Analysis of Industrial Internet of Things and Digital Twins

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Abstract: The industrial Internet of Things (IIoT) is an important engine for manufacturing enterprises to provide intelligent products and services. With the development of IIoT, more and more attention has been paid to the application of ultra-reliable and low latency communications (URLLC) in the 5G system. The data analysis model represented by digital twins is the core of IIoT development in the manufacturing industry. In this paper, the efforts of 3GPP are introduced for the development of URLLC in reducing delay and enhancing reliability, as well as the research on little jitter and high transmission efficiency. The enhanced key technologies required in the IIoT are also analyzed. Finally, digital twins are analyzed according to the actual IIoT situation.

Keywords: digital twins; industrial Internet of Things (IIoT); standards

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1 Introduction

In recent years, the fourth industrial revolution accelerated by the industrial Internet of things (IIoT) has raised a global upsurge[1–2]. A cognitive IIoT system helps to establish the information relationship between the real world and the virtual space, which includes the perceptual layer (by perceptual control technology), transmission layer (by network communication technology), and application layer (by information processing technology)[3]. The boom in IIoT cannot be achieved without technical support, including digital twins, edge computing, time-sensitive networks (TSN), and passive optical networks (PON).

With the application of IIoT, digital twins are endowed with new vitality. The concept of digital twins can be traced back to Dr. Michael GRIEVES in 2002. However, the unified concept of digital twinning has not been reached in the subsequent development, because different users have given different conceptual descriptions of digital twins based on different angles and needs. Digital twins mainly include the following technical features: digital representation, virtual-reality interconnection and data-driven. The IIoT extends the value and life cycle of digital twins, highlighting the advantages and capabilities of digital twins in terms of models, data, and services. The application and iterative optimization of IIoT are becoming the incubator of digital twins[4].

Based on the basic state of a physical entity, a digital twin enables a highly realistic analysis of the established model and collected data in a dynamic and real-time way, which is used for the monitoring, prediction and optimization of the physical entity. The digital twin creates a virtual model with a high degree of realism for a physical object, and simulates, analyzes and forecasts its behavior, which paves the way for the integration of information technology and manufacturing. In addition, as an edge-side technology, digital twins can effectively connect the perceptual layer and the transmission layer. Therefore, the industrial Internet platform is the incubator of digital twins, and the digital twin is important for industrial Internet platforms.

All kinds of data collection and exchange of physical entities may be realized in the IIoT. The advantages of the IIoT, such as resource aggregation, dynamic configuration, and supply and demand docking, will facilitate the integration and utilization of all kinds of resources. For example, the industrial Internet platform is used to associate the digital twin in the edge infrastructure in the downward direction, and transfer

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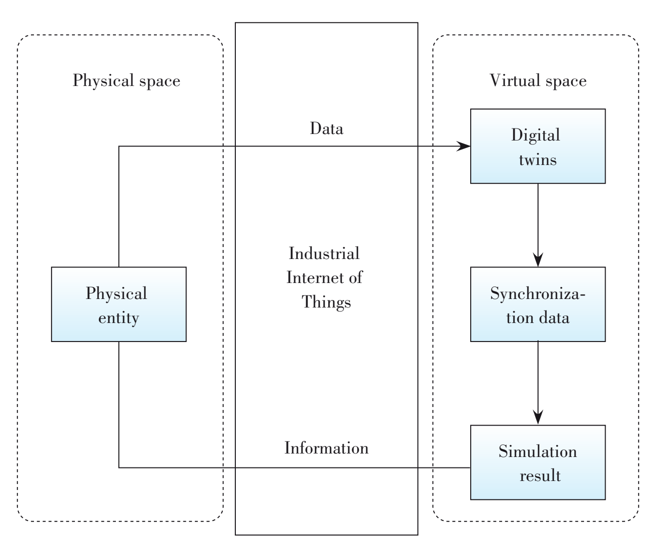
and store the data in the cloud in the upward direction. Moreover, users can set up digital twins through platform services according to their own needs. It can be said that the industrial Internet platform has activated the life of digital twins. As shown in Fig. 1, a physical entity in the physical space and a digital twin in the virtual space are connected through the IIoT. Among them, the miniaturization of IIoT equipment makes the creation of digital twins possible and sensor systems are used to realize data sharing between virtual and physical objects. Furthermore, the emerging 5G technologies can provide a faster connection speed between virtual and real objects, and improve operation efficiency and reliability by reducing the response time.

The transmission layer in a cognitive IIoT framework mainly includes the short-distance wireless communication network, low-power wide area network, and industrial Ethernet. As we all know, the cellular 5G, Long Term Evolution Category Machine 1/Machine 2 (LTE CAT M1/M2), Long Range Radio Wide-Area Network (LoRaWAN), and Narrowband-Internet of Things (NB-IoT) are representative technologies in the Internet of Things (IoT), while the IIoT relies heavily on the availability of wireless connections[5–6]. Considering that the features of classical field buses are incompatible with Internet features and their performance is not sufficient to transmit Internet packets, they cannot be directly included in the IIoT system. In particular, these classical networks do not support IIoT-based IPv6. However, they can be interconnected through gateway devices[7–8]. It is quite challenging to introduce industrial networks into an IIoT system, because their applications often have stringent quality of service (QoS) requirements, which may be difficult to meet, such as configuration, robustness, reliability, latency, determinism, energy efficiency, battery lifetimes, and security[9–11]. Refs. [12] and [13] report the suitability and achievable performance figures of industrial networks. As mentioned in Ref. [14], the low-power wide area network (LPWAN) is a new type of wireless network in IoT, which can be applied to indoor industrial monitoring[15], intrusion detection[16], remote monitoring and smart cities[17] with the help of robust communications, wide coverage ranges and low power consumption.

IIoT will completely change the manufacturing industry by faster transmission speed, more efficient transmission and access to more data; examples are smart manufacturing, smart agriculture, smart cities, smart home, smart health care, smart transportation, etc. IIoT promotes the strong demand for more data acquisition, communications, real-time analysis and data-driven decision making in various industrial vertical fields.

With the rise of IIoT and the advent of Industry 4.0, the application of ultra-reliable and low latency communications (URLLC) technology has attracted more and more attention[18]. URLLC is considered as a typical application scenario in 5G wireless communications[19] and is generally regarded as the technical basis of new applications such as industrial automation, autonomous driving, IoT and tactile Internet. Therefore, the ultra-reliable communication and ultra-low delay required by URLLC have always been difficult in academia and industry. Refs. [20 – 23] have proposed some schemes to ensure the QoS requirements of URLLC. Multipath diversity was proposed in Ref. [20] to improve transmission reliability. A cross-layer optimization design was proposed in Ref. [21], in which a variety of factors affecting packet loss are considered in wireless access networks. Considering the tradeoff between QoS requirements and system throughput, the source coding rules for tactile data compression were studied in Ref. [22]. Besides, Ref. [23] proposed scheduling free uplink transmission to avoid scheduling delay.



▲**Figure 1. Relationship between digital twins and the industrial Internet of Things**

Automation in different vertical domains has been developing rapidly. However, limited to the radio technology development, capital expenses (CAPEX) and operating expenses (OPEX), the communication technology applied in the vertical domains is mainly confined to the local area network, or even a network with wired connection. Although the cellular radio communication technology such as NB-IoT, Enhanced Machine-Type Communication (eMTC), and Long Range Radio (LoRa) can serve certain IoT use cases, it cannot satisfy all the requirements of any IoT use cases. For example, the requirements of the use cases in Refs. [24] and [25] cannot be served perfectly by the legacy cellular IoT system (Table 1). Generally, the use cases that cannot be satisfied by the legacy cellular IoT system always have rigorous requirements for low latency, high reliability, little jitter and/or frequent small data transmission. IIoT mainly focuses on providing wireless communications for these use cases.

The rest of this paper is organized as follows. Section 2 reviews the development of low latency and high reliability of

▼**Table 1. Communication service performance requirements**

Use case	Communication service availability: target value	Transfer interval: target value	Jitter
Motion control	99.999% to 99.99999%	500 μs	<50% of E-to-E latency
100 Mbit/s wired-to-wireless link replacement	99.9999% to 99.999999%	≤1 ms	
Mobile robots	> 99.9999%	1 ms to 50 ms	< Transfer interval
Mobile control panels: remote control of assembly robots, milling machines, etc.	99.9999% to 99.999999%	4 ms to 8 ms	< 50% of interval
Mobile operation panel: motion control	99.999999%	1 ms	
Robotic aided surgery	> 99.999999%	1 ms	
Robotic aided diagnosis	> 99.999%	1 ms	

URLLC in the field of IIoT, as well as the research process of little jitter and high transmission efficiency. Section 3 discusses the possible future research directions and objectives in the field of IIoT. Section 4 discusses the cases and advantages of the application of IIoT for digital twins. Section 5 concludes the paper and shows the cooperation of IIoT technology and digital twin technology.

2 Development of URLLC for IIoT Technology

5G URLLC has two basic features: high reliability and low latency. With high reliability, its block error rate (BLER) reaches 10^{-5} or even 10^{-6}, and in terms of delay, it can implement 1 ms or even 0.5 ms air interface transmission delay. As one of the three application scenarios of 5G system, URLLC is widely used in various industries, such as Augmented Reality (AR)/Virtual Reality (VR) in the entertainment industry, industrial control system, transportation system, management of smart grid and smart home, and interactive telemedicine diagnosis[26]. This paper will introduce the development of 3GPP Release15 (Rel-15) and Release16 (Rel-16) for URLLC in reducing delay and enhancing reliability, as well as the research on little jitter and high transmission efficiency.

2.1 Low Latency of URLLC

The 5G URLLC technology achieves a user plane delay of 0.5 ms in both the uplink and downlink between the gNB and the terminal. The delay refers to the time it takes to successfully transmit application layer IP packets/messages, specifically from the sender's 5G wireless protocol layer entry point, to the receiver's 5G wireless protocol layer exit point. Among them, the delay exists in both the uplink and downlink directions. The main technologies used by the 5G URLLC to implement low latency include: 1) introducing a smaller time resource unit, such as a mini slot; 2) the no-scheduling permission mechanism used for uplink access, with which the terminal can directly access the channel; 3) supporting an asynchronous process to save uplink time synchronization overhead; 4) adopting fast hybrid automatic repeat request (HARQ), fast dynamic scheduling, etc.

While 3GPP Rel-15 shows the research progress of URLLC delay , 3GPP further enhances on URLLC in the Rel-16 phase and proposes an improved delay reduction scheme[27].

2.1.1 3GPP Rel-15

The study of URLLC delay supports for a more flexible frame structure. The 5G new radio (NR) supports the carrier spacing of 15 kHz in the LTE system. It also supports more spacing schemes, including 30 kHz, 60 kHz, 120 kHz, and 240 kHz. The higher the carrier spacing, the lower the delay performance. In addition, 5G NR supports frame structure adjustment. A slot is the minimum scheduling period. Compared with the LTE in which a fixed subframe includes 2 slots, the NR can flexibly switch between 1, 2 and 4 slots and configure uplink/downlink ratios, thus reducing the air interface transmission time of each slot.

The study of URLLC delay supports for more flexible scheduling units. The LTE includes a slot consisting of 14 symbols. However, the NR supports mini-slots. Mini-slots support the length of 2 symbols, 3 symbols, and 4 symbols, and a shorter slot can reduce the feedback delay.

The study of URLLC delay supports for flexible PDCCH configuration. The search space consists of a group of candidate physical downlink control channels (PDCCH), and the search space can be configured with parameters such as search type, period, slot offset, number of slots, CORESET, and downlink control information (DCI) format. By configuring a reasonable monitoring period and offset of the PDCCH in a slot, the PDCCH monitoring opportunity can be achieved densely. The slot has multiple PDCCH monitoring moments, which can meet the requirements for the burst service scenarios of the URLLC and meet the requirements for low latency.

The study of URLLC delay supports for URLLC high-priority transmission. To meet the URLLC service requirement of high priority, 5G/NR proposes that a URLLC service can preempt enhanced mobile broadband (eMBB) service resources to reduce the delay.

The study of URLLC delay introduces the function of mobile edge computing (MEC). In a 5G network, the user-plane function (UPF) can be deployed on the user side. The edge computing server and the UPF are co-located. The UPF recognizes that the destination address of the service flow is local, so it distributes the service to the local edge computing server for service processing, which reduces the redundant transmission path of the service and the delay.

2.1.2 3GPP Rel-16

The study of URLLC delay supports for grant-free configuration. In the scheduling based on grant configuration, user equipment (UE) needs to obtain resources through the scheduling request. In order to reduce the delay, the resource can be pre-allocated to UE according to service characteristics[28].

The study of URLLC delay supports for intra-UE priority and multiplex mechanism. In Rel-15, eMBB dynamic grant takes precedence over URLLC configured grant (CG). In order to ensure the delay of a URLLC service, Rel-16 proposes a selection scheme based on logical channel prioritization (LCP) to transmit URLLC services with a higher priority.

The study of URLLC delay supports for time sensitive network (TSN) and 5G convergence. The following mechanisms are adopted to realize TSN: 1) supporting semi-persistent scheduling (SPS) with a shorter period; 2) supporting the configuration of multiple SPS and CG for a bandwidth part (BWP) of UE; 3) supporting TSN services that do not match the CG/SPS period.

2.2 High Reliability of URLLC

At present, the reliability index of 5G URLLC is 99.999% for a 32-byte packet at the user plane with a delay of 1 ms. If the delay allows, 5G URLLC can also use the retransmission mechanism to further improve the success rate. In terms of improving system reliability, 5G URLLC adopts the following technologies: 1) adopting a more robust multi-antenna transmit diversity mechanism; 2) adopting robust coding and modulation in order to reduce the bit error rate; 3) adopting super robust channel state estimation. The reliability of URLLC has been enhanced in Rel-15 and Rel-16 of 3GPP.

2.2.1 3GPP Rel-15

The study of URLLC reliability supports for PDCP duplication mechanism. The sender replicates the data at the PDCP layer and then sends the two duplications to two independent logical channels for transmission, so as to achieve the frequency diversity gain and improve reliability.

The study of URLLC reliability supports for optimizing MCS\CQI tables. The modulation and coding scheme (MCS) and channel quality indication (CQI) of the LTE cannot meet the requirements of NR for system reliability and transmission rate. Therefore, NR adds two lower bit rates in the CQI table, and the corresponding gNB adds two MCS low-frequency options. A lower bit rate can be chosen between the UE and the gNB to ensure reliability.

The study of URLLC reliability supports for less load DCI design. By reducing the DCI overhead and improving the aggregation level, the PDCCH encoding rate is reduced. The decoding error rate is reduced and the reliability is improved.

2.2.2 3GPP Rel-16

The study of URLLC reliability supports for multi-TRP transmission mode. Rel-16 proposes that transmission blocks can be transmitted repeatedly based on space division, frequency division, intra-slot division and inter-slot division based on Rel-15. In order to improve the diversity gain, it also supports the combination of the above modes and the dynamic handover between different modes (including combined modes).

The study of URLLC reliability supports for PDCP duplication enhancement mechanism. Rel-15 supports two-branch PDCP duplication, in order to achieve higher reliability. Rel-16 supports up to four-branch PDCP duplication. This mechanism can be implemented through carrier aggregation (CA) duplication, dual connectivity (DC) duplication and the combination of CA duplication and DC duplication.

The study of URLLC reliability supports for redundant transmission scheme. NG-RAN duplicates uplink packets and sends them to the UPF via two redundant link (N3 interface) channels, where each N3 channel is associated with a PDU session, and two independent N3 channels are established to transmit data. The gNB, SMF and UPF will provide different routes for the two links[29].

2.3 Little Jitter of URLLC

Requirements of time accuracy are typically specified with two values: the characteristic time and jitter. Characteristic time is the target value of the time parameter, e.g. end-to-end latency. The jitter is the variation of a (characteristic) time parameter and the maximum deviation of a time parameter relative to a reference or target value.

As depicted in Ref. [25], power distribution poses the jitter requirements and the traffic pattern is deterministic as well. In such a case, the maximum value of the characteristic time parameter needs to be known. Sometimes, a minimum value may also be given, and should not be undershot. A minimum value is only used in particular use cases, for instance, when putting labels at a specific location on moving objects. In Rel-15, a common understanding in radio access network (RAN) is that a delay-sensitive URLLC service with periodic traffic can be accommodated by the semi-persistent CG. That means the periodicity of the traffic should be a prerequisite in RAN to meet the data size and jitter requirements. An example is the variation of the end-to-end latency. If not stated otherwise, jitter specifies the symmetric value range around the target value (target value ± jitter/2). If the actual time value is outside this interval, the transmission will not be successful. Ref. [25] shows an example of transmissions with jitter. It should be noted that the end-to-end latency may scatter even for successful transmissions.

As an important feature of TSN, the jitter requirement is to provide a deterministic service with bounded delay. Typical characteristic parameters to which jitter values are ascribed are transfer interval, end-to-end latency, and update time. Further, the buffering mechanism is held and forwarded to eliminate jitter in the TSN. Device-side TSN translator (DS-TT) and network-side TSN translator (NW-TT) support a hold and forward mechanism to schedule traffic as defined in IEEE 802.1Qbv[30], if 5GS is to participate transparently as a bridge in a TSN network. The hold and forward buffering mechanism allows packet delay budget (PDB) based 5GS QoS to be used for time-sensitive communication (TSC) traffic since packets need only arrive at NW-TT or DS-TT egress prior to their scheduled transmission time. The way that TSN translator supports the hold and forward mechanism depends on the implementation.

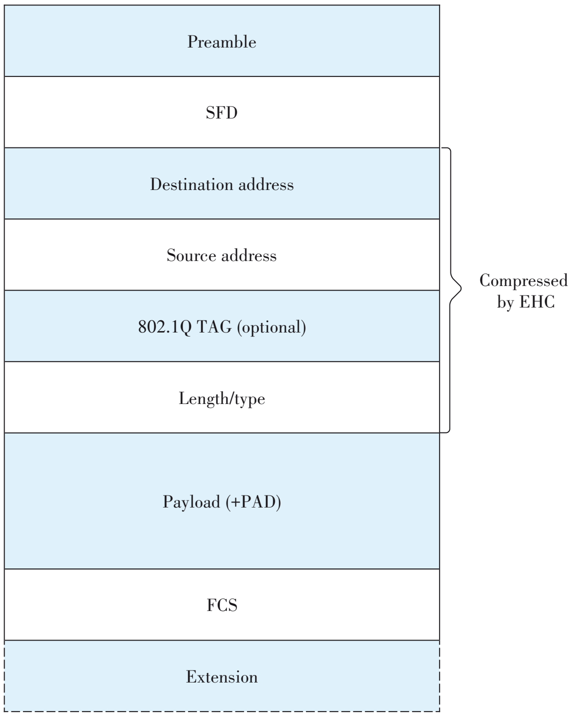
In addition, time synchronization precision is defined between a synchronization master and a synchronization device. The detailed objectives for NR TSC-related enhancements include specifying accurate reference timing delivery from gNB to the UE using broadcast and unicasting radio resource control (RRC) signaling for the synchronization requirements defined in Ref. [31]. To meet the high-precision time synchronization requirements of the TSN, a high-precision reference time transmission mechanism is introduced to NR. Broadcast messages (SIB9) or dedicated RRC messages (DLInformationTransfer messages) with the high-precision time can be sent. The time granularity is enhanced from 10 ms to 10 ns. According to the simulation result of radio access network work group 1 (RAN 1), radio access network work group 2 (RAN 2) assumes that delay compensation is required in the scenario where the service range is greater than 200 m for the user with the subcarrier interval of 15 kHz. However, in Rel-16, RAN 1 only provides transmission delay compensation for the base station and UE in the Time Division Duplex (TDD) and Frequency Division Duplex (FDD) scenarios according to half of the timing advance, that is, $N_{TA} \times Tc/2$. In addition, although RAN 1 discusses a lot about when and how to implement the transmission delay supplement, this topic has not finished in the Rel-16 phase.

2.4 High Transmission Efficiency of URLLC

In the field of IIoT, the small packets of TSN are transmitted frequently in the ordinary communication network. TSN is also introduced into the 5G system, which has the characteristics of small packets with frequent transmission, low latency and high reliability. In this case, reducing the packet overhead can effectively improve the effective utilization of system bandwidth. Therefore, for TSN packets, header compression can be used to further reduce the size of data packets, thus saving the wireless resources used by a single packet and improve the utilization of wireless resources. The data stream transmitted by TSN is mainly an Ethernet data packet, so the Ethernet header compression (EHC) is introduced to reduce the overhead caused by Ethernet header transmission.

EHC may be particularly beneficial when the payload size of an Ethernet frame is small relative to the overall size of the frame, which is typical in an Ethernet-based IIoT network. The EHC protocol compresses the Ethernet header as shown in Fig. 2. The fields that are compressed by the EHC protocol are Destination Address, Source Address, 802.1Q Tag, and Length/Type. The fields Preamble, Start of Frame Delimiter (SFD), and Frame Check Sequence (FCS) are not transmitted in a 3GPP system, and thus not considered in an EHC protocol. There may be more than one 802.1Q Tag field in the Ethernet header, and all are compressed by the EHC protocol. The padding is not compressed by the EHC protocol. The EHC compressor and the EHC decompressor store original header field information as an "EHC context". Each EHC context is identified by a unique identifier, called Context ID (CID). For an Ethernet packet stream, the EHC compressor establishes the EHC context and associates it with the CID. Then, the EHC compressor transmits the "Full Header (FH)" packet to the EHC decompressor including the associated CID. The EHC compressor keeps transmitting the FH packets until the EHC feedback is received from the EHC decompressor.

The source Medium Access Control (MAC) address, destination MAC address and type fields of the Ethernet header



EHC: Ethernet Header Compression
FCS: Frame Check Sequence
PAD: padding
SFD: Start of Frame Delimiter

▲**Figure 2. Ethernet packet format**

frame are all static and can be compressed, which is also the conclusion of the 3GPP RAN 2. Header compression is essentially the use of CID instead of Ethernet headers for transmission in the communication network.

The compression process includes: 1) The configuration of the CID is completed by the PDCP data PDU; 2) the compressor sends a full packet containing the full header and the CID; 3) the decompressor establishes the relationship between the header and the CID according to the received FH packet; 4) after the decompressor successfully establishes the context relationship, it sends the feedback message with the CID, informing the compressor that it can send the compression package; 5) after receiving the feedback information carrying CID, the compressor starts to send the compression packet corresponding to the CID. The header field in the compression packet is replaced by the CID, where the feedback information is sent by PDU control PDCP.

3 Future Research Directions of IIoT Technology

As a breakthrough in the integration of mobile communications and vertical industries, 5G is expected to bring about great changes to the whole society through URLLC services such as automatic driving, factory automation and smart grid. The research work for the 3GPP Rel-16 has been completed. At this stage, the research in related high-level technologies has laid a solid foundation for the integration of 5G and IIoT. With the development of IIoT, its services require more strict latency and are more deterministic, for example, up to 99.999999%. To this end, 3GPP has launched its research on standard technology in Rel-17 to further enhance the low latency and reliability, so that 5G can meet the various needs of the development of IIoT.

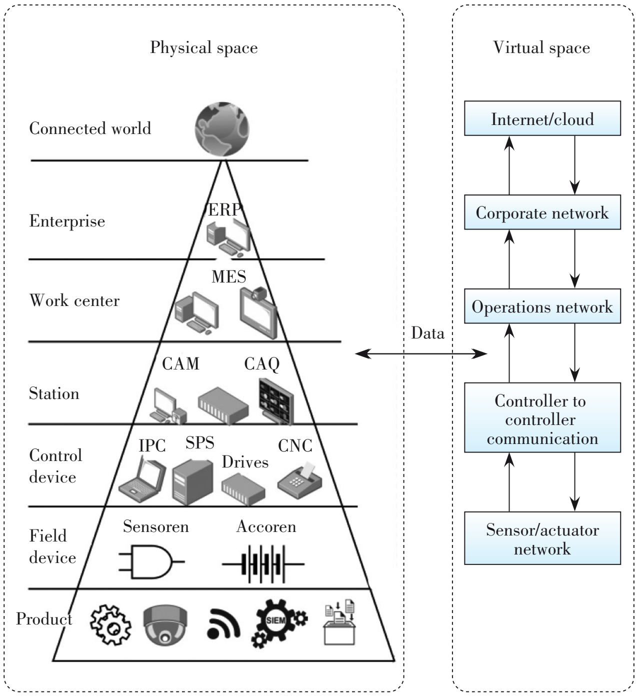
Considering the directions of the reliable private network of local service, extensible wireless connections of future platforms and multiple functions of new cases, a shorter frame structure will be selected in accordance with service development requirements to reduce the air interface delay of services. In addition, deep integration with the TSN proposed by the industry will also be considered to guarantee low transmission delay of services. On the road of the integration of 5G and industrial Internet TSN, related enhancements will be carried out in the following aspects: 1) Based on multi-carrier deployment, the reliability is further improved by introducing a PDCP layer and higher-level data replication transmission technology; 2) the feedback scheme for the physical layer will be further enhanced; 3) the UE service priority and uplink UCI will be enhanced; 4) with the NR-Unlicensed (NR-U), the 5G NR will support the licensed frequency, shared frequency domain and license-free spectrum; 5) URLLC will implement low latency, high reliability and multi-TRP cooperation;. 6) mobility will be enhanced;. 7) wired bus will be replaced by wireless bus; 8) requirements of network and equipment positioning, positioning in IIoT, and intelligent factory/vehicle-to-everything (V2X) centimeter positioning will be met; 9) with the penetration of artificial intelligence (AI) technology, new deterministic requirements and key standard technology of AI in IIoT applications will be explored. These will be the key research directions in the future.

4 Digital Twins in IIoT

With the continuous development of the manufacturing industry, digital twins have become the focus of every digital enterprise, although they have not yet become the mainstream technology. The core of digital twins is model and data, but the creation of virtual models and data analysis require professional knowledge. For those who do not have relevant knowledge, it is a long way to go to build and use digital twins. IIoT can just solve the above problems, through the platform to achieve data analysis outsourcing, model sharing and other services. For example, the IIoT can be used to associate the edge-side infrastructure downward with the digital twin, and to transfer and store data upward in the cloud. Any users can establish digital twins through the IIoT services according to their own needs. It can be said that the industrial Internet platform activates the life of digital twins.

IIoT is a key link in the process of enterprise digital transformation, which accelerates the integration of various elements of information technology (IT) and operation technology (OT). Data is the most important binder in the integration process. In order to make the IT and OT integrate better, the hidden asset of data should be handled first. In addition, the IIoT is trying to break the boundaries of enterprises, trying to fill the gaps between IT and OT, and creating a new ecology of software definition, data-driven and mode innovation. The digital twin just provides the interface of data and technology for the development of such integration.

As we know, when each object (such as cars, airplanes, factories and people) in the real world has a digital twin, the space-time relationship between the digital twins becomes more valuable than a single digital twin. When the interactions between objects are optimized at the same level of a system, compared with the partial or independent optimization of the system, the efficiency is greatly improved. But in order to realize the optimization of the whole system, communication becomes a crucial factor. As described in Ref. [25], most of the communication technologies currently used in industry are still wired. However, with the advent of Industry 4.0 and 5G, this may change fundamentally, since only wireless connectivity can provide the degree of flexibility, mobility, versatility and ergonomics that are required for the factories of the future. Therefore, with the support of IIoT, the digital twin technology has been further promoted in different application fields of a “future factory”, such as factory automation, process automation, hazardous material information system (HMIS) and production, logistics and warehouse, monitoring and maintenance. Fig. 3 contains enterprise resource planning (ERP), manufacturing execution system (MES), computer aided quality (CAQ), computer aided manufacturing (CAM), Internet process connection (IPC), symbolic programming system (SPS), computerized numerical control (CNC), and so on. Fig. 3 also shows the objects in the real production process, such as robots, cameras, mechanical arms, workbenches and mechanical tools. The information status of these objects in wired and wireless networks is uploaded to the Internet/cloud through sensors. After a high real-time data exchange, the state of a real object is simulated by a digital twin, and then the digital twin obtains the corresponding fault diagnosis results, evaluation and prediction results, behavior control of machinery, and other information. The high real-time network communication and the corresponding simulation information are used to control the production process. The high real-time data exchange between the real object and digital twin is the basis and prerequisite for the application of the digital twin technology. In addition, as an effective way to solve the interaction theory and implementation method of the physical world and the information world in the future, digital twins are gradually deepening in practice. This also means that the demand for network performance in its development is constantly improving, and it also promotes the improvement of IIoT related project research and standards. Thus, it is necessary to further study the low latency and high reliability of the IIoT.



CAM: computer aided manufacturing
CAQ: computer aided quality
CNC: computerized numerical control
ERP: enterprise resource planning
IPC: Internet process connection
MES: manufacturing execution system
SPS: symbolic programming system

▲**Figure 3. An example use case of industrial IoT via digital twins**

Therefore, digital twins can display, predict and analyze the interaction between a digital model and the physical world. The design based on digital twins is based on virtual mapping of existing physical products. A large amount of data is studied to obtain valuable knowledge for product innovation. Designers only need to publish the requirements to the industrial Internet platform, so that platform managers can precisely match the data services needed by designers, as well as the model and algorithm services for data processing. Digital twins are effectively applied to product design through services to reduce the modification caused by the inconsistency between expected behavior and design behavior. It greatly shortens the design cycle and reduces the design cost.

5 Conclusions

The development of IIoT technology makes the application scenarios of digital twin technology more extensive, fully demonstrating the advantages and capabilities of digital twins in terms of models, data, and services. As a new digital technology solution and human-computer interaction interface, it will effectively promote and deepen the further development of business models. On the basis of reviewing the development of URLLC and analyzing the future research direction in the field of IIoT, this paper discusses the application of IIoT in digital twin. The development of digital twin technology is closely related to the continuous evolution of URLLC technology in IIoT. In other words, the development requirement of digital twins also promotes the improvement of IIoT standards and technologies. Compared with the previous cellular mobile communication technology, the 5G URLLC technology has greatly improved in terms of delay, reliability, little jitter and high transmission efficiency. However, with the development of IIoT, the research of delay and reliability technology needs to be further enhanced to meet the needs of various services.

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