The Impact of 5G Technology on the Internet of Things

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Abstract. The introduction of 5G network technology has not only provided a significant boost but also a solid foundation for the advancement of the Internet of Things (IoT). In the future, the 5G IoT promises to realize the full potential of IoT in society. The emergence of 5G has revolutionized the landscape that once posed challenges to IoT development. Its exceptional network attributes, such as high data throughput and ultra-low latency, have seamlessly integrated with IoT, making them inherently intertwined. However, ensuring the network security of 5G IoT demands a departure from traditional encryption schemes. In this context, leveraging cryptography based on the principles of quantum computing offers a practical and reliable solution. It is only when robust cybersecurity measures are in place that the public can truly experience and enjoy the myriad benefits and conveniences that the 5G IoT brings to their daily lives.

Keywords: 5G technology, Internet of Things, network security

1 Introduction

The Internet of Things is an exciting technology that most envisions as a key enabler of a seamlessly connected life. It facilitates machine-to-machine communication, transforming a multitude of physical objects into smart devices, ranging from phones and computers to smartwatches, homes, cars, and beyond. Researchers foresee that IoT will revolutionize daily life, enhance comfort and efficiency, and spur economic growth [1].

Significant advancements in IoT over recent years have made large-scale, cost-effective device interconnectivity possible, thanks to the internet [2]. Future IoT applications promise robust data transmission and exchange across various environments. Systems like traffic control, unmanned machinery, and medical facilities, among others, stand to benefit significantly from IoT. However, to successfully integrate into these domains, IoT must overcome challenges such as latency, security, reliability, and availability [1]. Traditional technological solutions find it difficult to address these challenges. The advent of 5G technology, with features like Massive Multiple Input Multiple Output (MIMO) and cloud Wireless Access Networks (C-RAN), presents a promising solution. Expected to revolutionize communications and IoT modeling, 5G technology is believed to be pivotal in addressing the needs of the IoT and fostering future connectivity [3].

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2 Literature Review

The swift advancement of 5G is making its derived devices and applications increasingly accessible, establishing it as a crucial propellant for IoT's evolution. With 5G, a myriad of IoT devices can achieve extensive connectivity, robust security, broader wireless coverage, lower latency, and larger throughput. The technical hurdle of providing reliable 5G applications for the IoT has already been surmounted. The future focus of 5G progress lies in the transformation of its technology, architecture, and business processes [4].

The emergence of the 5G IoT is expected to elevate a vast number of existing IoT devices within three years, catering to the enormous demand stimulated by the rapidly expanding wireless business market, and contributing significantly to social and economic growth (Table 1).

Li (2018) detailed the current state of wireless technology and the IoT, highlighting that while previous wireless technologies like 3G and 4G cover most of the world's population, they have been a limiting factor in the progression of IoT due to data interaction constraints. After years of 5G research, it is poised to meet the diverse requirements of the future IoT while grappling with the security challenges of device-to-device transmission.

The IoT, by enabling various devices to communicate seamlessly, has the potential to transform the way people live and work. While the IoT concept has been around for a decade, it's only now, thanks to recent communication technology advancements, that the integration of diverse devices is truly accelerating. The current 5G cellular system, offering new connection technology, high equipment standards, reliability, scalability, and affordability, is anticipated to be a linchpin for the IoT's rapid progression.

Table 1. Literature review

Author	Topic / Discussion Problem	Solution	Weakness
Shancang Li et al.	Internet of Things development issues	5G technology addresses the progress of the Internet of Things	5G technology faces security issues between devices
Maria Rita Palattella et al.	The Internet of Things develops network demand	5G offers new solutions	The Internet of Things still requires new ways to host wireless networks
Lalit Chettri et al.	Old wireless networks cannot keep up with the demand	5G technology basically meets the needs of the Internet of Things	The deployment of the Internet of Things still requires trial and error, and 5G network security issues need to be addressed urgently

The Internet will be central to the future of 5G and IoT research. However, before this vision materializes, hurdles like high latency in data transfer must be addressed, potentially requiring new radio technologies [5]. As the public increasingly recognizes the importance of IoT, its further development will depend heavily on 5G support.

Wireless technology has advanced rapidly, with 5G emerging as critical, as 4G no longer adequately supports low latency and high data rates across multiple devices. 5G can largely address these challenges and further the progress of technologies like millimeter-wave technology, heterogeneous network technology, and augmented reality, thereby driving IoT development. Smart systems such as cities, vehicles, factories, agriculture, and healthcare can benefit significantly from 5G IoT advancements [6].

While technical issues surrounding the 5G network have been largely resolved, network security and privacy remain to be addressed. With IoT's multi-layer functionality, many aspects will need redesigning and redeployment with 5G implementation. Even with 5G's arrival, challenges like mobility, latency, and connectivity will require ongoing attention [5].

The deployment of the 5G network largely relies on LPWAN communication technology, with ZigBee, SigFox, LoRa, and NB-IoT considered the most effective fast deployment strategies. The primary focus of 5G is the IoT, where continuous, wireless connectivity is critical, making 5G network security paramount [7]. Therefore, new security and privacy solutions are needed to ensure 5G reliability. Ensuring the integrity, confidentiality, and non-repudiation of the 5G technology architecture is essential, although many questions remain unanswered.

The growth of heterogeneous devices connected to the Internet reflects the IoT's burgeoning reality. Further IoT development and expansion will require support from next-generation 5G cellular systems. With cellular or non-cellular D2D communications, 5G will significantly influence the IoT's growth [8]. Ongoing research should pave the way for an advanced ecosystem with 5G and IoT working in close integration.

One of the key technologies in IoT and 5G applications is Mobile Edge Computing (MEC), which requires cloud computing support, software-defined networks/network function virtualization, data-centric networks, virtual machines, and volumes, smart devices, network slicing, and computing offloading. When MEC is combined with 5G and IoT, it can dramatically enhance smart transportation, smart grid, smart factory, smart healthcare, smart home, smart city, virtual reality, and smart agriculture [9]. In the ongoing advancement of 5G IoT, people must consider key aspects such as edge intelligence, server and system deployment, pricing, security, and privacy. With the integration of 5G networks, the emerging IoT technology can significantly enhance our living standards, making life smarter, more comfortable, and more convenient. In 5G engineering, network slicing is seen as a pivotal technology catering to networking requirements across varied devices, enabling IoT to function in diverse scenarios [9].

However, integrating IoT with network-slicing technology presents its own set of challenges and research problems in real-world operations. Leveraging technologies such as SDN, NFV, and cloud computing, network slicing aids in expediting the progression of wireless networks, providing solutions for IoT network transmission between heterogeneous devices. It offers a strong technical backbone for the development of 5G technology in the IoT space [10]. Emerging applications and systems like virtual reality, intelligent cars, intelligent environments, and healthcare will streamline our lives. Yet, these applications require enormous data throughput and low latency, which 5G IoT can support robustly. Besides, 5G technology brings forth key components such as carrier aggregation, MIMO, CoMP, and device-to-device communication to aid IoT development and deployment. For advanced AI, machine learning, and deep learning algorithms to process and predict data efficiently, the high data transmission rate and low latency provided by 5G IoT are crucial. However, 5G IoT has unique challenges, such as traffic transmission differences from traditional 5G networks and partial standardization of heterogeneous nodes, which industry and academia need to address [10]. Moreover, with the advent of quantum technology, traditional security mechanisms embedded in the 5G IoT may be compromised.

A secure, reliable, and efficient encryption mechanism, Quantum Walk, offers a solution. As a quantum computing model with inherent encryption capabilities, it provides key block cryptography technology in 5G IoT, ensuring the safe transmission of sensitive data [11].

IoT's potential to interconnect heterogeneous devices over the internet is immense. As it evolves, communication technologies can leverage the extensive demand for machine-type communications (MTC) to accelerate IoT's vision. However, current cellular models aren't apt for most low-power and low-data devices, many of which are IoT devices. The inception of 5G networks can overcome these limitations, advancing IoT development. 5G enhances cellular-based low-power wide-area solutions and promises further developments in IoT radio that meet the demands of various services, thus improving user experiences [12].

The progress of 5G IoT brings with it a significant increase in network traffic load, a tremendous challenge for network management. Traditional server environments may buckle under such heavy data loads, necessitating new concepts like "Service Aggregation and Caching" (SAaC). This approach not only accelerates server response times and reduces traffic load, but also substantially curtails power consumption. Despite SAaC's effectiveness, concerns around data security and privacy during transmission remain, demanding further attention [12].

The advent of 5G technology has immensely increased the potential and prominence of the Internet of Things. With the unique technical capabilities of 5G, IoT's vision of smart life can be realized more efficiently. However, 5G and IoT face challenges such as massive simultaneous access, power consumption, latency, and privacy concerns. Hence, the introduction of 5G technology is decisive for the deployment and implementation of IoT [13].

In the context of 5G and IoT, resource optimization is crucial, particularly given the scarcity of spectrum. Self-optimization, wherein devices adapt based on user-perceived quality, has been suggested as a suitable approach. However, some researchers advocate for the classic optimization approach, transforming problems into ones with established optimization techniques. Thus, the search for optimal resource allocation solutions continues [14].

The transition from older technologies such as LTE to 5G also poses significant challenges. Given the incomplete deployment of 5G and the significant infrastructure already established for LTE, the transition period will require intricate planning and a lot of time. Ultimately, a stable 5G coverage environment is crucial for the successful adoption and use of IoT [15].

Yan (2019) outlines the role of 5G technology in facilitating the Internet of Things. Through faster data transmission, lower latency, and higher user density, 5G aids in realizing IoT's potential and its transformative impacts on our everyday lives [16].

The intersection of 5G, IoT, and blockchain presents intriguing challenges and opportunities, according to Dwivedi et al. (2021). Blockchain, as a decentralized, immutable, and encrypted data storage method, could address issues of privacy and security in the IoT. Despite existing challenges, such as storage scalability, privacy concerns, and consensus agreement, the authors suggest potential solutions including Raft consensus, bloXroute, Hyperledger Fabric OS, and ZK Ledger [17].

Zhang and Gong (2021) explore how 5G and IoT could mitigate the "bullwhip effect" in supply chain management. Through efficient information sharing, IoT could reduce this effect, leading to improved operational efficiency in supply chains. However, room for progress remains in areas such as enterprise digitalization and human-computer interaction [17].

The blend of 5G, IoT, and Artificial Intelligence could enhance "virtual reality" experiences and enable "digital twins," as posited by Zhang et al. (2022). These technologies can stimulate the creation of smart factories and immersive training environments [18].

Esenogho et al. (2022) delve into how 5G and IoT can boost the functionality and performance of smart grids. While offering advanced features like self-healing, user protection, and attack prevention, smart grids also face challenges that could be addressed by integrating blockchain, IoT, 5G, and AI [19].

Lastly, Guo et al. (2022) argue that 5G and IoT are complementary, with 5G technology advancing the development of the IoT and vice versa. Technologies such as network slicing, machine learning, and 3D beamforming could further enhance this mutual advancement, leading us toward an era of ubiquitous internet connectivity [20].

3 Discussion for Proposed Solution

5G technology, with its capabilities such as low latency, massive data throughput, and reliable transmission between numerous heterogeneous devices, is finally equipped to drive the rapid progress of the Internet of Things. Several technologies, including LPWAN communication and AR, provide robust support for the IoT's development, contributing to the swift deployment of the 5G network. However, with this swift advancement, challenges like cyber security and privacy loom large, necessitating immediate solutions.

Public awareness about cybersecurity and privacy has increased, yet the current 5G network hasn't put forth effective solutions. Quantum computing could potentially break traditional mathematical network security protocols, warranting improved protection for the 5G network.

El-Latif (2020) proposed the development of a quantum cryptographic protocol, a promising solution to the 5G IoT network's security issues. This future-oriented security protection scheme uses quantum techniques to construct hash functions, pseudo-random number generators, and replacement box mechanisms [11]. Such a forward-looking encryption mechanism provides a robust system and network security for the 5G IoT and reliable privacy protection for users.

The complexity of the 5G network environment suggests that blockchain technology can provide security for IoT devices. This method, already used in virtual currency and digital RMB for security protection, requires the Raft consensus algorithm to enhance the throughput of the blockchain. Concerning the openness of the blockchain distributed ledger, zkLedger can address security and privacy issues between the blockchain and the IoT [16].

4 Conclusion

In this era of information technology, people begin to pay attention to their information privacy and security. However, 5G and the IoT, as emerging products in this era, are not as good as the mature LTE technology in this aspect. Our research goal is to the impact of 5G and IoT technology on our society and its future development. The problem of information security is the biggest focus. Author compared several solutions dealing with information security issues, blockchain, AI regulation, and quantum encryption, and finally chose quantum encryption, because blockchain and AI are facing more problems. In 2021, Hengtong Optoelectronics Company launched the first 5G+ quantum encryption security solution. This technology entered society before blockchain and AI, which also represents the realization of this technology will be simpler indeed. However, this does not mean that quantum encryption is watertight. One is that Repeaters are vulnerable to attacks, and the other is that large data packets are more likely to be intercepted by large keys. For these two points, our idea for the future is not only to increase the number of signatures of quantum encryption but also to realize a multi-party linkage mechanism of quantum cryptograph-data link-AI management by establishing correlation. To achieve a small key, difficult to decipher, difficult to intercept, error detection effect.

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