

Nanjing: a Smart City in China

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ABSTRACT

This research paper aimed to explore various aspects and dimensions of a smart city-Nanjing, especially the smart managements of government mainly in transport, healthcare, power grid, community, and government data center project, the harmonious development between man and nature, and concluded which factors made Nanjing become a smart megacity within a few decades. To bridge the gap in literature regarding the concept of smart city and its implementation, a directed qualitative conventional content analysis is used to analyze the collected ideas. It is found that the government plays a crucial role in the construction of smart cities. Smart government can enables citizens to coordinate with the smart construction of transport, healthcare, education, communities and ecological protection. As a conclusion that the smart government and harmonious citizens have made Nanjing become a smart city.

Keywords: Smart city; Nanjing; transport; healthcare; power grid; community; government

1. Introduction

More than half of global population is now urbanized, and growing in a fast pace ^[1, 2], which expected to increase from 7.3 billion in 2015 to 9.5 billion by 2050 ^[3], and caused different issues to the environment, economic and social sustainability of cities ^[4]. Problems related to the traffic crowd, poor healthcare, backward and ageing urban infrastructure, educational issues, housing shortages, inadequate energy, insufficient power generations capacity, increasing crime rates, lower employment, power security, issues in supply connections, high power loss in transmission, frequent power troubles and lack of real time data sharing have been arising and hence caused the development of city to fall apart mostly in many developing countries ^[5, 6]. This has ignited the usage of technology as a solution of all these issues and to deal them with a smarter way. Hence the concept of "smart city" is coming up, and becoming critical in bridging the research, projects and initiatives exploring the role of technology in urban life.

With the rapid urbanization and increasing population, current cities are deprived of key elements as quality of life and socioeconomic development. "smart city" is a futuristic approach to relieve obstacles triggered by the growing population and rapid urbanization which is going to benefit the governments as well as the citizens. Smart cities try to make cities more efficient, sustainable and livable. Namely, a smart city is a city that can monitor and integrate functionalities of all the critical infrastructure like railways, roads, tunnels, airways, waterways, communication power supply, etc., control maintenance activities and can help in optimizing the resources while keeping an eye on the securities issues as well ^[7].

Smart city is a new tendency of urbanization, Wey (2014) have argued about the new urbanism and smart growth concept to deal with city problems especially environmental, housing and citizens' well-being ^[8]. The focuses of smart cities development are improvements in citizens' life, environment efficiency, security and sustainability with centrally controlled and monitored technological infrastructures^[9-11]. Giffinger (2007) have defined smart governance, smart people,

smart environment, smart economy, smart mobility and smart living as six major aspects of a smart city ^[12]. The smart cities would incorporate the ICTs and Internet of Things (IoT) embedded into most of the sector of urban development such as government functionalities, services deliveries, city operations, and intelligent analytics to optimize the services, production and usability ^[13-14]. Ojo (2014) have discussed the purpose of smart cities such as carbon reduction, energy efficiency improving, high quality living surroundings, green urban areas, artistic infrastructure and city evolution as living and innovative laboratory to compete at global levels ^[15]. The smart city transformation is a complex and multidimensional process ^[16], which depends upon the collective integration of technological, governmental, institutional and transitional components. Smart cities can offered infrastructural and information-based services along with businesses opportunities for the economic development ^[17].

To design and develop smart services, urban planners and regulators should seek the views and needs of citizens' to resolve local priorities and requirement of citizens ^[18]. The new required policies and regulations facilitated the smart services in an easy manner in smart cities. In developing countries, paucity of resources, government accountability and structure are some major causes for the failure of public service delivery ^[19]. There is an intense desire of structured governance for designing new urban policies, participatory decisions making processes and accomplishment of policies by involving multi stakeholders for the effective design of smart cities ^[20].

In order to boost the sustainability and livability of real-world smart cities, its deployment is ascertained to improve the competitiveness of cities, According to the CIMI (Cities in Motion Index) index results, City of New York (USA), London (UK), and Paris (France) topped the list respectively, while San Francisco (USA), Boston (USA), Amsterdam (Netherlands), Chicago (USA), Seoul (South Korea), Geneva (Switzerland), and Sydney (Australia) round out the top ten ^[21]. New York City topped in economy index with strengths in human capital, governance, and technology. London is placed as the second smartest city in the world according to CIMI ^[21].

London city is distinguished for its aberrant passenger management and transportation systems. The transportation system of London has introduced congestion management from number plate recognition, which has efficiently reduced vehicle congestion during rush hours. Moreover, it includes Wi-Fi connectivity on the Tube, intelligent road management, and cycle renting schemes.

San Francisco (SF) is famous with the greenest city in Northern America according to US and Canada green city index ^[22]. SF uses technology to improve operational performance of buildings, extend transportation system, centralize waste management procedures, and reduce energy consumption. In other words, SF includes smart transportation, smart energy, and smart community as its main components that serve citizens of SF. Novel waste management approaches of municipal are considered as the main smart community aspect that upholds the title “greenest city”.

New York (USA), San Francisco (USA), London (UK), and Paris (France) are the typical examples of smart city. In China, more and more cities, such as Shanghai, Nanjing and Hangzhou are striving to become smart cities.

2. The context of Nanjing

Historically, Nanjing was one of the Four Great Ancient Capitals of China (Xian, Nanjing,

Beijing, Luoyang). It is an important birthplace of Chinese civilization and also is the political, economic and cultural center of southern China.

Nanjing has a long history. The discovery of the fossils of Nanjing ape-man (Fig. 1) was a major discovery of world significance in the research field of Paleoanthropology and Paleolithic archaeology in China. The discovery of two human races at the same fossil site in Nanjing is the only place in the world where two human races were found. This not only makes the cave of Nanjing ape-man the only place in the world where two human races were found at the same fossil site, but also provides a strong basis for the multi-origin theory of human beings.

These unearthed cultural relics (Fig. 2) indicated that the Neolithic Age was appeared about 7,000-8,000 years ago, and represented by the primitive villages of North Yin-yang Camp, Nanjing, P.R. China.

Nanjing was the capital for 6 dynasties, Nanjing and Rome are together known as the world classical civilization center.

Nanjing was once the seat of the Chinese Nationalist Government. It has withstood the baptism of the Second World War and the War of Liberation. So, people can't help asking what is Nanjing like now? and what make Nanjing become a city smart?

Now, Nanjing, as the capital of Jiangsu province and a core city of Yangtze River Delta economic zone, has long been ranked as the second largest commercial center in the East China region, following Shanghai. It has an area of 6587 km² and a population of 8.23 million in 2016 which is expected to rise to 10.6 million by 2020 with 86% being urban dwellers [23]. As many other Chinese cities, Nanjing has enjoyed rapid urbanization, sharp economic growth, and large-scale motorization during the last decade, yet at the same time all these have brought the city (including urban and suburban areas) serious problems such as air pollution, traffic congestion, and greenhouse gas emission [24].

In this research paper, I have explored the smart managements of government mainly in transport, healthcare, power grid, community, and government data center project, and the harmonious development between man and nature, and concluded which factors made Nanjing become a smart megacity within a few decades.



Fig.1 Tangshan museum of homo erectus fossils and site in Nanjing, P.R.China



Fig. 2 Cultural relics of 6000 years ago was unearthed in North yin-yang camp, Nanjing

3. Results

3.1 Three Major Field of Smart Nanjing

3.1.1 Smart infrastructure supports "smart Nanjing"

Smart infrastructure includes urban infrastructure such as information and emergency response of transportation and power grids. The integration of the three networks enables citizens to fully enjoy the resources of radio, television, telecommunications, cable, wireless broadband network and 4G communication network (Fig.3), and promote the intensive infrastructure, intelligent mode and wireless urban coverage of the city. Three operators of China Mobile, China Unicom and China Telecom have been coexisting and competing in Nanjing communication area for many years. Due to the use of a large number of 4G towers and sensors, the 4G network signals have covered the whole Nanjing city. By using 4G network, citizens can communicate each other or in a group by QQ or WeChat (Fig. 4) timely and expediently. As a result of the introduction of competition mechanism, the public get the price preferential benefit and the service quality enhancement obviously. The integration and comprehensive access of services between various network operators was strengthened, and a smart city infrastructure that ranks among the top in terms of scale and capacity, technology level and service level was built, so as to lay a solid foundation for smart Nanjing.

The foundation of intelligent Nanjing also includes social security and ecological environment. Peace in Nanjing is the premise of wisdom in Nanjing. A comprehensive intelligent three-dimensional emergency protection system was built, and organically links 110/119/122 alarm scheduling command system, GPS vehicle anti-theft alarm system, remote image transmission system, remote intelligent phone alarm and GIS system, Realize crime implementation and fire occurrence real-time continuous alarm at the scene of remote visualization, real-time positioning control, synchronous scheduling command, turn the city security from the afterwards controls to beforehand control, really improve the citizens' security and satisfaction.

Ecological Nanjing is the dependent environment of intelligent Nanjing. In the construction of intelligent ecology, sustainable energy such as solar, wind and biomass will be widely adopted. Rainwater and sewage diversion, garbage classification and treatment, waste recycling, air quality control will be widely used.

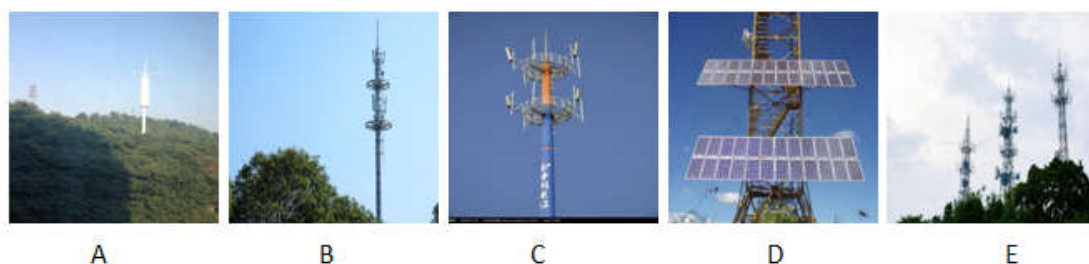


Fig.3 4G towers and sensors, A and B represent China Mobile, C and D represent China Telecom, E represent China Unicom

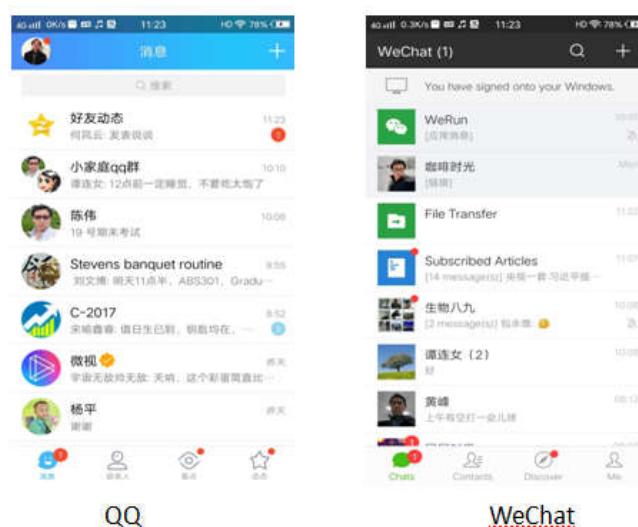


Fig. 4 QQ or WeChat styles of communication timely and expediently

3.1.2 Smart industry leads "smart Nanjing"

Nanjing's intelligent industrial pattern mainly with the contents of software development, service outsourcing, industrial design, cultural creativity, consulting and planning is increasingly emerging; insisting the principle of government-guided, enterprise-led and market-oriented development; persisting in the innovation system combining production, education and research; fully support and promote the independent innovation of smart enterprises and accelerate the construction of smart industrial clusters.

Smart Nanjing relies on the Internet and the IoT to achieve efficient flow of information, and the IoT has formed an industrial group with Nanjing characteristics; a number of public service platforms and demonstration application projects also has been built.

3.1.3 Smart government serves "smart Nanjing"

After ten years of efforts, Nanjing e-government has formed its own characteristics, mainly reflected in the following areas: (1). A number of key e-government projects, including government data centers and comprehensive government platforms, have been promoted; (2). Urban management, safety, emergency command, and other information projects closely related to

maintaining urban stability and ensuring urban safety have been constantly improved; (3). Government operations, services and management are more efficient and intelligent.

Perfect, efficient public services is the starting point and the foothold, wisdom of Nanjing public services involving wisdom of healthcare, education, transportation, social security, ecology, and comprehensive emergency management. All these are the citizens' most direct and most realistic interests problem, the solving of these problems make all people share the achievements of informatization and urbanization.

3.2 Five Symbol Projects of Smart Nanjing

Five symbol projects are important images and demonstrations of smart Nanjing. They are smart transport, smart healthcare, smart power grid, smart community, and Government data center project.

3.2.1 Smart transport

Intelligent traffic system is an advanced integrated traffic management system, which is the nerve of a smart city.

At present, the urban land use layout of Nanjing has been basically determined. A well-connected urban transportation network has been formed (Fig. 5). On the premise that the roads in the central urban area are not allowed to be expanded or transformed on a large scale, only the intelligent transportation system (ITS), such as the use of a large number of sensors (Fig.6) and establishment of Nanjing comprehensive traffic information exchange platform, can be used to control and make urban traffic more effectively, improve the mobility and safety of intersections, and maximize the efficiency of existing road resources.

It has been a consensus that metro is an affordable, clean, convenient and sustainable travel mode. By the end of May 2018, ten metro lines were running in Nanjing (Fig. 7(A)), covering 378 km and 174 metro stations. According to “the urban planning of Nanjing city (2007-2030)”, 25 metro lines with a total length of 1011.2 kilometers were designed to run in Nanjing metro network by 2030 (Fig. 7(B)).

With the rapid development of the Internet and the use of new technology, the more and more convenient ways of buying tickets is not only convenient and popular, but also shows the magic charm. The first way is to buy a special ticket (Fig.8(A)) automatically by throw money in a machine. The shortcoming of this way is that much time will be wasted on waiting in line, especially during rush hour. The second way is to directly enter the station by swiping card (Fig.8(B)). The third way is to use AliPay payment method. Holding a smart phone, travelling the whole Nanjing. Meanwhile, a preferential policy has been in implementation, that is, in 90 minutes, RMB ¥1 Yuan can be saved by swiping the same card to transfer any vehicles.

Shared-bike system is a characteristic of smart Nanjing. More than three types of shared-bike are circulating in the smart city (Fig. 9). The method of unlock to use is very simple, only to sweep the qr code by the APP of smart phone Modern bike share schemes have the potential to overcome some major shortcomings of integrating private bicycles and metro. Metro-bike share systems enable citizens to use bicycles on a flexible “as needed” basis, potentially making transit and biking simpler options for more frequent use^[25-26]. Cities with high levels of transit usage and cycling face onboard capacity constraints. Bike share systems at metro stations could help alleviate the crowding of transit systems related to onboard bicycles^[27-29]. Encouraging bicycle use for egress trips is more difficult, as some public transportation policies do not allow bicycles

to be brought onto transit vehicles at certain times of day. In these situations, a case could be made for bike share to make it simpler for commuters on the last leg of their public transport journeys^[30-32]. As bicycle vandalism and theft often occur around transit stations, bike share systems help encourage rail commuters who worry about or have experienced bicycle thefts to apply bike share-metro integration^[33-34]. Because of these advantages, many citizens may be tempted to shift their trip modes into metro-bike share integration mode.

Besides shared-bike, The government has invested heavily in public bicycle systems (Fig. 10) and new energy green bus systems (Fig.11) for the construction of ecological city. The online taxi-hailing services, such as Di-Di(Fig.12); Mei-Tuan; Cao-Cao; Yi-Dao, are more convenient for the citizens' outgoing.

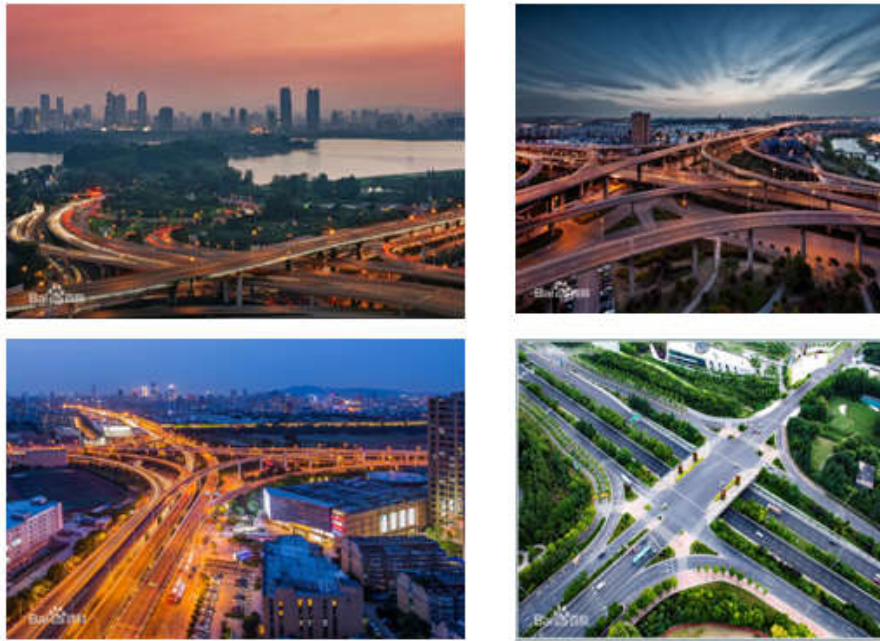
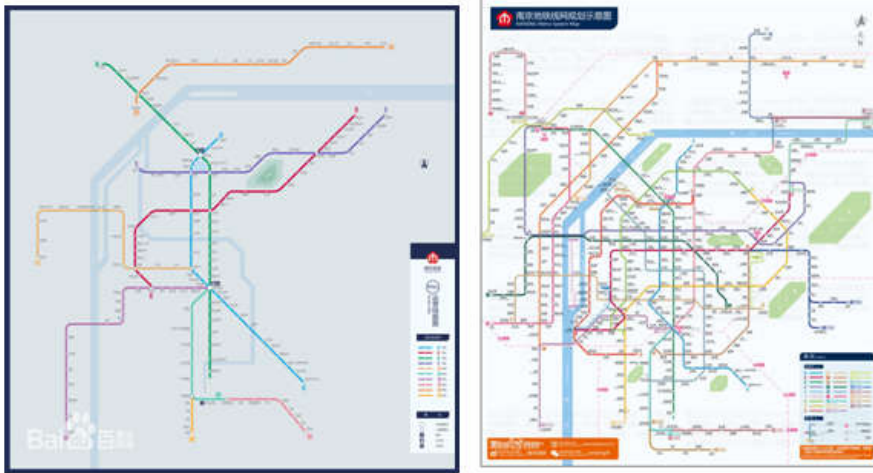


Fig. 5 A well-connected urban transportation network has been formed in the smart city of Naning



Fig.6 a large number of sensors in the smart transport of Nanjing city



(A). 10 metro lines by the end of May 2018 (B). 25 metro lines by the end of 2030

Fig. 7 Metro lines in smart Nanjing, by the end of May 2018 (A), and 2030 (B).



(A). Only used by metro, and single use

(B). Can be used not only by metro, but also by bus or taxi for ever.

Fig. 8 Smart vehicle cards used in Nanjing

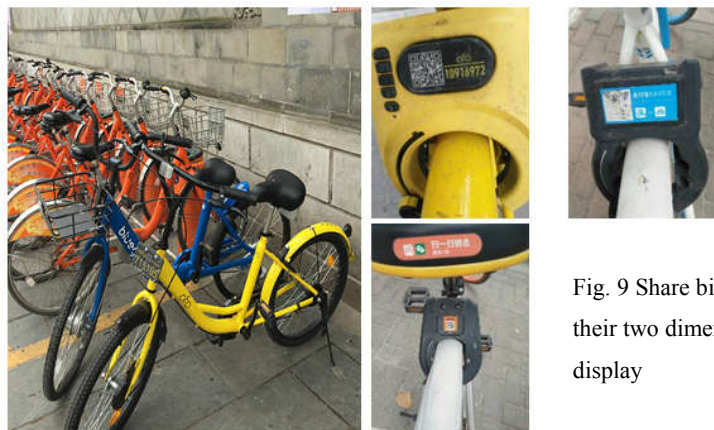


Fig. 9 Share bike types and their two dimensional codes display



Fig.10 public bicycle systems



Fig.11 new energy green bus systems

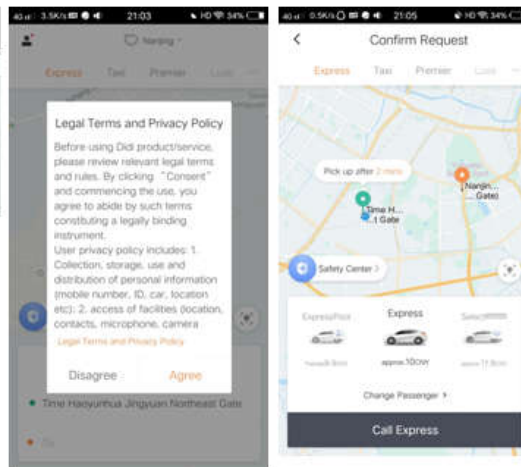


Fig. 12 Online taxi-hailing service of Di-Di and it's APP download in smart phone

3.2.2 Smart healthcare

"Smart Healthcare" is relying on the Internet of Things (IoT) technology, deeply digging into the user demand from four aspects of data acquisition, storage, processing and sharing. The health information sharing platform has been constructing, which based on two big foundation databases of the citizen's personal electronic health archives and public health resources management information

At the beginning of mobile 4G net was used commercially in 2013, Nanjing Mobile immediately gathered Nanjing emergency center, combined 4G technology with big data, cloud computing, and IoT technology together applied it into 120 emergency medical service system, and pushed out the first batch of 4G - 120 emergency vehicles in China. The mobile 4G network connects the emergency center, hospital and 120 emergency vehicles into an organic integrity, which can transmit the data of patients' life signs and symptoms to the hospital in real time. Before the ambulance arrives at the hospital, it can not only effectively carry out effective pre-hospital rescue, but also allow the hospital to have enough time to arrange medical rescue equipment and emergency plan, so as to win valuable first-aid time for patients and doctors.

In 2016, Nanjing Mobile innovatively applied the country's first 120 pre-hospital emergency "Wireless Medical Platform (WMP)", once again led the development trend of emergency industry information applications. Accordingly, the WMP applied many integrate mobile information technologies, such as 4G wireless private network, Internet+, big data, and intercom, phone cloud platform on collecting the patient's real-time physical sign information, and proceeding to the cloud in real time by intelligent vehicle-mounted terminal equipment, based on the Interactive applications such as mobile telemedicine cloud platform, audio and video interactive system, and electronic medical record management system to build a seamless communication bridge between pre-hospital emergency and hospital.

In August, 2017, the "health cabin" jointly created by Nanjing Mobile and Nanjing Health Planning Bureau and firstly appeared on Zhujiang Road of Nanjing, which can provide convenient self-service diagnosis and treatment services for citizens and bring them new experience of Internet+ the era of smart medical treatment. The "health cabin" allows citizens to use the health testing integrated machine to test their height, weight, body temperature, ECG (electro cardio), blood pressure, blood oxygen, blood sugar and other components body self-test. It has the characteristics of self-monitoring, data automatically uploading, personal health files, big data analysis and batch health management. It is suitable for all kinds of nursing homes and other health care units, the application prospects are very broad. Nanjing Mobile will use cloud service rental mode, and in stages carry out pilot promotion model of government-scientific research institute-hospital, so as to protect the health of Nanjing citizens and deeply enhance the application level of Nanjing smart healthcare practice.

Over the years, Nanjing Mobile has been committed to the top-level design of 120 emergency medical information system, continuously expanding the service field on the basis of keeping cooperation with Nanjing emergency medical center, actively guide the medical system to make full use of big data on the Internet and other means to share regional resources on interconnected platforms. In addition, Nanjing Mobile also built a three-layer network platform of "smart healthcare" to connect the health information center, community health service center, and community health service station; and build a high megabytes medical private network for citizens. All these smart healthcare policies administrated by the government really offered the citizens

more convenience and large supporting.

"Smart Healthcare" makes the medical resources of "Smart Nanjing" rationally allocated and fully utilized. At present, the pattern of Nanjing smart healthcare has basically formed. More than 3.4 million citizens' CARDS could be used in 173 medical and health institutions in Nanjing, 460 independent medical service terminals have been invested in 22 hospitals.

"Intelligent medical treatment" will bring revolutionary changes to Nanjing urban medical treatment.

In addition, "Traditional Chinese Medicine (TCM)" therapy is a major feature of Chinese medicine. The decoction time and heat of traditional Chinese medicine is also a kind of technology. In order to serve patients well, Jiangsu Provincial Hospital of Traditional Chinese Medicine has set up a special window to help patients for decoction and post to home by post (Fig.13).



Fig. 13 TCM cabinets and decoction helping windows in Jiangsu Provincial Hospital of TCM

3.2.3 Smart power grid

Nanjing has a good foundation for the development of intelligent power grid. It is an important city in the area of domestic power automation researching development and equipment production, occupying 60% of the market share of power automation control equipment. The government put "smart grid" construction on the first of emerging smart industry cultivation. By 2015, an industrial cluster of ¥100 billion Yuan has been built. Nanjing seized the opportunity of the first domestic smart grid industrial foundation loading in Jiangning district, and vigorously developed the smart grid industry. Jiangning foundation has provided a strong support on independent technology research of China's smart grid, the core equipment manufacturing, the key product testing; and have extended to the new energy and materials areas; gradually formed an emerging industry chain with complete system, high value-added and strong competitive; continuously enlarge the effect of industrial agglomeration and the enterprise cluster to promote the development of intelligence industry.

3.2.4 Smart community

Smart community aspires to uplift citizen satisfaction and wellbeing of urban citizens. In this context, smart community converges large number of smart buildings, water management systems, and waste management systems. Smart buildings include smart homes and other business infrastructure i.e. offices, schools, data centers, factories, warehouses, etc. For standalone components cannot achieve much in terms of performance. So, smart community is connected with various other components to maximize the benefits of smart city.

The smart community experiment was carried out by selecting several communities eligible with basic conditions, the elements of "smart Nanjing" were firstly expressed in the smart community demonstration project in 2016, which led the citizens to experience the convenience and quality improvement in their life, work and study.

Smart communities provide community websites, electronic shopping malls, distance teaching, online public services, digital democracy, e-commerce and other services. Residents living in smart communities can enjoy intelligent family comprehensive services.

3.2.5 Government data center project

In order to further promote the construction of intelligent government in Nanjing, and create the e-government mode of co-construction and sharing, interconnection and interrelation, Nanjing municipal government has vigorously promoted the application of comprehensive government platform, accelerated the construction of the city's e-government data center, and strengthened the service of "smart Nanjing". Nanjing government affairs data center aims to build an e-government construction and management mode integrating "technical service, resource service and management service". At present, the project has been completed and implemented.

4. Conclusion

This paper has explored the role of Nanjing government mainly in transport, healthcare, power grid, community, and government data center project, the harmonious development between man and nature, and concluded that Nanjing government plays a crucial role in the construction of smart cities. The smart government and harmonious citizens have made Nanjing become a smart city.

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