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Design Strategy and Case Study of Distributed System Resilience in the Chinese Context

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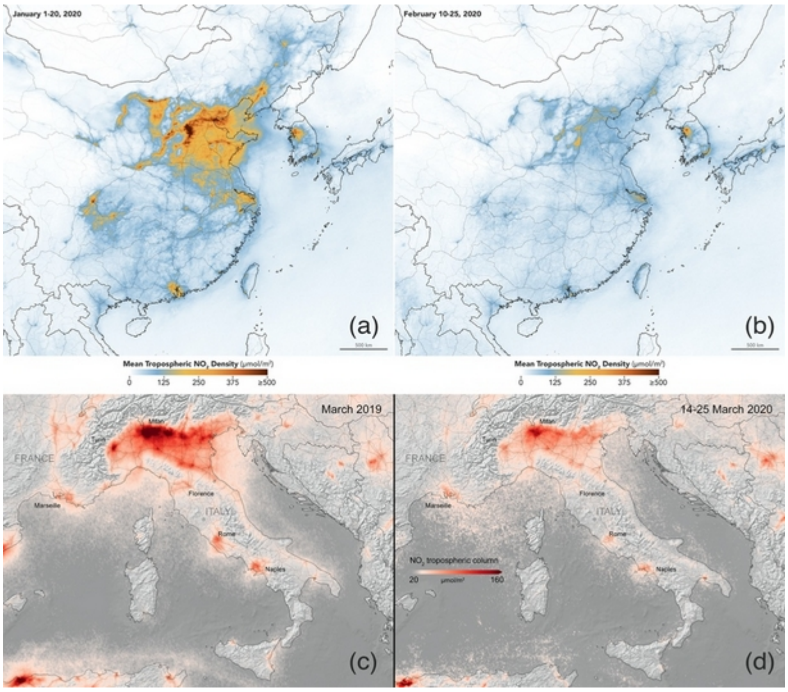
ABSTRACT

Whether for a large-scale complex challenge or a radical change, a more resilient and sustainable socio-technical system needs to be implemented. The distributed system is a new trend of sustainable transition of the socio-technical system, and the research on its related design strategies contributes to a better understanding of its nature; moreover, it helps to define the role of designers, allowing them to deal with future challenges in a more controlled manner. This paper reveals an in-depth understanding and discussion on the resilience of socio-technical systems and on the relationship between distributed systems and resilience. It selects and analyzes three representative cases, combined with a series of response measures taken by Wuhan, China during the COVID-19 outbreak. Three types of distributed system design strategies suitable for China are identified.

Keywords: Radical change, distributed economics, distributed system model, socio-technical system, resilience

1. PANDEMIC AND RADICAL CHANGE

As of June 2020, the sudden COVID-19 pandemic had infected more than 10 million people, becoming perhaps the greatest global challenge faced by mankind since World War II (UNDP, 2020). Research from NASA and ESA shows that in China and Italy, where the situation was most severe in the early stage of the epidemic, the NO2 concentration in the atmosphere changed significantly within two months of the outbreak. This reveals that the spread of the virus has had a serious impact on human activities worldwide. People have realized that the implications of such radical change extend to a global scale and that the threat and impact of the virus goes far beyond human health; in order to prevent the spread of the virus as effectively as possible, the world has entered a "great pause" (Janoo & Dodds, 2020). Many countries have closed their borders, and remote working and the online life have gradually become the norm. A study from the Harvard School of Public Health believes that COVID-19 will continue to affect the world in social, economic, and other fields in the next five years (Kissler, Tedijanto, Goldstein, Grad, & Lipsitch, 2020), meaning that humans must learn how to coexist with the constantly mutating virus. At the same time, the "great pause" has made us realize the fragility of our socio-technical system (STS) and triggered a series of discussions about social, economic, and cultural resilience and adaptability.



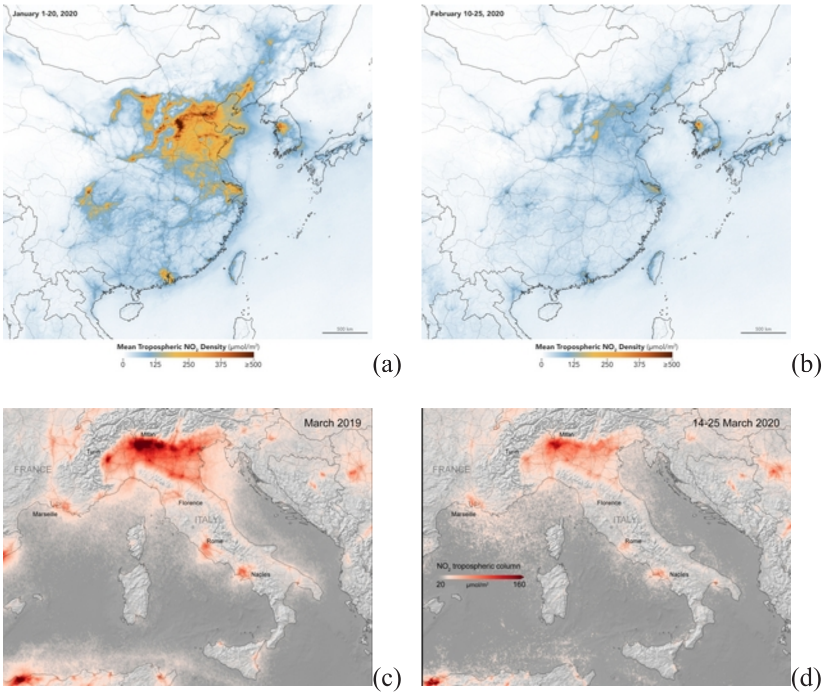


Figure 1: Changes of NO_2 concentration in different regions and time periods. Jan 2020, China; (b) Feb 2020, China; (c) Mar 2019, Italy; (d) Mar 2020, Italy

A substantial part of the research on radical change comes from discussing how to trigger a transformation of the existing development model into sustainable development through technological innovation, social innovation, and business model innovation (Leong, 2017; Stø, Throne-Holst, Strandbakken, & Vittersø, 2008; Tischner & Verkuijl, 2008; Verganti, 2008). Although we have always been aware of the possible impact of climate change, financial crisis, war, and other factors, we are still relatively optimistic that we have enough time to devise countermeasures. Despite being warned about the 2° Fahrenheit increase in global warming, we believe that it is not too late. Before COVID-19, there was no imminent risk that could stop society's current development model; for this reason, new sustainable economic paradigms such as circular economy and distributed economy could not disrupt the mainstream status of Business as Usual (BaU)(Temesgen, Storsletten, & Jakobsen, 2019).

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However, the radical change brought by the outbreak of COVID-19 completely changed the trajectory of globalization.

All industries, individuals, and organizations have stepped up the fight against the pandemic, and designers are no exception. On GitHub, designers from all over the world have contributed several pieces of personal protective equipment (PPE) that can be 3D-printed. Many "designs for epidemics and health" have also emerged on major social media and design platforms, covering everything from products to service systems. However, it should be noted that in the face of radical change, a superficial design movement cannot fundamentally solve the problem. As designers, we must acknowledge that the root cause of the problem is not only a tangible lack of infrastructure and equipment but also the lack of resilience of the STS that supports our society's operation during the epidemic is the core problem that needs to be resolved. Designers need to examine and understand the STS under the influence of radical change and wicked problems through a more flexible, systematic, and broad perspective (Manzini & M'Rithaa, 2016).

2. RADICAL CHANGE CALLS FOR A RESILIENT SYSTEM —— DISTRIBUTED SYSTEM

For a long time, human society has been a "risk society" surrounded and affected by severe events such as natural disasters, wars, financial crises, and climate change. Therefore, the sustainability of a society lies in its recoverability to overcome crises and resist pressure and destruction (Beck, Lash, & Wynne, 1992; Manzini, 2015; Walker & Salt, 2012); in ecological and social ecosystems, Holling calls this *resilience* and defines it as the persistence of a system's relationships and ability to absorb external changes (Crawford S Holling, 1973; Crawford Stanley Holling, 1996). With periodical changes and development, the concept of resilience has also begun to be widely used in the discussion of STSs. Taysom and Crilly proposed three main characteristics of resilience in STSs (Taysom & Crilly, 2017):

- **R1-** resilience to resist changes and influences
- **R2-** resilience to regeneration and recovery
- **R3-** resilience to adaptation and change

These three characteristics can also be expanded as three strategies for providing resilience to STSs:

- **S1'-** Respond to the changes and impacts caused by radical change through strengthening and resisting
- **S2'-** Respond to the changes and impacts caused by radical change through regenerating and recovering
- **S3'-** Respond to the changes and impacts caused by radical change through adapting and changing

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With the continuous integration of social and technological innovation, a new STS created by a distributed system is gradually replacing the traditional centralized system. The structure of the distributed system shifts from a hierarchical to a heterarchical one. Compared with the central system, the distributed model (whether an economic or a system one) is considered to effectively improve the resilience of infrastructure, promote social innovation, and reduce environmental pressure (Biggs, Ryan, & Wiseman, 2010; Manzini, 2015; Manzini & M'Rithaa, 2016). Especially in the production and consumption fields, such as food production, renewable energy generation, manufacturing, information and knowledge, and so on, distributed systems have been widely promoted, gradually penetrating and affecting the existing economic model (Emili, 2017; Kohtala, 2016; Petrulaityte, 2019).

With the transition from centralized to distributed system, resilience is closely related to its degree of distribution. To better clarify this connection, we propose a model describing the relationship between the degree of distribution and system resilience. The relationship between the distribution degree of a system and its resilience are explained in Figure 2. When the degree of distribution of the system is low (centralized system), a large-scale and high-complexity task or challenge (or a radical change) requires the system to utilize a certain amount of resources and energy support, and the challenge (radical change) puts the system under great pressure. As the system gradually transforms from centralized to distributed, the time, resources (materials, people, and so on), capital, and energy required for the system to deal with large-scale and high-complexity tasks gradually decrease and eventually become tasks performed by independent nodes (i.e., from ENIAC to laptop). At the same time, the system will also face new, more complex and large-scale tasks/challenges. With the further integration of technology and social innovation, a complex large-scale task will eventually be borne by the creativity and productivity generated by a node, and the STS at this time can face more complex challenges. This is a dynamic process of reciprocating cycles; on the one hand, it can be understood as a positive correlation between the degree of system distribution and system resilience, that is, the higher the degree of system distribution, the stronger the system resilience; on the other hand, it also revealed that in the face of complex and changeable systems and scenarios, we must flexibly choose and apply appropriate strategies to improve the resilience of the system.

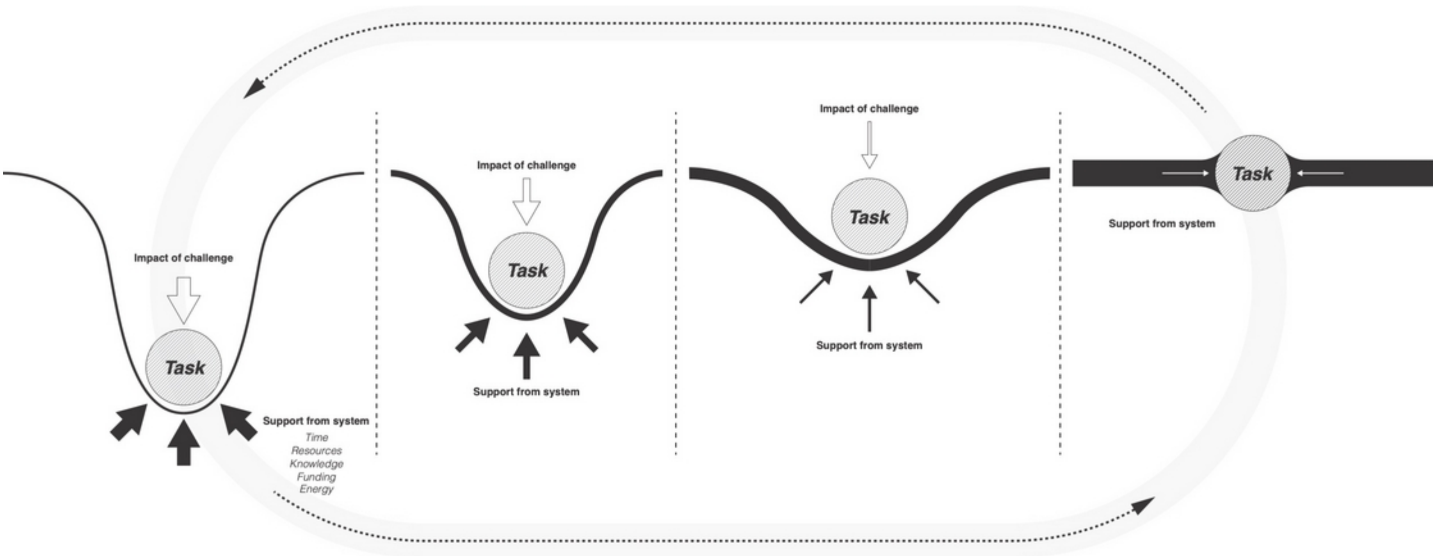

Figure 1: The relationship between the degree of distribution and flexibility of the social technology system (Author Credit)

From the perspective of social organization structure, China's social technology system is a highly centralized hierarchical structure; on the other hand, its technical system has formed a highly distributed heterarchical structure. Due to this combination of organizational centralization and technology distribution, China's choice and application of resilience strategies when facing radical change is unique. We will expand on this uniqueness further by exploring three cases that highlight the kind of alternative solutions that we might be able to create if we could build a better understanding of the system.

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3. CASE STUDIES

The following three cases are from Wuhan, China during the COVID-19 pandemic and represent three different response methods of the system in the face of radical change. The three cases correspond to the resilience of resisting change, the resilience of regeneration and recovery, and the resilience of adapting to change, respectively and reveal the differences and reasons of the strategies adopted by the system under different elasticity driving.

3.1. Square-Cabin Hospital In Wuhan

In the early stage of the epidemic, all hospitals in Wuhan and the surrounding cities experienced severe congestion, and many patients or suspected patients swarmed in for further testing, diagnosis, and treatment. In the face of such emergencies, the entire medical system of Hubei Province faced the dilemma of a lack of resources (medical equipment, beds, and so on), manpower, and experience. The most severely affected medical system in Wuhan and the surrounding cities found itself on the verge of collapse. To cope with the situation, the government decided to establish temporary square-cabin hospitals. Since January 23, 2020, 16 square-cabin hospitals had been constructed, and a total of 12,000 patients had been admitted. The separation of patients in the square-cabin hospital was effective. The ground eased the pressure for hospitals in Wuhan and the surrounding areas. In April 2020, all square-cabin hospitals in Wuhan were closed, marking that the COVID-19 pandemic has been effectively controlled in China—at least temporarily.

Figure 3. Top view of the square-cabin hospital in Wuhan (Credit: The Telegraph, 2020)

The first way to deal with the radical change system is to quickly resist its impact by implementing some kind of change that would prevent the system from crashing in a short period of time. From the case of the square-cabin hospitals, it can be learned that the vast majority of resources, funds, and energy can be selectively and temporarily mobilized in local areas to complete a large-scale and highly complex task through a top-down strategic system. By increasing the number of nodes in a short period of time and establishing connections with the system, it can gain time for the system to make necessary adjustments when facing radical changes and reduce damage to a certain extent. However, we cannot expect a central top-down strategy to provide permanent protection once and for all. This strategy may only be a short-term emergency measure, but it will be highly effective. Both Beijing during the SARS period and Wuhan during the COVID-19 period proved this point.

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3.2. Doctors' Inn

On January 23, 2020, Wuhan has shut down due to the pandemic and suspended all public transportation in the city. Many doctors and nurses could not return home to rest or reach their workplace smoothly due to traffic reasons. Xiao Yaxing, a hotel manager in Wuhan, launched a hotel support service for a medical staff, established a fast communication and information release platform through WeChat's group function, and united a total of about 300 local hotels to provide accommodation for doctors and nurses in nearby hospitals. Taking advantage of the relative convenience of hotel's location, it was used as a transfer station for materials, so that the support team in the surrounding area could pick up and drop off materials when passing through Wuhan. These hotels used as temporary residences for medical staff are called "doctors' inns."

Figure 4. Volunteers preparing medical resources for the hotel (Credit: Kai Xiang, 2020)

The second response to the radical change system is to remedy the system through bottom-up, spontaneous behavior. After top-down measures have gained time for the system, the system needs a more durable strategy to cope with challenges and increase flexibility, which requires nodes in the system to adopt a more proactive approach. In the case of the doctors' inns, we find that the occurrence of a radical change will cause the connection between nodes in the system to be severed, and the bottom-up approach can quickly restore this connection in a short period of time. The above strategy can also strengthen the node that originally formed a weak connection in a short time and "grow" a stronger network in the process of system recovery.

3.3. Community Griders & Volunteers

Since 2019, the Wuhan Municipal Government has standardized the community grid for urban management in accordance with the standard of 300–500 households, or a resident population of about 1,000, and has assigned a "grider" as manager for each grid. The main responsibility of the grider is to inspect and discover problems in municipal engineering (public) facilities, city appearance, and environment as well as social management affairs in their management area (namely the grid) and to verify, report, and record them; the grider is also responsible for notifying the related unit that is responsible for the problem and assisting in solving it. At the same time, the grider is responsible for collecting, sorting, and analyzing related information and data of their community, advancing suggestions for urban governance optimization in the grid. After the outbreak, griders, as the people with the clearest information and conditions in the community, became a critical hub and link point in community control and management. However, due to the complex situation, the number of grid members was limited, and each family's situation was different; similarly, the large number of people complicated the situation. Therefore, a group of volunteers including community leaders and administrators was temporarily recruited for maintaining daily life and provide supplies to the residents of the entire community.

Due to the lockdown of the city, all communities in Wuhan adopted a 24-hour closed management. Many communities have elderly residents who do not use the internet or mobile phones for shopping; therefore, a considerable number of them had to rely on community grid members to assist in the purchase and delivery of food and medicine. In addition to the medication problems of critically ill patients, community griders were also responsible for distributing everyday supplies in the community and for keeping statistics and managing the health status of the residents in their community.

Figure 5. Grider Feng Feng helping elderly people purchase daily medicine (Credit: Xingxin Zhu, 2020)

The third strategy for dealing with radical changes is to gradually form/generate a new mechanism in the process of bottom-up and top-down actions, which can be a new policy, a new mechanism, new social consensus, and so on; in this way, the system can adapt to making changes in the face of impact. Hybrid strategy requires the system to propose a new and far-sighted strategy from top to bottom before radical change occurs and put it into practice. At the same time, the grassroots/bottom nodes have a clear understanding of related policies. When the radical change comes, each node has a clear understanding of its own responsibilities/responsibility, and the relationship between the nodes will follow the challenge according to the impact, flexibly adjusting the strength of the relationship between different nodes.

4. DISCUSSION

Through the discussion of the cases above, we identified the strategies and mechanisms of a system for responding to radical changes in three different scenarios:

1. Bid time for the system through a top-down approach (temporary, partial, and selective) – **resisting**
2. Through a bottom-up approach, nodes autonomously and spontaneously rebuild and strengthen connections (weak social relations briefly become a strong relationship) – **recovering**

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3. Hybrid, top-down, predictive, preventive mechanism + combination of self-organizing behavior of bottom nodes (establish a long-term cooperation) – **adapting to change**

These three strategies provide inspiration for how designers can make more effective design interventions for more resilient STSs.

First, we believe that with the continuous integration of technology and social innovation, the popularization of distributed systems will enable society to have better resilience in response to radical changes. However, at this stage, we also cannot ignore that the centralized strategy will have a significant positive effect in dealing with great changes by mobilizing social resources and concentrating power in a specific region, system, and cultural context. The formulation and implementation of this top-down strategy requires a decision maker and a policy maker to develop a more comprehensive and far-sighted strategy with broader system thinking; on the other hand, it also requires more designers to participate. In the strategy formulation process, a kind of "glue" is used to fill the gap between different stakeholders.

Second, in the post-pandemic stage, design needs to participate in the creation, repair, and regeneration of the STS in a more active way, injecting greater vitality and greater flexibility/resilience into it. At the same time, we have also noticed that some practices based on distributed system models play an active role in the epidemic. With the support of distributed design and manufacturing, local residents can obtain PPE and information/knowledge more conveniently and quickly. With the help of social media platforms, which are even faster and often more accurate than the government, an information platform regarding the spread of the epidemic has been created for public reference. In the future, we believe that more distributed economic models will have a greater and more positive impact on the resilience of the STS at different levels, which will surely generate a large number of new design opportunities, design strategies, and design methods.

Last, design interventions should be more deeply involved in activities that change system resilience rather than shallow interventions. In the superblock project in Barcelona, the designer deeply engaged in the cooperation between the Barcelona City Council and the Urban Ecology Agency, reshaping the neighborhoods of Barcelona, providing high-quality public space for local residents, improving the mobility of the streets, and enhancing social cohesion. It is worth learning that the implementation of superblock shows that the improvement of the STS does not often require huge changes or the reconstruction of a large part of the infrastructure. This purpose and effect can also be achieved through small-scale, low-cost actions; therefore, in the future design of distributed systems, the participation of all stakeholders, especially low-level citizens, will be a key point of the design process, representing one of the best ways to ensure that the design output is accepted by society.

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