Terminal Evaluation System Based on Digital Twin and Its Application

Jianan Yuan, Yan Zhen, Chao Huo and Libin Zheng *
Beijing SmartChip Microelectronics Company Limited
*COrresponding author’s e-mail: yuanjianan@sgitg.sgcc.com.cn

Abstract. Many deployed terminal devices require high stability after equipment delivery, and the project cycle is short, the task is many, the time is tight, and the manpower is limited. At present, the test of this kind of equipment is carried out by the combination of manual configuration of test instruments and manual duty, and there are many problems. In order to reduce the test cost and promote the development of the industry, this paper studies the terminal evaluation method and system based on digital twin technology, realizes the simulation test of terminal function integrity, performance compliance, protocol standard compliance, compatibility, security and reliability at the virtual level, and selects the necessary test items. The application of project results can ensure the high scalability of terminal evaluation and reduce the waste of resources caused by unnecessary testing.

1. Introduction
With the gradual maturity of Internet of things related technologies and the increasing demand of industry and production life for intelligence, a large number of intelligent applications of Internet of things and the emergence of massive, multi type and multi modality Internet of things terminals have emerged, which has brought a variety of terminal quality problems such as inconsistent standards, poor equipment compatibility, and potential information security problems that affect the lifeline of national economy[1-2]. This poses a great challenge to the detection means of IOT terminals and application systems and the monitoring measures of information security, but there is no comprehensive and mature solution in China, so it is urgent to study and establish a sound quality evaluation and testing certification service system for IOT core equipment.

2. Digital twin and key technology
The term "digital twin" was put forward by Dr. grieve in PLM course in 2003, and the three-dimensional model of digital twin was given: real physical product, digital virtual product, virtual and physical product data and information connection[3]. Although there is no unified definition of digital twin, and it is still in constant progress and development, we can still summarize the core elements and key technology system of digital twin.
(1) Comprehensive perception of data. Data is the power and foundation of intelligent production management and control system, and the core driving force of digital twin [4]. Based on the data information of real physical products, digital twin carries out simulation calculation in virtual space to predict and optimize the behavior of production system in each life cycle stage in real time. Comprehensive data sensing technology mainly includes sensor collaborative measurement and layout optimization technology, heterogeneous resources real-time sensing and access technology, measurement technology, quantum sensing technology and so on.

(2) Efficient transmission of connections. Connection is to realize universal interconnection among physical entities, virtual entities, application services and data, so as to support real-time interconnection and integration of virtual and real-time [5]. Once the communication between physical entity and virtual entity is not synchronized due to hardware delay, it may lead to serious consequences of model non-convergence [6]. The digital twin system establishes the real-time synchronization between the digital world and the physical world, so as to support the subsequent analysis and processing [7]. This connection and synchronization is different from the advantages of traditional simulation. The efficient transmission technology of connection mainly includes wireless communication technology, interface and protocol technology, interaction technology, security technology, human-computer interaction technology, communication network architecture technology, etc.

(3) Data management and sharing. Data integration integrates information data and physical data, meets the requirements of consistency and synchronization between information space and physical space [8], and provides more accurate and comprehensive data support for all elements/whole process/whole business.

Data management and sharing technology mainly includes big data technology and platform technology. Big data technology mainly includes data storage technology, data processing technology, data fusion technology, data visualization technology, etc. Platform technology mainly includes data sharing service technology.

(4) Modelling of digital twin. Digital twins can describe physical entities from multi dimensions, multi spatial scales and multi temporal scales. When the internal physical mechanism of the modelling object is clear and the process is fully observable, mechanism modelling can be used [9]. If the object behavior is complex, the parameters are difficult to observe, and the behavior results are random, data-driven modelling can be used [10]. If the training samples of the model are limited and the reliability requirements are high, data and knowledge fusion can be used to integrate the advantages of data modelling and mechanism modelling while reducing the number of samples, and improve the calculation accuracy, efficiency and reliability.
Digital twin modelling technology mainly includes physical modelling technology, data-driven modelling technology, data and knowledge fusion driven modelling technology, model verification technology and so on.

(5) Forecasting and decision making. It is one of the core characteristics of digital twin that decision instructions based on artificial intelligence technology feedback control physical entities. If digital space can't make state prediction and system decision, and act on physical equipment, digital twin will evolve into "digital shadow" proposed in early years [11]. Data transmission is unidirectional, and can't realize the real meaning of digital twin. On the whole, the current digital twin system lacks the control ability of feedback optimization [12].

Prediction and decision-making technology is mainly intelligent computing technology represented by artificial intelligence, which is based on data-driven to realize system behavior simulation, prediction of process faults, adaptive control of operating variables, optimal decision-making of production process, etc. It includes deep reinforcement learning, deep transfer learning, knowledge reasoning and so on.

3. Terminal evaluation based on digital twin

Before you begin to format your paper, first write and save the content as a separate text file. Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads—the template will do that for you.

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

3.1. Abbreviations and acronyms

The terminal evaluation system based on digital twin is as follows:

![Figure 2. Architecture of terminal evaluation system based on digital twin](image-url)

Physical perception: physical perception is the foundation of the digital twin system of energy Internet, which realizes the perception and collection of massive data of various terminals in the real world Internet of things.

Virtual space: the main Internet of things full model simulation, which consists of digital twins mapped by physical entities, realizes the mirror copy of the terminal equipment in the virtual space. Among them, the digital twin construction of physical entities mainly includes mechanism model, data driven model and mechanism and data fusion driving model. 1) mechanism model is a model for terminal equipment with fixed port information, flow characteristics and behavior characteristics; 2) Data driven model is a model formed by collecting data, processing it on the edge side, integrating and refining relevant information and sharing data, and training and fitting on the basis of data; 3) The model of mechanism modelling and data driven modelling can also be integrated.
Transmission interaction: it is a network facility for building all parts of the digital twin system of the Internet of things, which can realize the efficient connection, real-time interaction and interaction cooperation of all links. Data transmission includes the connection between physical entity and Internet of things terminal test information center of Cloud Architecture, physical entity and virtual space, Internet of Things terminal test information center and virtual space connection of cloud architecture. For the high bandwidth, large connection, low delay and high reliability transmission requirements of the Internet of things, heterogeneous network fusion technologies such as 5g, power line communication, micro power wireless communication and other communication technologies can be adopted. In combination with cloud, edge and end collaborative resource allocation, different end-end tests are carried out according to complexity, and low complexity of the Internet of things terminal test can be conducted, the paper adopts the collaborative automatic test mechanism based on “ARM+FPGA”, and uses the fast automatic test method based on digital twin for cloud test with high complexity.

Data sharing: it is the power base of the digital twin system of the Internet of things, which realizes the data storage and sharing platform, which provides a powerful driving force for the construction of virtual space model. The data includes static attribute data and dynamic data of physical entities, simulation data of virtual space, knowledge data stored and application data. The attribute data of physical entities are generally geometric attribute, function, performance and other inherent attribute data, as well as port information, traffic characteristics and behavior characteristics of the terminals of the Internet of things; The simulation data of virtual space is mainly generated by the full model simulation; The stored knowledge data is mainly technical specification, standard and other normative data; The application data is to use big data, artificial intelligence and other algorithms to forecast and simulate the data through virtual space.

Application service: realize closed loop feedback optimization of virtual space to physical entities. Based on the algorithm models of big data and artificial intelligence, the feedback optimization of physical entities is based on the predicted results in virtual space, which can effectively improve the failure detection rate of automatic test system.

3.2. Terminal evaluation method based on digital twin
This paper proposes a terminal evaluation method and system based on digital twin. According to the actual needs of IOT terminal equipment evaluation, combined with perception, transmission, platform, application, simulation and other business links, the digital twin model of IOT is proposed. Through digital technologies such as sensors, IOT, artificial intelligence, etc., the characteristics, behaviors and characteristics of physical entities and intelligent entities in the real world are analysed The formation process and performance are described and modelled to realize the real-time and complete mapping of physical entities and intelligent entities in the virtual space.

Based on a variety of sensors and collection terminals, realize the characteristic data of port information, traffic characteristics and behavior characteristics of terminal devices in the Internet of things, and realize the comprehensive perception and collection of massive data in the Internet of things. Upload the collected data to the cloud, compare it with the cloud model library, and judge whether it is consistent. If it is, the evaluation type can be output directly.

Technology, data-driven modelling technology, data and knowledge fusion driven modeling technology, space mapping modelling is carried out to establish the virtual space corresponding to the physical entity. The mapping process from physical entity to digital bit is realized.

Carry out full type test simulation in the virtual space, establish the corresponding model of equipment characteristic data and test results, and establish the correlation model of characteristic data and test items. Upload the model to the cloud model library.

At the same time, test simulation, operation prediction and fault prediction can be carried out according to the operation information of terminal equipment.
4. Application scheme
The application of the terminal evaluation system and scheme proposed in this paper is expanded. According to the simulation of terminal business data in different industries, the evaluation and verification of terminals in different industries are realized. The specific scheme is as follows:

Internet of things Finance: This paper studies the reliability, applicability and availability indexes of the key terminal equipment in the field of Internet of things finance, such as frequency band, maximum transmission power, data rate, receiving sensitivity, transmission power consumption and receiving...
power consumption, and evaluates the real-time performance, accuracy and communication performance of the movable property supervision equipment in the Internet of things finance system, form the process and system of financial evaluation of Internet of things.

Intelligent security: This paper studies the typical application of perimeter intrusion prevention terminal equipment in intelligent security, and evaluates the reliability, applicability and usability of AD sampling rate, remote upgrade time, detection distance, alarm response time, anti-static interference, anti RF electromagnetic interference and other indicators in terminals, form the evaluation process and system of perimeter intrusion prevention terminal in typical intelligent security field.

Intelligent transportation: Research on vehicle geomagnetic detector, which is the key terminal equipment in intelligent transportation field, and evaluate the reliability, applicability and availability of vehicle geomagnetic detector, such as accuracy, frequency band, maximum transmitting power, data rate, receiving sensitivity, transmitting power consumption and receiving power consumption, form the key terminal equipment in the field of intelligent transportation vehicle geomagnetic detector evaluation process and system.

Smart sanitation: for the key equipment in the smart sanitation Internet of things, such as vehicle mounted equipment and intelligent trash can, the relevant function and performance index system of the Internet of things is established, and the reliability, applicability, availability and other key indexes of the key equipment are evaluated, forming the technical requirements for the evaluation of the key equipment in the smart sanitation Internet of things.

Smart Municipal: Research on the evaluation technology of smart meter reading, smart dry column equipment and other typical equipment in smart municipal, evaluate the reliability, applicability, usability and other key indicators of typical equipment, and form the typical equipment evaluation process of smart municipal.

Smart home: This paper studies the evaluation technology of typical smart lock products in smart home, including the reliability, applicability, usability and other key indicators of typical devices, forming the typical device evaluation process of smart home.

Smart pipe network: Research on Evaluation Technology of typical equipment in smart pipe network, including key indicators of reliability, applicability and availability of typical equipment, forming typical equipment evaluation process of smart pipe network.

5. Conclusion
In this paper, the digital image is used to simulate all types of terminal test, and the corresponding model of device characteristic data and test results is established, which can effectively improve the fault detection rate of IOT terminal test system; The proposed terminal evaluation system architecture, physical space terminal equipment with edge computing function; The rapid automatic test method based on digital twin is adopted, and the corresponding model in virtual space can be used for fault prediction and other application functions. This paper evaluates the terminal equipment in seven typical environments, including finance, security, transportation, sanitation, municipal administration, home furnishing and pipe network, and initially constructs a business oriented typical equipment evaluation process system to realize the accurate identification and evaluation of terminal equipment in different application scenarios.

Acknowledgments
This work is supported by “National Key R&D Program of China No.2018YFB2100202”.

References
[1] Chen Guoping, Dong Yu, Liang Zhifeng, et al. Analysis and Reflection on High-quality Development of New Energy With Chinese Characteristics in Energy Transition[J]. Proceedings of the CSEE, 2020, 40(17):5493-5505+S9(in Chinese).
[2] GEBIZLI C S, SOZER H. Automated refinement of models for model-based testing using exploratory testing [J]. Software Quality Journal, 2017, 25: 979 − 1005.
[3] GRIEVES M. Digital twin: manufacturing excellence through virtual factory replication[J]. White Paper, 2014, 1:1–7.

[4] Tao Fei, Liu Weiran, Zhang Meng, et al. Five-dimension digital twin model and its ten applications[J]. 2019, 25(01):1-18

[5] Kaishu Xia, Christopher Sacco, Max Kirkpatrick, et al. A digital twin to train deep reinforcement learning agent for smart manufacturing plants: Environment, interfaces and intelligence[J]. Journal of Manufacturing Systems

[6] Shen Chen, Jia Mengshuo, Chen Ying, et al. Digital Twin of the Energy Internet and Its Application[J]. Journal of Global Energy Interconnection, 2020, 3(01):1-13

[7] X. Song, T. Jiang, S. Schlegel and D. Westermann. Parameter tuning for dynamic digital twins in inverter-dominated distribution grid[J]. IET Renewable Power Generation, 2020, 14(5):811-821.

[8] P. Jain, J. Poon, J.P. Singh, et al. A Digital Twin Approach for Fault Diagnosis in Distributed Photovoltaic Systems[J]. IEEE Transactions on Power Electronics, 2020, 35(1): 940-956.

[9] Tang Wenhu, Chen Xingyu, Qian Tong, et al. Technologies and Applications of Digital Twin for Developing Smart Energy Systems[J]. Strategic Study of CAE, 2020(04):1-12

[10] Weihan Li, Monika Rentemeister, Julia Badeda, et al. Digital twin for battery systems: Cloud battery management system with online state-of-charge and state-of-health estimation[J]. Journal of Energy Storage 2020. https://doi.org/10.1016/j.est.2020.101557

[11] XIE Jiacheng, WANG Xuewen. YANG Zhaojian. Design and operation mode of production system of fully mechanized coal mining face based on digital twin theory [J]. Computer Integrated Manufacturing Systems, 2019, 25(6): 1381－1391.

[12] A. Rasheed, O. San, T. Kvamsdal. Digital Twin: Values, Challenges and Enablers From a Modeling Perspective[J]. IEEE Access, 2020, 8:21980-22012. doi:10.1109/ACCESS.2020.2970143.