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A Survey on the Integration of 6G, IoE, and Quantum Computing Technologies

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Abstract. this survey paper comprehensively examines the emerging integration of three pivotal technologies: 6G (Sixth-generation wireless systems), IoE (Internet of Everything), and Quantum computing. The combination of these cutting-edge technologies will be seen leading in the computer-based communications era. The paper starts by providing the underlying reasons for such an integration, which are driven by high demands for higher data speeds, connectivity, and massive computation powers. The main part of this paper deals with examining the personal traits of every kind and contemporary trends in this field. 6G is expected to be way ahead of 5G when it comes to throughput, with applications such as holographic communications and virtual reality to span internationally. IoE is an extension of the concept known as the Internet of Things (IoT), forming a broader inter-network where people, processes, data, and smart things are connected to turn raw data into useful, relevant information that can be acted upon. The emerging data technology of Quantum Computing offers an entirely different paradigm in terms of speedy and complicated computation and solving problems. This further leads to an exploration of the possible advantages and usefulness of combining these technologies. It is expected that this integration will give a big push towards the improvement of communication, information analysis, and computation power across sectors such as health, smart city and cyberspace. The paper also discusses some problems arising from such integration, like complexities on the technical end, security issues and major infrastructure needs. This paper provides basic knowledge for researchers, practitioners, and policymakers interested in technological integration by providing ideas on how 6G, IoE, and Quantum Computing can play major roles in defining future technology frameworks.
Keywords—Integration, 6G, Internet of Everything, Quantum Computing

I. INTRODUCTION

A and things together in an integrated network. As such, it strives to increase the efficiency of information sharing and transforms data into smart initiatives by which informed decisions can be made opting emerging technologies like 6G (sixth generation wireless systems), IoE (Internet of everything), and quantum com- puting will mark an emerging frontier in computing and communications that will bring about new paradigms for computations and communication [1]. This integration is not just an incremental step, however – it's bringing together multiple breakthrough technologies at the absolute leading edge of their fields into a new way of being connected and computing power. 6G is expected to re- place 5G, providing remedies for all its shortcomings and catering to the ever-growing needs of a highly digitised environment. This would offer ultra-broadband connectivity with very high speed. Its expected capabilities include low latency and reliability. The IoE enhances the idea of IoT by

connecting people, processes, data, among industries [2]. However, quantum computing takes its mis- sion beyond where classical computing could venture. Quantum computing has immense speed and can solve very complex, im- possible issues using normal computers [3]. There are challenges in combining 6G, IoE and Quantum computing. The merger of these technologies is in its infancy; this fact gives rise to serious technical, ethical and operational problems. However, this poses a challenge of synchronising them so that they can operate as a unit and not contradict each other's duties or functions. Such an integration will fully realise each technology's potential as well as applications, which may completely change industries, economies, and societies. This is why integration is important. For example,

6 G's higher speed and connectivity together with vast networks of IoE and powerful computation abilities of quantum computing can transform healthcare into live real-time remote monitoring and precision medicines [4]. Likewise, integration in urban planning and management might develop intelligent as well as smart cities. The possible uses are limitless and broad-ranging, affecting almost every area of contemporary culture [5, **?**]. This survey will serve as an overview of the main aspects of both 6G, IoE, and Quantum Computing individually before considering how they collectively work. The survey aims to. Outline the status quo, capabilities, and opportunities for 6G, IoE and Quantum Computing individually. These will include the technical aspect, the ethical perspective, as well as the practical approaches. Highlight potential areas of application and possible advantages of this integration in multi- ple fields. Outline the difficulties involved in merging them, with recommendations on how best to do it effectively.

II. 6G TECHNOLOGIES

With time passing and moving into a new era of wireless com- munication, it becomes evident that the change from 5G to 6G is crucial. The 6G of wireless systems, known as 6G, envisions more than just simple improvement on the previous system but also re- engineering of the wireless infrastructure that has the potential to transform the interaction between people and technologies [6, **?**]. 6G technologies are examined in this chapter with regard to their possible features, how they will be better than fifth-generation (5G) technologies, and the challenges and opportunities in this respect. The 6G is conceptualised as being all-encompassing and intelli- gent, encompassing AI, IoT development and much more. It tries to promote pervasive wireless intelligence to which everyone can have access. These are key 6G driving technologies, including advanced antenna technology, higher-frequency bands, and edge computing. Terahertz (THz) is expected to be utilised by 6G at a frequency higher than that of 4G for high speeds and reduced latency. These frequencies are higher; therefore, they create more bandwidth, though there are still challenges like signal loss and short range [7, **?**]. A significant advancement of 6G is the idea of intelligent surfaces or smart surroundings. These are the sur- faces covered with thousands of tiny antennas aimed at guiding the wireless signals to make 6G more efficient and widespread. This is a very important technology that can help overcome the issues associated with high frequency. 6G would significantly depend on AI predictive systems for enhancement of network quality of service (QoS) towards the end-users [8, **?**]. Resources will be utilised effectively, and the network will adapt to dynamic changes at a fast speed. Furthermore, AI can be of assistance in the field of security, where it would help trace and neutralise threats. Fig. 1 shows some of the advantages offered by 6G technology.

III. INTERNET OF EVERYTHING (IOE)

IoT is just the starting point, so we need to further encom- pass IoE—the networked digital environment within which people

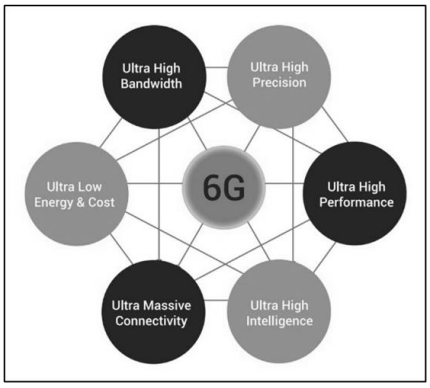

Figure 1. Advantages of 6G Technology

and machines communicate. The Internet of Everything (IoE) in- volves a major turnaround point in which technology finds itself positioned within our world regarding the merger between man, operations, data, and matter [9]. This section will explore the IoE concept and components, how it extends beyond traditional IoT, and how it aids in data generation, collection, and processing.

Figure 2. Internet of Everything

This an example of alphabetical list:

a) A review of IoE concepts and components. IoE is built on four foundational components: people, processes, data, and things. The people are linked in more useful and meaning- ful ways, leading to more productive interactions. ’Processes’ entails ensuring the relevant information is offered to either in- dividuals or machines on time, leading to enhanced decision- making and automation. Sophisticated analytics transforms ’data’ into useful information through which raw data result- ing from IoE is rendered valuable and useful. In addition, ’things’ mean the physical entities attached to the Internet and others which can sense and act. The ecosystem of the IoE covers items such as Smart sensors, wearable devices, home appliances, automobiles and many others [10]. These interconnected devices gather and provide data regarding user behaviour, system performance, and the environment. How- ever, this connectedness goes beyond simply collecting infor- mation; it entails creating learning networks.

b) Why IoE Goes beyond traditional IoT. However, IoE goes the extra mile compared to IoT by considering the processes and people involved in its operation [11]. IoE is also more than merely linking devices but generating smart

systems with the perception ability to understand, learn and decide. This tran- sition illustrates the transformation from a network of devices to a network of intelligence systems. Big data analysis/AI ex- tension is one of the major growths of IoE from common IoT. This integration transforms huge volumes of data produced through connected devices into meaningful, actionable de- tails. However, in IoE, data gets captured, analysed, predicted, adapted and responded to instantly, making the system smart. In its outreach and effectiveness, it is another area where IoE supersedes IoT [12]. IoT looks into a few applications, such as smart homes and industrial automation, whereas the ap- plication scope for IoE is wider and stretches across various disciplines, including health, education, transport, and urban planning.

c) The Role of IoE in Data Generation, Collection, and Pro- cessing The volume of data generated by billions of devices is beyond imagination. This information can be drawn from numerous channels, such as sensors, user interactions, and business transactions [13]. The volume, variety, and velocity of data generated by IoE are critical to its function. Regarding data collection, IoE devices contain sensors and other tech- nologies that collect environmental data [14]. Such data may include measurements like the body's temperature reading or a heart monitor, as well as traffic patterns and power use. IoE offers better quality information about the environment be- cause the data collection process is much more dynamic and all round as opposed to ordinary information systems. In IoE, the data processing transforms large volumes of raw data into intelligible information. It is an AI-guided data mining proce- dure to discover patterns, trends, and insights. For example, in smart cities, data acquired from traffic cameras, pollution sensors, and social media could be used to enhance traffic management, environmental monitoring, and emergency re- sponse service provision. IoE also facilitates live analysis of operational data during its processing. Predictive analytics is another aspect of these techniques that makes use of data to predict future occurrences. Predictive ability is particularly significant for use cases like preventive maintenance within an industry setup or custom healthcare practices [15]. IoE has become a revolutionary notion, which implies broader coverage than just "IoT". IoE integrates people, processes, data, and things, making a smart network whose application will transform society and the way we run our businesses. IoE plays a critical part in converting large volumes of un- processed information into valuable decision-making outputs. Moving forward, we can all see that IoE will be instrumental in setting the stage for the evolutionary journey we are all on towards an increasingly digitalised tomorrow.

IV. QUANTUM COMPUTING

a) Basics of Quantum Computing and Its Current State Quantum computing is the most fascinating frontier of contemporary science. It involves the creation of new computing paradigms using the laws of physics that describe the behaviour of energy and matter at the microscopic level [16]. In contrast, quantum computing differs from traditional computing, which uses a bit as its basic information unit. Classical bits are binary, existing in one of two states: 0 or 1. However, Quantum Computing employs qubits that are able to display multiple states through superposition. Quantum computers can con- duct computation on thousands of outcomes simultaneously. Thus, it enables such computers to showcase exponential pro- cessing capacity against conventional machines. The other important aspect of Quantum Computing is entanglement, the quantum phenomenon whereby pairs or sets of qubits are tied together such that the condition of one Quantum can have an instantaneous effect on the condition of another Quan- tum, irrespective of space separation [17]. Because of this property, quantum computers are able to outperform classical computers at solving complex computations. However, as it stands, Quantum Computing is still in its infancy. There is great competition amongst technology companies and start- ups that

are currently racing to implement practical, usable quantum computers. Progress has been made in developing qubits that are stable and controllably accurate. "Quantum supremacy" – which is about the ability of a quantum com- puter to resolve a subject beyond the competence of a classical one within a reasonable period is pronounced in certain en- vironments; however, there is no generally available practical application for quantum computers up until nowadays.

b) Potential Impacts on Computing Capabilities and Data Pro- cessing There is much that Quantum Computing can do to computing abilities as well as processing data. Cryptogra- phy is one of the major domains that are influenced by this factor. This means that the development of quantum-resistant cryptographic systems is necessary since these quantum com- puters can break most of the existing conventional cryptosys- tems. Quantum Computing, a new tool in data processing, has great potential to improve the handling of difficult tasks at scale [18]. Due to its capacity to carry out concurrent data processing operations and enormous databases, it may contribute to innovations in fields like drug development, climatology, or economic projection. In addition, quantum computing can be instrumental in the further improvement of artificial intelligence as this technology would allow for faster processing of huge volumes of data that is necessary for cre- ating more advanced AI programs [19]. The potential impact of Quantum Computing can be immense. For example, in physics and materials science, it could be used to explain
complex molecular structures, which is not possible using conventional computers. This may reveal newly developed materials and even drugs [20].

c) Challenges in Developing and Implementing Quantum Com- puting Although it has great potential, deployment of Quan- tum Computing is faced with quite big hindrances. The main problem in this respect is the concept of "quantum decoher- ence" or Quantum stability. However, such small changes as in temperature, electromagnetic fields, or colliding with air particles may alter the qubits' quantum properties. The development of these qubits, which can stay in the same state for a longer time duration needed to conduct complex com- putations, is a big challenge [21]. Another challenge is error correction. Errors in quantum computers occur because of the presence of quantum noise as well as decoherence. Effec- tive quantum error correction methods are vital ingredients in the manufacture of dependable and feasible quantum comput- ers. It is also a key concern regarding scalability. Building a practical application of a quantum computer requires a large number of qubits, and each additional Quantum makes the system more complex. Researchers [22, 23][22-24] continu- ously attempt to develop more refined methods of managing and controlling a large quantum system. In addition, it is hard to design quantum-suitable algorithms as well. A plethora of issues and concerns require developing new sets of algo- rithms that will be able to fully explore the potential of quan- tum computers. Thirdly, it comes to issues on integration and marketing. It is important to plug quantum computers into various traditional IT infrastructures and identify practical purposes for their use in various commercial activities.

V. INTEGRATION OF 6G, IOE, AND QUANTUM COMPUTING

6G, coupled with IoE and Quantum Computing, is poised to be the next big thing in digital communication. The integration is not of its parts, but a combination to an effect which cannot be imagined for it is not of its parts. We will discuss the ways in which these technologies can be mixed and the possible advantages of such interconnection; the technical and operational aspects of such combination will also be reviewed.

a) Analysis of How These Technologies Can Be Integrated 6G, IoE, and quantum computing come together to improve over- all performance. The ultra-fast and low latency communi- cations in 6G can lay down the necessary infrastructure for

the big data transfer demands by IoE and QC. The vast net- work of connected devices and sensors can produce big data for quantum calculations in real-time within the ”Internet of Everything”. The fact that it is too much information for classical computers is another argument for using Quantum as they process this data at an incredible speed and provide insights and answers that cannot be seen in classic ones. The
use of 6G networks to relay Quantum encrypted data for se- curities and safety assurance for IoE is one way of integrating these technologies. Using enhanced quantum computing al- gorithms, 6G and IoE will be able to optimise their networks, analyse information, and provide a reliable cyber-secure en- vironment.

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c) Technical and Logistical Challenges Although the advantages are enormous, integrating these technologies poses many technical and operational complications. The first major dif- ficulty is interoperability and compatibility. It is critical to define and create common standards for 6G, IoE, and quantum computing in order to facilitate smooth interaction between these technologies. The other one entails handling vast data volumes from IoE that are to be processed by Quantum Com- puting. Such advanced data storage solutions and effective real-time, on- access data are required for data analysis to take place in time. It is imperative that a solid and safe means of communication be established. There is a need to use quan- tum computing in encryption and cyber security with high cyber risks in an inter-networked world. However, ensuring secure communication using the quantum-secure protocols over the 6G and Ion platforms are some of the challenges for the near future in quantum crypto. Furthermore, there are issues of infrastructural capacity and scale-up. Construct- ing the foundation on which to operate 6G with low latency and massive IoE connections, as well as the unique needs of Quantum computing, is an enormous challenge. In order to realise this, there are huge costs that must be involved in the collaboration of several stakeholders, such as governments, industries, and research facilities. However, logistic issues arise during the deployment and maintenance of such inte- grated systems. This involves sophisticated installation of new hardware, updating services, and the unceasing reliabil- ity and operation of the networks and computing facilities.

VI. CASE STUDIES AND APPLICATIONS OF THE INTEGRATION OF 6G, IOE, AND QUANTUM COMPUTING

Integrating 6G, IoE, and Quantum Computing provides an ar- ray of innovation possibilities in numerous industries. This part of the book includes several actual as well as fictitious cases of the practical implementation and outcomes of such techno conver- gences.

1) Case Study 1: Healthcare - Remote Surgery and Patient Mon- itoring With the integration of technologies, the healthcare sector can completely change how patients are treated and health procedures are undertaken. For instance, what if a surgeon in any metropolitan operates a difficult procedure on a patient in a faraway place through robotics. First, 6G offers ultra-low latencies and

high bandwidth, enabling real-time control for robot surgeons. Second, this can be made possible due to IoE, which ensures smooth connectivity of medical devices [21]. As for processing patient data and perform- ing surgical simulations as well as real-time analytics, it is important that they be precise and contain minimum errors, which Quantum Computing guarantees. Furthermore, IoE devices, including wearable health monitors, gather patients' raw information and the data is processed by Quantum Com- puting algorithms for personalised healthcare. The essence lies in improving the quality and extending health care to the underprivileged and remote areas.

2) Case Study 2: Smart Cities - Traffic Management and En- ergy Efficiency The smart city is an example where 6G, along with IoE and Quantum Computing, will make urban life more efficient and sustainable. Imagine an urban environment in which traffic lights, public transportation and mobile objects form one system of IoE. Quantum Computing will help anal- yse the real-time data from these providers to enhance traffic flow and reduce congestion and emissions in the process. The 6G network allows for quick and accurate transmission of such information, which means it can be used to effect in- stant changes. Additionally, Quantum Computing can be used to manage the city's energy consumption. The system uses smart meter data across the network of sensors and optimises energy sharing while taking into consideration waste man- agement and incorporating renewable energy sources, which all contribute to the city's sustainability goal.

3) Case Study 3: Finance - Fraud Detection and Risk Man- agement The combination can improve fraud detection and increase risk management in finance. IoT involves real-time transaction data collection to banks and financial institutions in this context. By analysing a huge dataset, Quantum Com- puting will help establish such patterns and anomalies that denote dishonest operations. Real-time fraud detection pro- vided by Quantum Computing in a dynamic financial market is very important. 6G provides fast and reliable delivery of
these analyses to the concerned stakeholders;
thus, timely actions can be taken.

4) Case Study 4: Environmental Monitoring and Climate Change Analysis The integration of the components will be particularly beneficial for environmental monitoring and cli- mate change analysis. Sensors that are part of the IoE are present in several locations, and they can measure parame- ters such as temperature, humidity, contamination rates, etc. It will be possible for quantum computing to calculate this massive set of data on the future predictions to model the po- tential climate change, prediction of environmental disasters, and decision-making on the policies. This implies that the re- mote sensors transmit environmental data to the data centres in real-time, which is achievable through 6G high-speed data transmission capabilities.

5) Case Study 5: Autonomous Vehicles and Transportation Au- tonomous vehicular systems integrated with IoE technologies in the arena of transportation can communicate among them- selves and with the city's infrastructures for enhanced safety and productivity within the transport sector. Because of this, quantum computing can help process all the data generated by these cars for routing optimisation purposes, reducing traf- fic congestion and preventing accidents. The reliability and speed of 6G systems are essential for transmitting real-time necessary information for safe driving activities.

VII. FUTURE TRENDS AND DIRECTIONS IN THE INTEGRATION OF 6G, IOE, AND QUANTUM COMPUTING

The combination of 6G, IoE and Quantum Computing will re- shape our relationship with technology and information exchange. In this section, we examine projections pertaining to these tech- nologies' evolution, state possible future research areas, and high- light new trends and emerging technologies.

1) Advancements in 6G Technology Predictions about the Evo- lution of These Technologies: Future developments of 6G will most probably concentrate on faster speed, low latency, and higher reliability. In turn, we may look forward to the emergence of more advanced antenna systems using differ- ent spectrum bands, such as in terahertz frequency range. Also, 6G may include artificial intelligence-directed network management that adjusts operations upon the occurrence of change in a dynamic environment.

2) Expansion and Sophistication of IoE: IoE will continue to grow as more and more machines and sensors are integrated. Future trends could also involve building better edge comput- ing abilities that will enable real-time on-site data processing. In addition, the IoE will be more intelligent through improved AI algorithms that will enable devices to make more indepen- dent decisions.

3) Quantum Computing Breakthroughs: We will see significant advancements in Quantum stability and error correction in the field of quantum computing, leading to more practical and hardy quantum computers. Their complexity will increase, and they may appear in industries that require complex cal- culations, like medicine, finance, and material production.

• Potential Future Research Areas: 6G-IoE-Quantum Computing Convergence: Research is going to be in- tense on how to incorporate it into 6G, IoE, and Quan- tum Computing to ensure safety and create unique struc- tures.

• Energy Efficiency and Sustainability: Over time, these problems with energy use and the environmental issues around them are highly significant. In contrast, the development of energy-efficient parts and processes in support of global IoE and massive quantum computing usage will nevertheless be important for future research.

• Human-Technology Interaction One of the research that will be undertaken in this study will be on understanding this interaction and its processes towards improving hu- man understanding of these complicated technologies. It encompasses interface design, affordable access for all to technology, and exploring what happens when you integrate technology into society as an entirety.

VIII. EMERGING TRENDS AND TECHNOLOGICAL ADVANCEMENTS

1) Ubiquitous Connectivity: Among all the prominent trends, the shift towards omnipresent communications that can be attained with any device at any place will become one of them. Such will happen with the widening of 6G networks and the increase in Internet-connected objects.

2) As quantum computing gets better, so would there be a de- mand for quantum-secure communication systems. The con- sideration of this aspect assumes great importance in the con- text of the security of information transmissions through 6G networks that employ common cryptographic techniques.

3) AI and Machine Learning Integration: 6G, IoE, and Quan- tum Computing will have embedded smarter networks, more efficient data processing, and better decision-making capa- bilities that are achieved through AI and machine learning integration.

4) Personalised and Predictive Systems: The convergence of these technologies will certainly drive towards advanced personalised and predictive systems, including customised healthcare relying on instantaneous monitoring or predictive maintenance in production.

5) Ethical and Regulatory Frameworks: The need for ethical guidelines and regulation of these advancing technologies

would also increase since they come with questions that re- volve around issues like data privacy, safety, and the social impacts of widespread technological uptakes.

IX. CONCLUSION

This survey has shown the way forward, which is the conver- gence of these technologies leading to unimaginable opportunities and challenges in the sixth generation networks technology. The combination of high speed, low latency 6G, the ubiquitous connec- tion and intelligence of IoE, and

the power computing of quantum computing will revolutionise healthcare, urban management, environment monitoring, finance, and transport. This survey provided some important insights into what 6G is set to be capable of. It may go beyond today's communication systems and offer groundbreaking apps that will change the way we interact digitally. In this regard, the expansion of IoE far exceeds IoT, with more smart and linked devices capturing huge quantities of information to be transformed into timely, meaningful business knowledge. How- ever, where does the hope for future success lie? The answer is in quantum computing which will be able to tackle such problems as big data analysis and solve otherwise unsolvable tasks which lie currently out of the scope of classical computing. Integration of these technologies does, however, have its limitations. The main difficulties include technical complications, data storage, safety issues, and related infrastructure. Solving these problems creates opportunities for new inventions and improvements. The survey is important, as it takes an in-depth look into how each technology and all the technologies as a whole function. This emphasises the transformational nature of their integration that serves as a cru- cial guidepost for researchers, policymakers, and industrial players to predict subsequent breakthroughs in technology. In future re- search, a multidisciplinary approach should be considered involv- ing collaborative efforts of different fields that are multi-faceted in nature. Sustainability is stressed, and considerations of ethics, regulations, and realistic pilot implementations are key. Besides, further examination and funding of the field should be done as it can only be realised by improving the Quantum and creating quantum algorithms.
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مستخلص. هذه الورقة تفحص بشكل شامل التكامل الثنائي لثلاث تقنيات حيوية: الجيل السادس من أنظمة الاتصالات اللاسلكية، والأنترنت من كل شي والحوسبة الكمية يتوقع أن يكون تجمع هذه التقنيات المتقدمة الحافز الرئيسي في عصر الاتصالات المبنية على الحواسيب. تبدأ الورقة بتوفير الأسباب الأساسية لهذا التكامل، والتي تعتمد على الطلب المتزايد على سرعات البيانات العالية والاتصالات والقدرات الحسابية الضخمة. تتناول الجزء الرئيسي من الورقة فحص الخصائص الشخصية لكل نوع والاتجاهات المعاصرة في هذا المجال. يتوقع أن يكون الجيل السادس متقدماً بكثير على الجيل الخامس من حيث النقل مع تطبيقات مثل الاتصالات والواقع الافتراضي تمتد على نطاق عالي. يعتبر الانترنت من كل شي تمديداً لفكرة انترنت الأشياء، وهو يشكل شبكة تفاعلية أوسع حيث يتصل الأشخاص والعمليات الذكية لتحويل البيانات الخام الى معلومات مفيدة وملائمة يمكن اتخاذ إجراءات على أساسها. تقدم تكنولوجيا البيانات الناشئة للحوسبة الكمية نمطاً مختلفاً تماماً من حيث الحسابات السريعة والمعقدة وحل المشكلات يؤدي ذلك إلى استكشاف المزايا والفوائد المحتملة لدمج هذه التقنيات. من المتوقع أن يمنح هذا التكامل دفعة كبيرة في تحسين الاتصالات وتحليل المعلومات وقدرات الحوسبة عبر قطاعات مثل الصحة والمدينة الذكية والمجال الافتراضي. تناقش الورقة أيضاً بعض المشكلات التي تنشأ من مثل هذا التكامل، مثل التعقيدات على الصعيد التقني وقضايا الأمان واحتياجات البنية التحتية الرئيسية. توفر هذه الورقة المعرفة الأساسية للباحثين والممارسين وصناع القرار المهتمين بالتكامل التكنولوجي من خلال تقديم أفكار حول كيفية لعب الجيل السادس والأنترنت من كل شي والحوسبة الكمية وادواراً رئيسية في تحديد إطارات التكنولوجيا المستقبلية.

الكلمات المفتاحيةـ التكامل، الجيل السادس، انترنت الأشياء، انترنت كل شي، الحوسبة الكمية.