

Analysis of Internet of Things in Medical Applications

Background: Why IoT and medical application

Internet of things, serving as the extension of telecommunication and internet, using perception and intelligent devices to interactive with the physical world, interconnecting each objective through data mining, processing and calculation. This seamless connection between things can achieve real-time control of physical world, precise management and scientific decision making. According to market research of [1], there will be 26 to 50 billion terminal devices based on IoT technologies by 2020 and will up to 100 billion by 2030. With the explosive development of AI, cloud calculation, 5G and related technologies, the digitalization of medical industry has been paid attention worldwide these years. As Mckinsey predicted, the potential impact of Internet of Things will reach from 3.9 trillion to 11.1 trillion dollars per year in 2025, and the human sector which serves for monitoring and managing illness or improving wellness ranks third behind sectors Industry Internet of Thing (IIoT) and smart cities, may have economic impact from 0.2 to 1.6 trillion dollars [2].

Medical IoT Application

Take Huawei medical IoT solution [3] for example, there are four applications as following.

- Pre-hospital first aid: With the help of IoT devices, the ECG, pulse and other vital signals can be transformed to the hospital, and the doctor can complete diagnose in advance and acquire more time for treatment when patients arrives.
- In-hospital asset management: With the help of IoT label and localization technologies, the state and location of medical equipment such as PACS cart and ventilator can be tracked in real time. Besides, when infrared and gravity sensor in infusion pump can monitor the speed of infusion and automatically close in case of medical accidents.
- Medical security management: With the help of electric fence, the access control system can alarm an unauthorized baby when it approaches the exit, and automatically close the door to protect baby from stolen.
- Out-of-hospital recovery monitoring: For patients with chronic disease, doctors can capture long-time data from patients and made a more proper diagnose and plan. For patients with emergency such as heart attack, the IoT system can inform his family or hospital to take first aid measures.

Besides that, the complete medical IoT system is the great tool for dealing with severe infectious disease such as SARS and COVID-19. To deal with COVID-19 patients, UK government suggested that mild patients should isolates themselves at home, but the issue is that patients without proper medical care would be more likely become severe. Maybe with developed IoT technologies applied on medical system, hospitals or governments could monitor the patient condition to take more efficient and effective action when faces the same issues in the future.

The Architecture of IoT in Medical System

The base architecture of IoT contains four layers which are application, network, support

and perception layers, and detailed illustration of architecture will be delivered in the following content. Three-layer architecture of IoT is typically applied, and the whole system can be divided into perception layer, network layer and application layer.

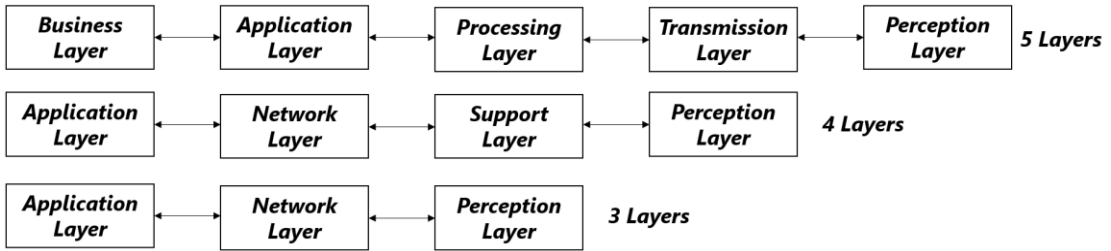


Figure 1. The hierarchy of three, four, five-layer architectures of Internet of Things

a. Perception layer

Perception layer is the data foundation layer of entire IoT system, it utilizes sensors to obtain physical, chemical or biological data and transferred analog signals into digital signals. It also transfers the data collected from electronics devices to application layer directly. This layer contains various of hardware devices as smart meters, sensors, chips, modules, and kinds of controllers. In four-layer based medical IoT system proposed by Huawei [3], the perception layer are related to various functionality as baby anti-theft, infusion monitoring, chronic disease management, asset management, and smart building. For the sensors applied in an IoT based healthcare system, accelerometers, gyroscopes, magnetometers and ECG sensors as well as temperature sensors and heart rate sensors are the most popular and wildly used.

b. Network layer

The transmission layer of the Internet of Things is mainly responsible for transmitting and processing the information obtained by the perception layer. It is divided into two categories: wired transmission and wireless transmission. Among them, wireless transmission is the main application of the Internet of Things. Some subdivision technologies for wireless transmission are shown in figure 2, besides, Zigbee, Bluetooth and WIFI are the wireless protocols currently applied in most IoT scenarios.

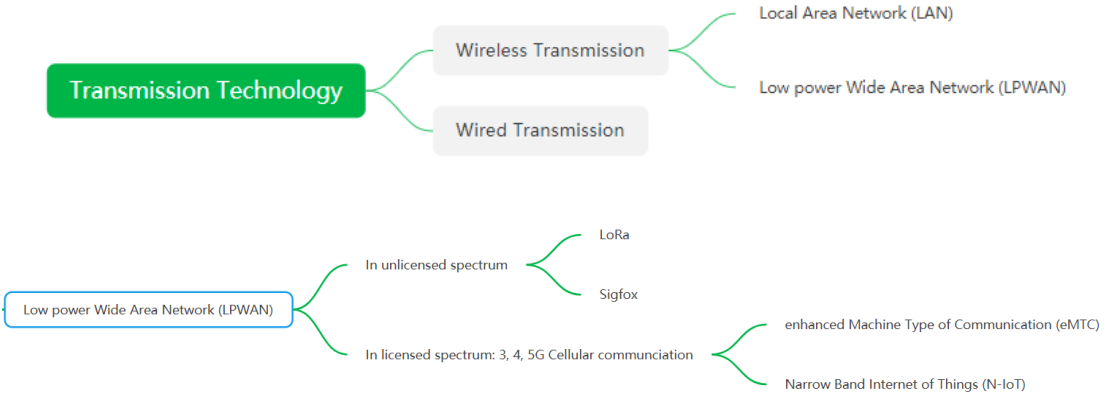


Figure 2. Mapping of transmission technologies referred to [4]

c. Application layer

The application layer could be complex based on user requirements. It carries user services and function. Currently, most of systems realize data storage and calculation in this layer. Project [5] proposed a completed healthcare system based on Galileo platform, Arduino, Raspberry Pi, and microcontroller based systems. It consists of blood glucose monitoring systems, temperature monitoring systems, electrocardiogram heart monitoring systems and heart rate monitoring.

d. Support layer and Business layer

Compared with three-layer architecture, the fourth layer support layer increases the security of IoT system, which can confirm that information is sent by the authentic users and protect data from threats through the authentication [6]. As for five-layer architecture, it is also designed to increase performance on security and storage compared with four-layer architecture.

PEST Analysis of Smart Medical Industry in China

PEST analysis is an analytical logic where the user can assess their products or organization development through political, economic, social and technological ingredients. The following content would present PEST analysis of medical industry with IoT in China.

Politics

In July 2015, the "State Council's Guiding Opinions on Actively Promoting" Internet + "Action" encouraged the development of Internet-based online medical care, remote services, and cross-hospital data sharing [7]. Then, in the next years, there are many state and policies releasing to promoting the application of IoT in health care. From company perspectives, there are many industry policies encouraging companies to apply IoT on medical project. Thus, the politics should generally benefit the development of IoT.

Economy

On the one hand, medical mistakes and over-medical treatment cause a huge waste of resources. On the other hand, rapid urbanization, lack of a sporty lifestyle and changing eating habits and increasing obesity are increasing the trend of chronic diseases as cancer, heart disease and diabetes. China has the most diabetes patients reaching to 1.14 billion [8]. The medical needs would be increased, and development of IoT would cover and satisfy more market segments. Meanwhile, the increasing economy would also promote IoT industry upgrading.

Society

Basically, China owns the strongest internet infrastructure capabilities in the world, in 2018, 4G internet covered 99% of population [9]. The internet foundation is good for IoT development, and the popularity of internet also creates greatest demands in IoT area. But consider the IoT applications in medical industry, possible challenges may be that the digitalization process of medical industry may decrease the income of medical institutions due to current unsound profit system. Less patients and more accurate diagnoses [10]

squeeze the manual space to get more profit from patients.

Technology

Currently, the related technologies as edge calculation, Artificial intelligence, blockchain are rapidly developed around the world, and there have been many IoT solutions come out for medical purpose. The realization of IoT is proved to be achievable. The challenges are many companies have achieved the proof of concept but haven't demonstrated measurable value. The scrutiny if IoT projects will only intensify [11]. Another apparent issue is that demand exceeds the development of edge computing.

Reference

- [1] Ethan A. R, Eric J. (April 2017). *Intelligent Efficiency Technology and Market Assessment* [Online]. Available: <https://www.aceee.org/sites/default/files/publications/researchreports/ie1701.pdf>
- [2] James M, Michael C. (June 2015). *Unlocking the potential of the Internet of Things* [Online]. Available: <https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/the-internet-of-things-the-value-of-digitizing-the-physical-world>
- [3] Huawei. (March 2019). *Embrace IoT, Huawei Medical IoT Solutions* [Online]. Available: <https://e.huawei.com/cn/eblog/industries/healthcare/201903181142>
- [4] wweiru. (May 2019). *Four layers of IoT* [Online]. Available: <https://blog.csdn.net/wweiru/article/details/90613617>
- [5] N. Kumar, "IoT architecture and system design for healthcare systems," *2017 International Conference On Smart Technologies For Smart Nation (SmartTechCon)*, Bangalore, 2017, pp. 1118-1123. doi: 10.1109/SmartTechCon.2017.8358543
- [6] Burhan, M. et al., 2018. IoT Elements, Layered Architectures and Security Issues: A Comprehensive Survey. *Sensors*, 18(9), p.2796. Available at: <http://dx.doi.org/10.3390/s18092796>.
- [7] IDC, *2020 Medical industry predictions* [Online]. Available: <https://www.idc.com/>
- [8] Bo C, Axel B. (July 2019). *Future is coming: Smart hospitals development* [Online]. Available: <https://www.mckinsey.com.cn/>
- [9] Yuying L. (June 2018). *China 4G network covers 99% population* [Online]. Available: <http://www.xinhuanet.com/>
- [10] Terri. C, Rohan H. (March 2018). *2018 Global Health care Outlook* [Online]. Available: <https://www2.deloitte.com/content/dam/Deloitte/cn/Documents/life-sciences-health-care/deloitte-cn-lshc-2018-global-health-care-sector-outlook-zh-180322.pdf>
- [11] Brendan M. (Jan 2020). *5 IoT Challenges and Opportunities for this Year* [Online]. Available: <https://www.informationweek.com/cloud/5-iot-challenges-and-opportunities-for-this-year/a/d-id/1336721>