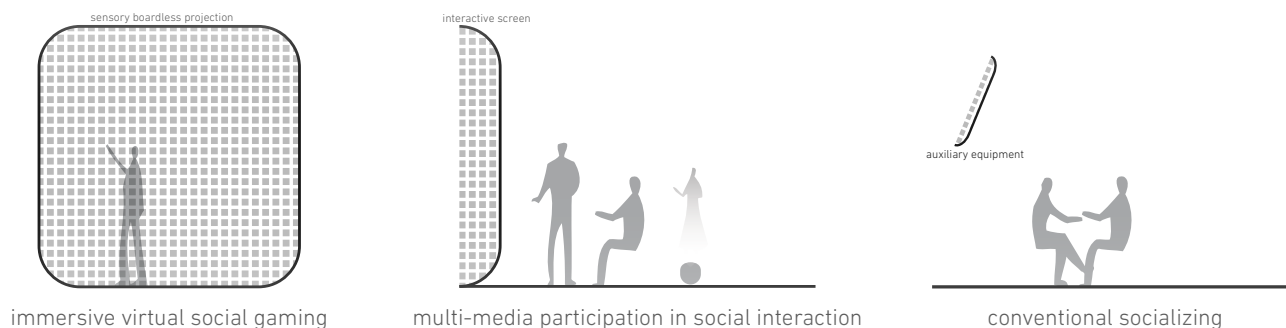


Figure 5.2.3 Three Spaces of Social Gaming

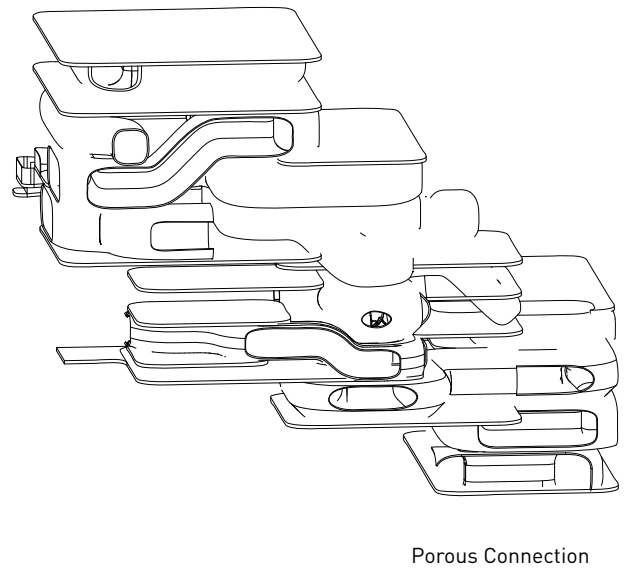
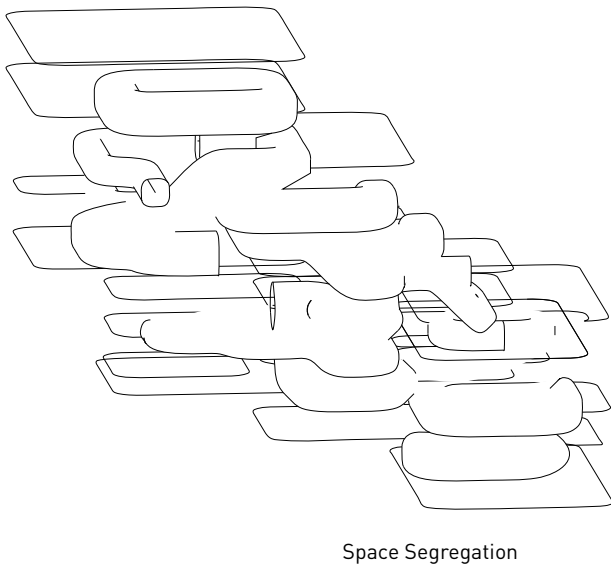
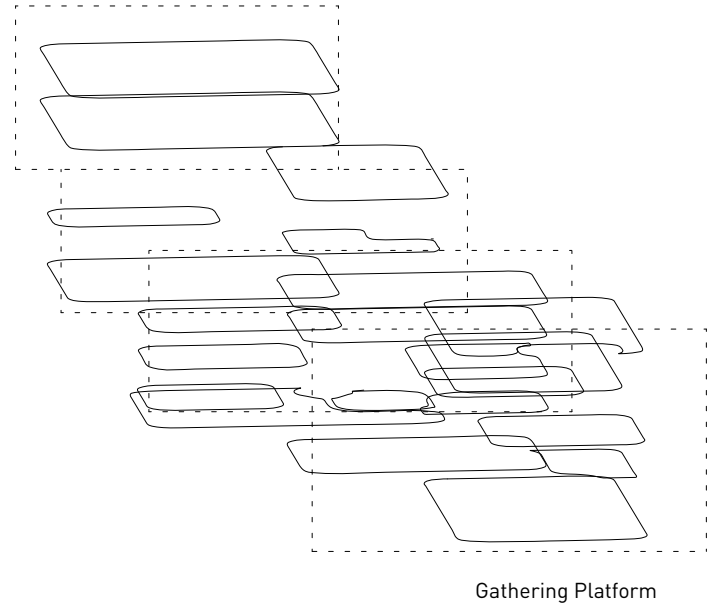
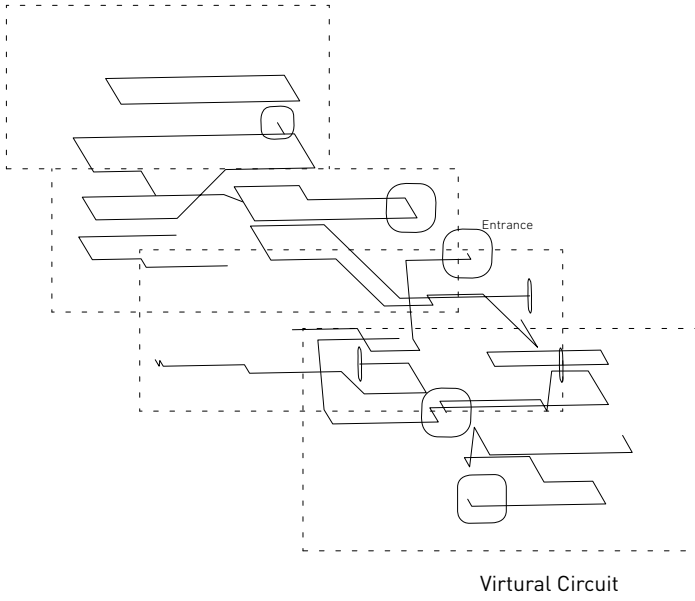


Figure 5.2.4 Connection Incubator Diagram

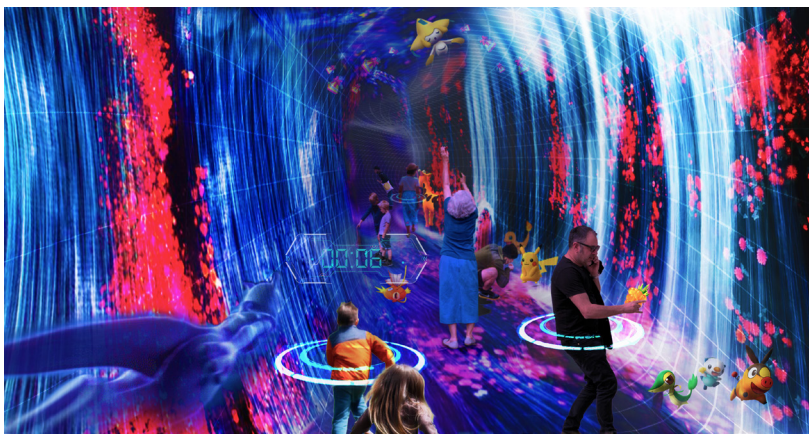
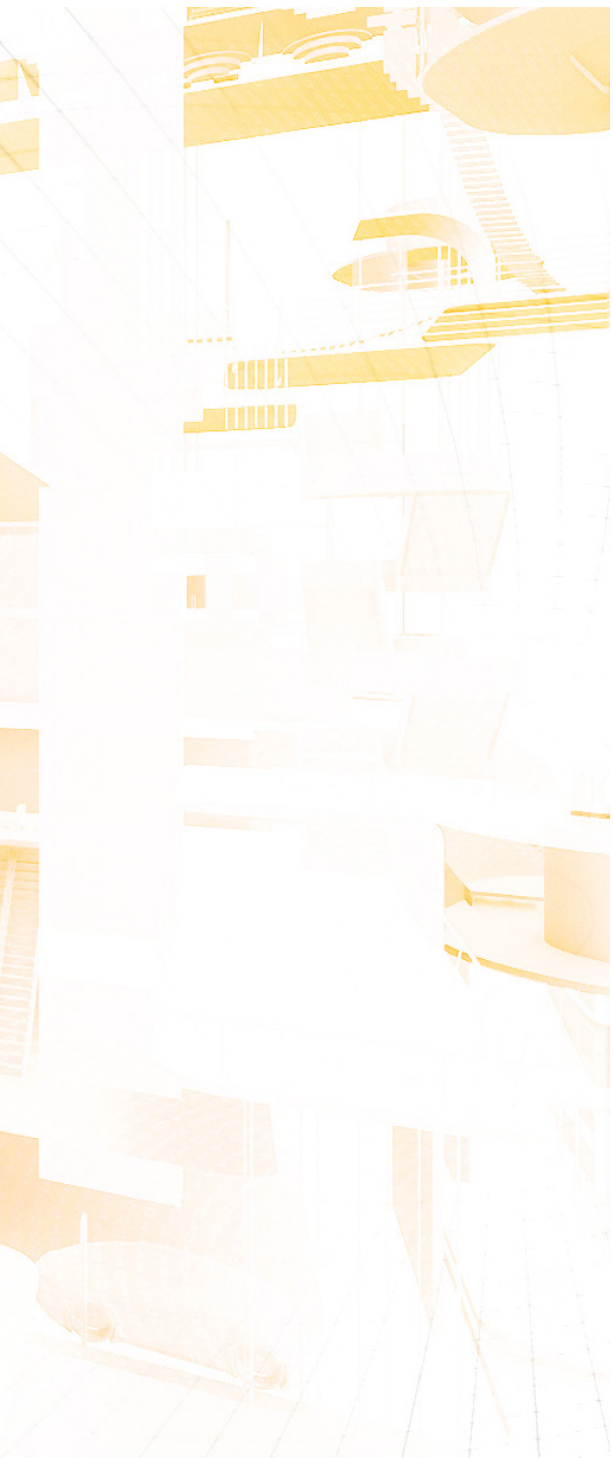
The immersive gaming space is enclosed by a board-less screen turning the space into a tunnel, which allows the game content to be projected out. The tunnels are scattered in the volume and creating different circuits which have different undulation and porosity. They can be used for different games and themes. There are also many sensors installed in the tunnel, like a 4d cinema, which can simulate the sensation of vibration, temperature, humidity, smell, etc. These circuits tunnels will lead people to different social platforms, where people can take an intermission break, discuss game strategies or make friends. The interface space and social space are juxtaposed on these platform. The exterior wall of the tunnel is an interactive screen, as an extension of this social platform into the cyberspace. Just as the Internet provides extensive and interactive ways of displaying, linking and retrieving information, IoT may now allow unexpected ways of accessing, interfacing and uploading the body itself. So People who stay at home can upload their body onto the screen through VR and authentically communicate with real people in the physical space.

Smart technologies allow conversation to transcend the boundaries between digital and physical. There's no necessary to distinguish which is physical or digital in this incubator, because in the smart future, both of them are real in our lives. The overlapping and hybrid architectural space enables our connection wider, more real and more joyful than ever before. This infrastructure as the trigger for interpersonal relationships is realized through social games, it will accomplish its promise of an "empathy engine," using the medium to connect people from around the world.

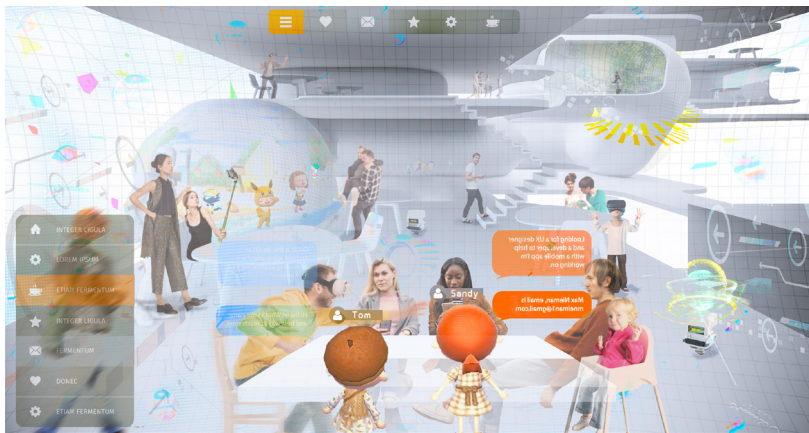


Figure 5.2.5 Connection Incubator





Immersive Gaming



Virtual Participation`



Hybrid Platform

### 5.3 Memory Pavilion

With the adept use of technology, people are gradually drowning in the massive amount of data generated by themselves. Programmes now tries to extract memories for its users such as a smartphone will remind it's user occasionally of the photos taken in the past month. Social media such as Facebook and Instagram often have specific nostalgic hashtag activities that advocate individuals post their photos or videos. The perception of time on these digital platforms are shrinking as Moments are instantly captured and easily shared. People's practice of the discourse on the platform shows immediacy working both as an emotional trigger and storytelling. The language of the hashtag encourages people from around the world to connect and collectively participate in the discourse. They are triggers for one to be nostalgic, and people are responding by displaying their memory—their piece of identity—on public spheres.

In today's technology-saturated culture, nostalgia is an experience of immediate memory production and self-reflection, such as posing and reviewing photos on social media. It is a feeling that not only rests on the past but also takes the learning from the immediate history to define and shape the future (Adams, 2014). The definition of Nostalgia then, is no longer about going back to the past, as much as it is about bringing the past into present—or “presenting’ of the past” .

In the future, nostalgia and technology may fuse, one inseparable from the other, allowing users to interact with their memories freely. But to better mobilize people's senses and deepen nostalgic emotions and spirituality, a space that can juxtapose memories with the body itself and provide the public sphere with collective memories is more significant than an electronic screen in hand.

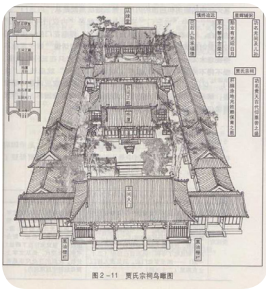


Figure 5.3.1 Traditional Chinese Ancestor Temple

"One of the main points held in common by the sacred architecture of both the East and the West is the spatial sequence which lead from the mundane world into the metaphysical inner spaces," said Monta Mozuna. By referencing to a Chinese traditional memorial temple as a local building typology for connecting people to their memories, a spatial sequence was distilled out to render a space of spirituality for the connection between memory and the body. The symmetrical configuration with a progressively elevated series from a threshold between exterior and interior, to self-purification by a skylight and to a memorial hall at the highest point, utilizes time and space to create an architectural drama for leading people gradually into a spiritual dimension of the existing environment.

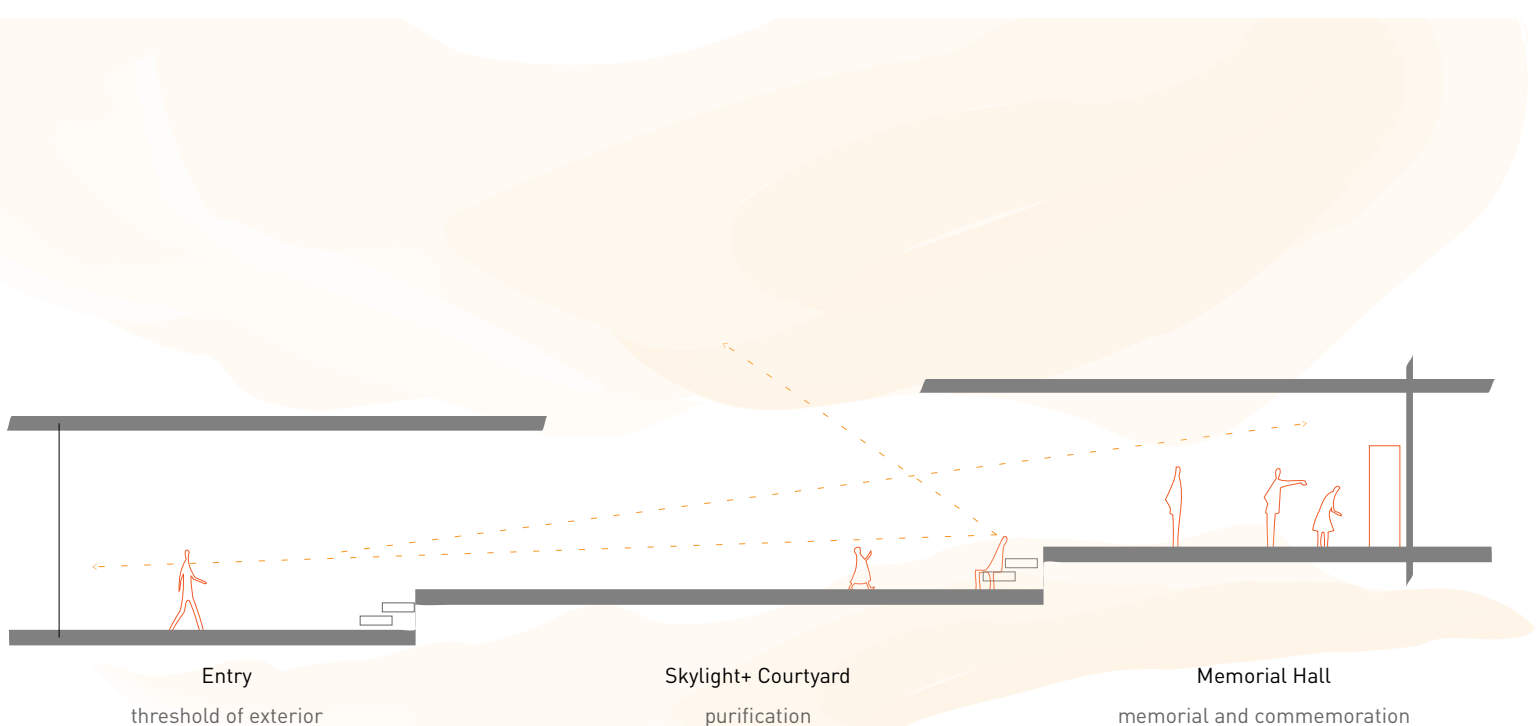
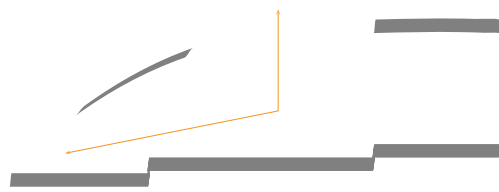
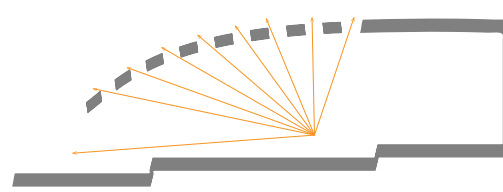


Figure 5.3.2 Abstractionl Section



Exterior Connection



Integral Roof

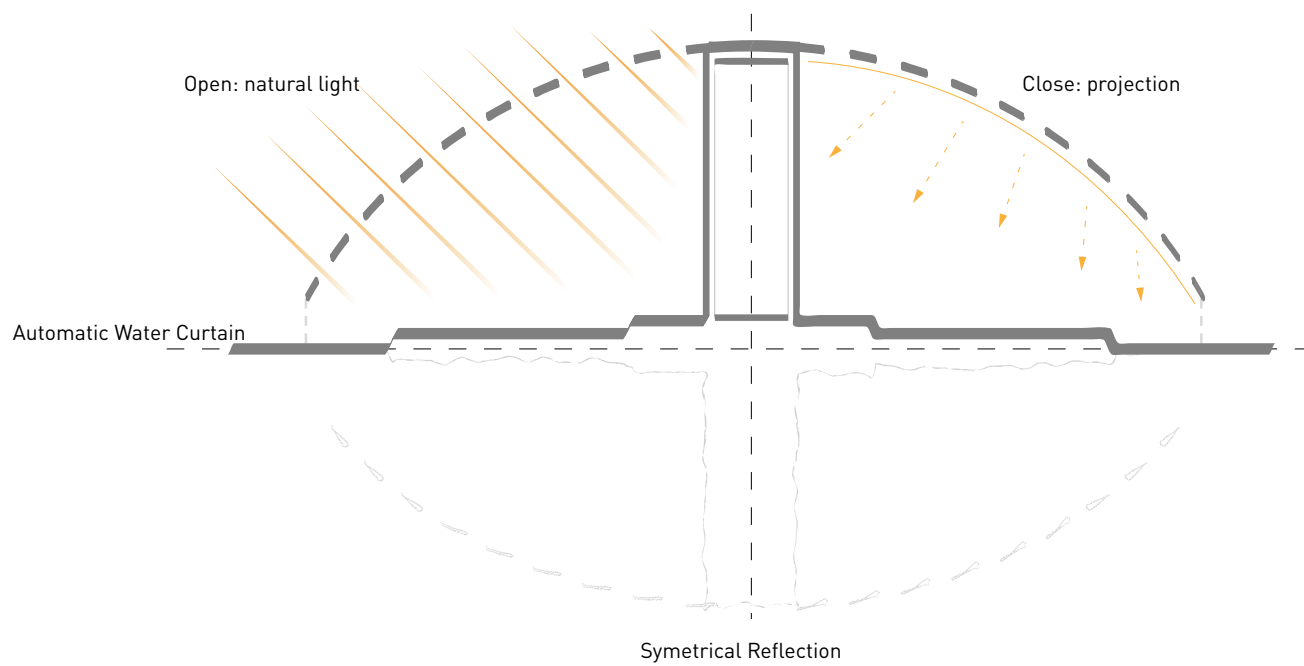


Figure 5.3.3 Form

To create a sphere for public participation, the skylight repeats in an arch and becomes a dome shape. The dome is always a symbol for spiritual expression across cultures, from the most ancient dwellings to the Pantheon of Rome and the Pao dwellings of Mongolia to the Imperial palaces of China. Also, the dome shape it is widely used for a spherical projection to visualize the imaginative virtual world. It is a typical expression of mankind's architectural view of the universe that connects people from the East to the West, from the past to the future and from the real world to the surreal one.

Additionally, the rotatable tablets on the dome enable itself to switch in different patterns from dark, enclosed to bright, open, from the sunlight to projections as a showcase of collective memory in the forms of photos or videos. The mirror-like water on the floor enhances the vibes for each case and complete the dome to a womb-like oval shape through reflection. Here it elaborates the dialect relationship between physical and digital, natural and virtual, real and surreal. (On the ceiling, the penetrated sunlight is real while the projection is virtual, the water pound is real while the reflection of photos is virtual, the the physical surround is real while the memories and emotions are "virtual"). An automatic water curtain at the gateway is also an accentuation on this ambiguous overlapping condition. The nostalgia trigger is made of a comprehensive sensorial reaction of the body and the architectural environment. At the same time, however, users are allowing this power relationship to exist as they produce, archive and display their memories online.



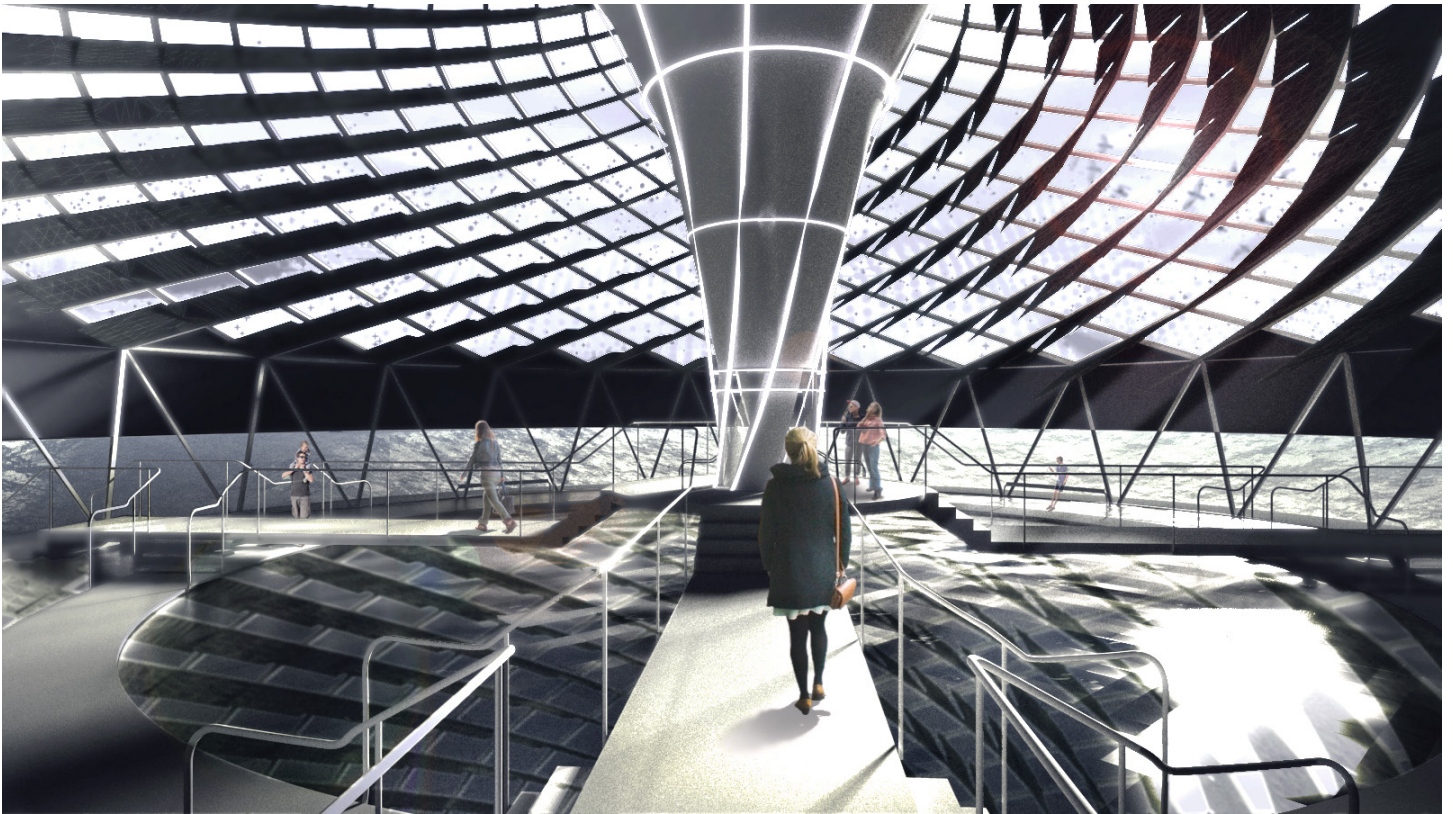


Figure 5.3.4 Open Condition

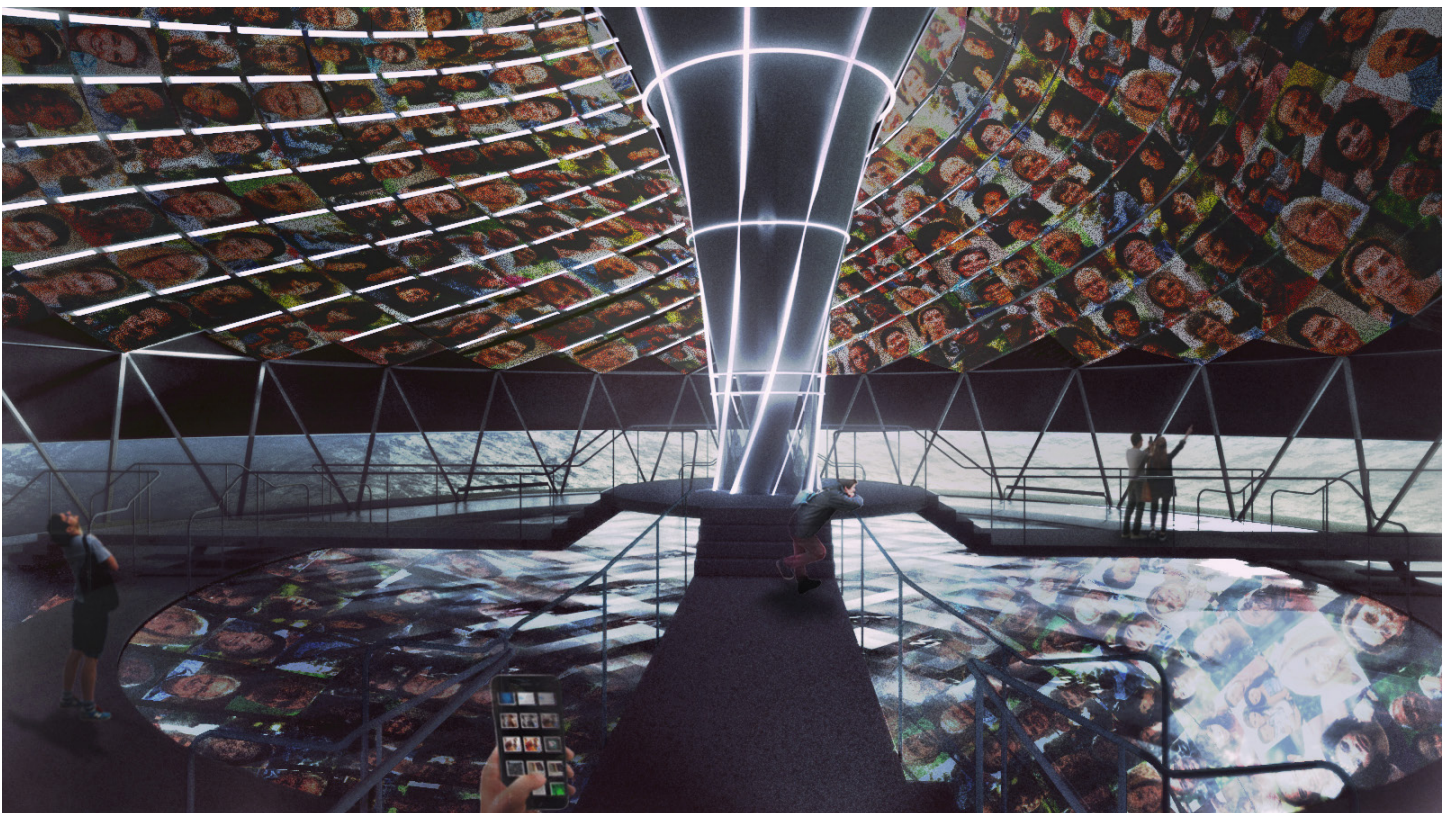


Figure 5.3.5 Closed Condition

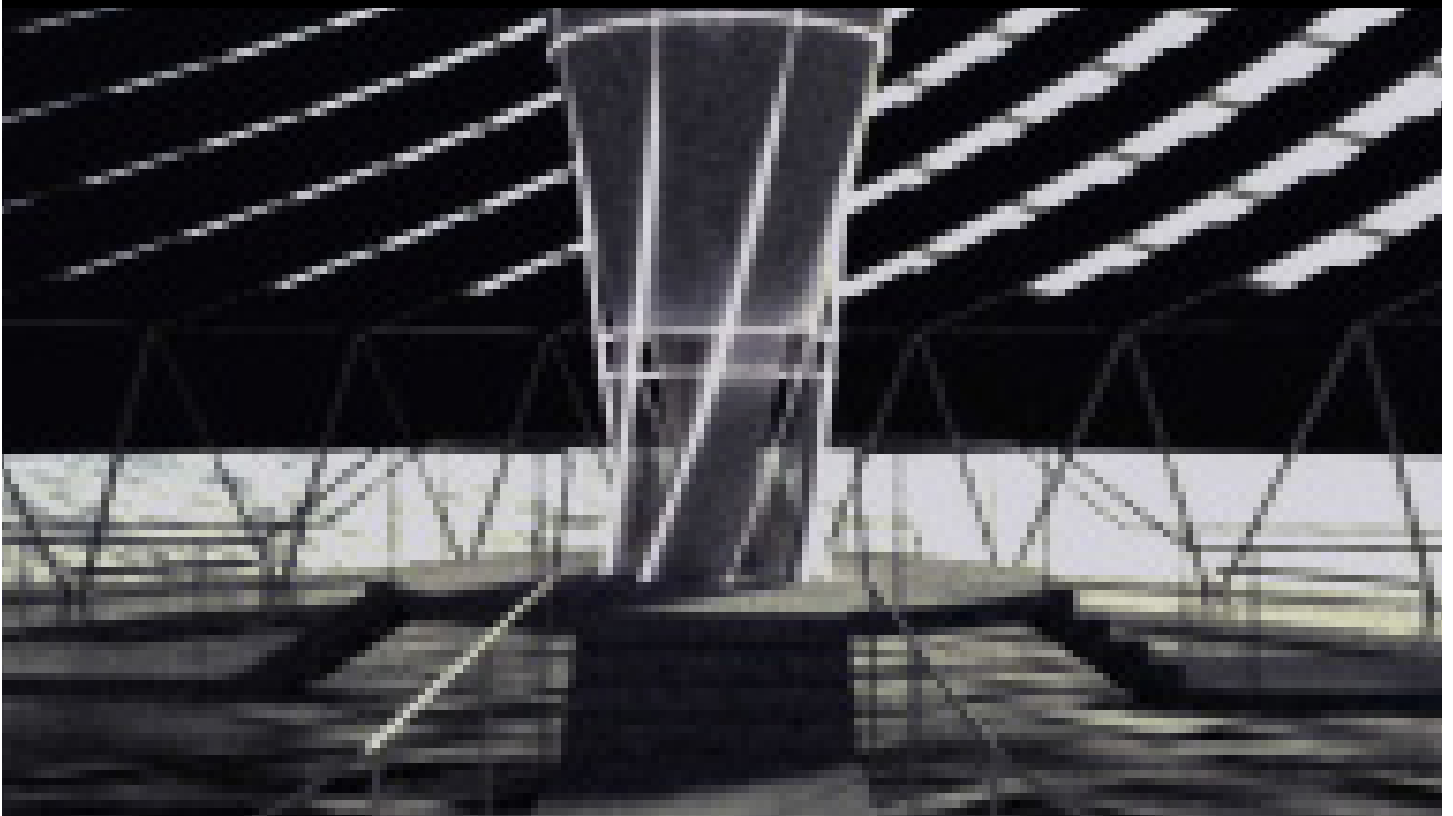


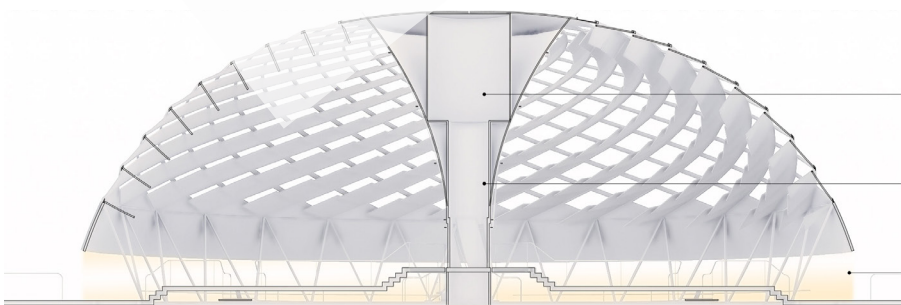
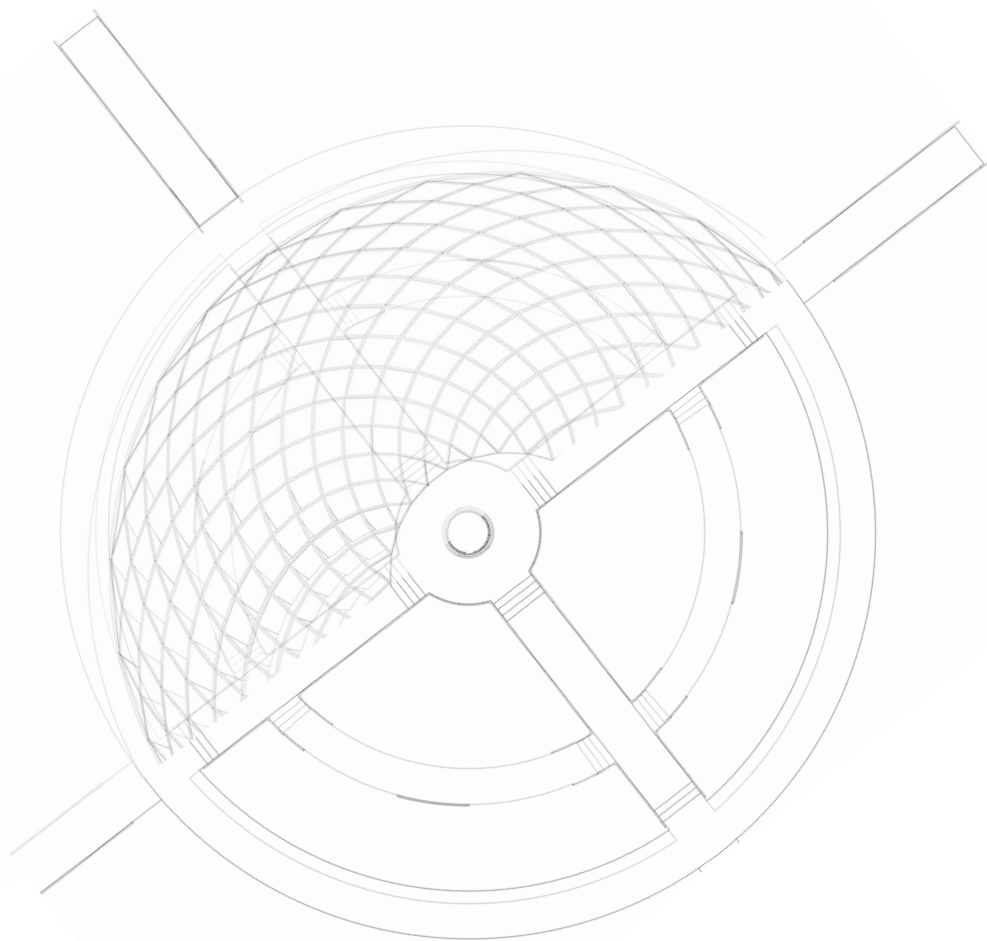
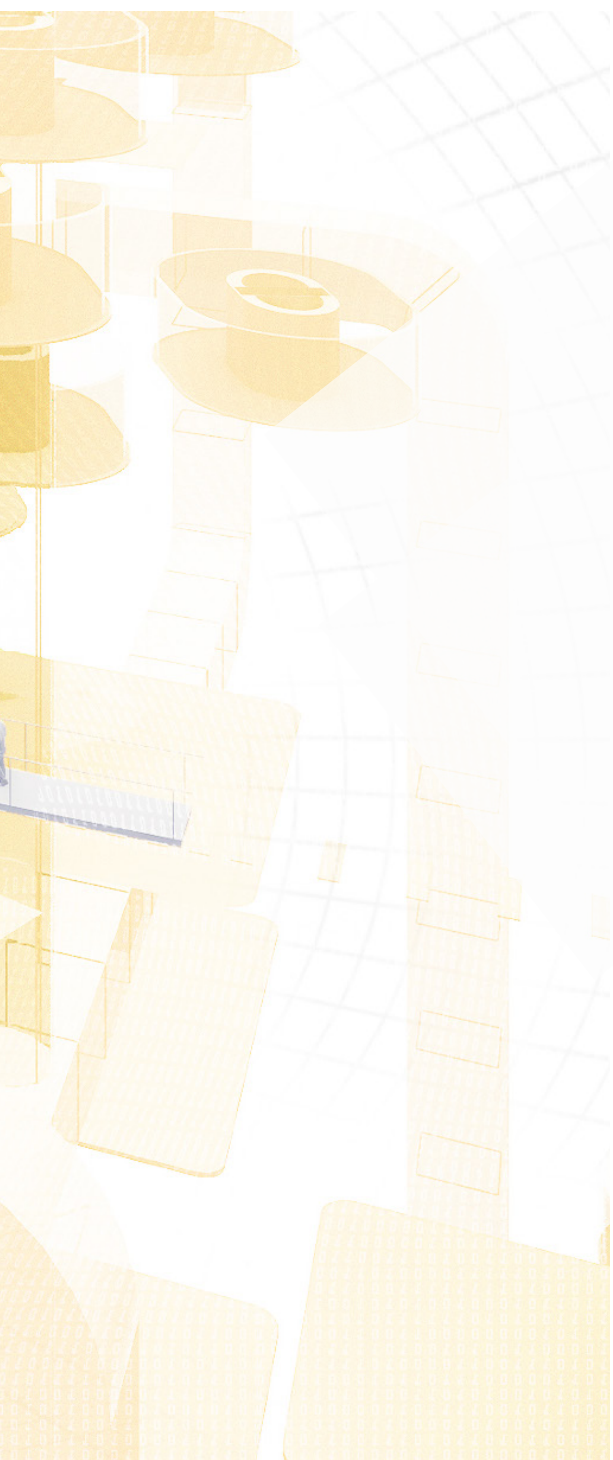
Figure 5.3.6 Rotatable Tablets





Figure 5.3.7 Memory Pavilion





## 5.4 System of subsystems

The interoperability of different spaces is realized by interconnected devices and sensors. Devices in space of the same level realize people's different living needs through data exchange, thereby making the space more flexible. These devices can also link across spaces of different level with the network to allow conversation between spaces. Each device is a subsystem that collects, processes, and manages certain data from the users. Each subsystem is transferred to the higher level in accordance with the user's permission, thus ensuring the security of the data in a very hierarchical manner. The entire IoS system macroscopically expresses everyone's different life tendencies. This diagram shows a system with different subsystems of smart devices in each scales and as a whole.





## 5.5 Future Colony of Spaces

In the smart era, virtuality and reality will become more indistinguishable due to the interconnection of everything, and it will allow the space to contain people's bodies and consciousness with ultra-flexibility and heterogeneity. The organization of different spaces is also more decentralized, scattered and free, and more temporary, instead of highly organized configuration as functionalism nowadays. With AVs and drones, transportation has also become more liquid, seeping into the gaps in people's lives and spaces. Therefore, the blur of indoor and outdoor is not only visibility but also accessibility--the linkage of the indoor and outdoor traffic system. With the exponential development of smart technology and new energy, the exploitation of energy will also lead to ubiquitous digital devices and carriers. A carrier that provides customized routine on-call connects different spaces, which is not only efficient in function but also rich in experience.

Although the emerging technology has also raised many questions about our future society, the discussion on these issues can make us more aware of how we position ourselves in the post-digital age. However, the future is yet to be defined, this thesis opens up the discussion with three independent spaces on the possibilities of how IoT will reshape our living environment and provide new connections to the self in three scales--solo, social, spiritual. The colony indicates an organic, mercurial and interconnected of spaces for the smart age. With the advent of digitally connected architecture, we have an opportunity to reinvent architecture as a source of meaning



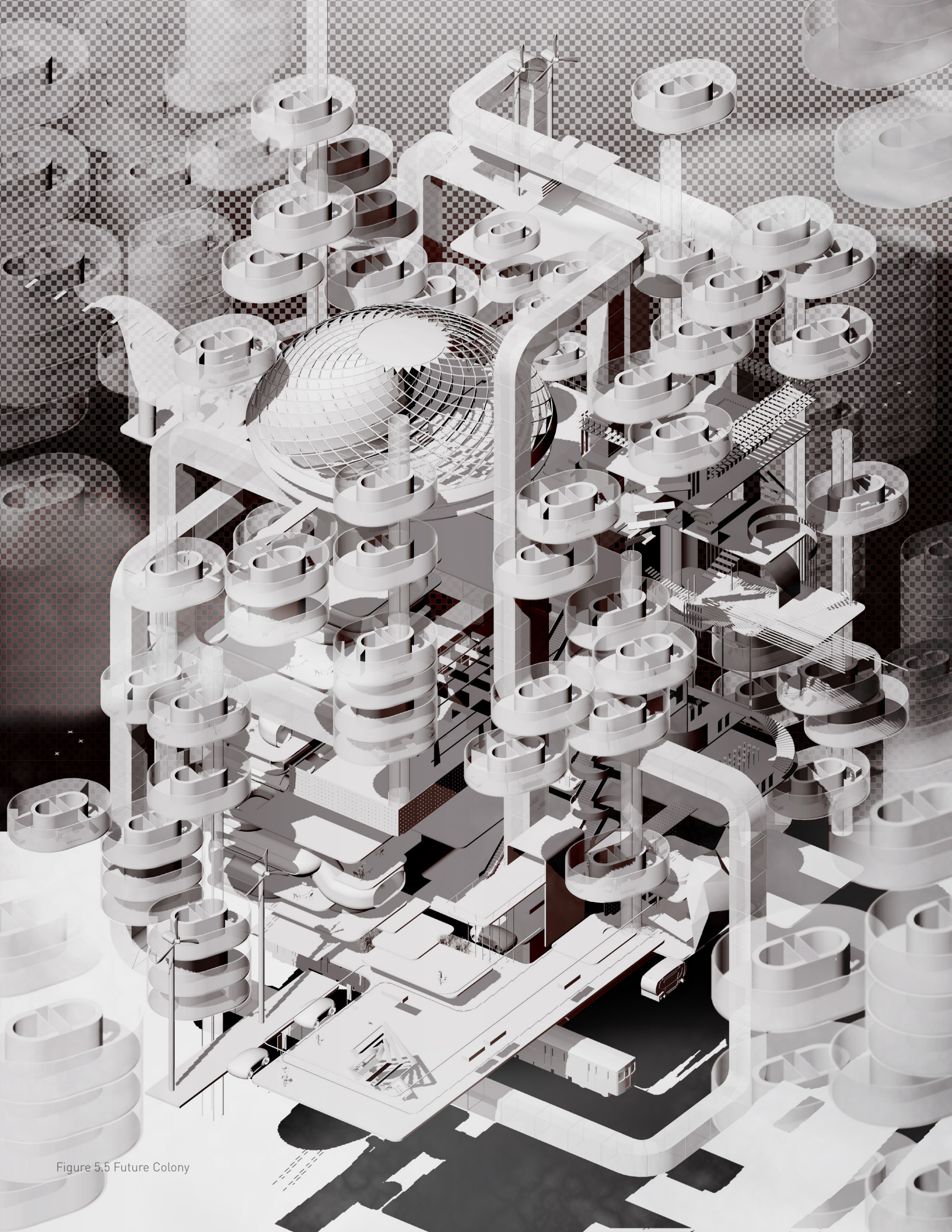


Figure 5.5 Future Colony



## **Appendix**

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Image Citation

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Figure 2.4	Ibid.

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### Chapter 4

Figure 4.1	By Author
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## Chapter 5

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Figure 5.1.7	By Author
Figure 5.2.1	By Author
Figure 5.2.2	By Author
Figure 5.2.3	By Author
Figure 5.2.4	By Author
Figure 5.2.5	By Author
Figure 5.3.1	By Author
Figure 5.3.2	By Author
Figure 5.3.3	By Author
Figure 5.3.4	By Author
Figure 5.3.5	By Author
Figure 5.3.6	By Author
Figure 5.3.7	By Author
Figure 5.4	By Author
Figure 5.5	By Author

