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RESEARCH ARTICLE

A Study and Future Challenges in 6G Networks: Aeronautical Network, AI and Blockchain

6G Ağlarında Bir Çalışma ve Gelecekteki Zorluklar: Havacılık Ağı, Yapay Zeka ve Blockchain

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Abstract

This study addresses aeronautical networks, artificial intelligence (AI) and blockchain technologies that will shape the future development of 6G networks and the challenges that the integration of these technologies may face. While aeronautical networks offer wide coverage areas and uninterrupted communications, AI is revolutionizing network management and service personalization. Blockchain, on the other hand, provides security and transparency, allowing the protection of user data and the implementation of smart contracts. This integration enables the development of new services and applications while increasing the flexibility and reliability of 6G. The study highlights that the development and implementation of 6G networks requires a multifaceted and interdisciplinary research effort. Topics such as aeronautical communication, development of AI algorithms, blockchain scalability and energy efficiency should be the focus of future research. Additionally, socio-economic factors such as reducing the digital divide, legal and regulatory compliance, and user-centered design should also be taken into account. Serving as a starting point for future researchers, this study is an important step that will determine the success of 6G and shape the communication networks of the future.

Keywords: Artificial Intelligence, Blockchain, Aeronautical Network, 6G

Öz

Bu çalışma, 6G ağlarının gelecekteki gelişimini şekillendirecek havacılık ağlarını, yapay zekayı (AI) ve blockchain teknolojilerini ve bu teknolojilerin entegrasyonunun karşılaşabileceği zorlukları ele alıyor. Havacılık ağları geniş kapsama alanları ve kesintisiz iletişim sunarken yapay zeka, ağ yönetimi ve hizmet kişiselleştirmede devrim yaratıyor. Blockchain ise güvenlik ve şeffaflık sağlayarak kullanıcı verilerinin korunmasına ve akıllı sözleşmelerin uygulanmasına olanak tanıyor. Bu entegrasyon, 6G'nin esnekliğini ve güvenilirliğini artırırken yeni hizmet ve uygulamaların geliştirilmesine olanak sağlıyor. Çalışma, 6G ağlarının geliştirilmesi ve uygulanmasının çok yönlü ve disiplinler arası bir araştırma çabası gerektirdiğini vurguluyor. Havacılık iletişimi, yapay zeka algoritmalarının geliştirilmesi, blockchain ölçeklenebilirliği ve enerji verimliliği gibi konular gelecekteki araştırmaların odak noktası olmalıdır. Ayrıca dijital uçurumun azaltılması, yasal ve mevzuata uygunluk, kullanıcı odaklı tasarım gibi sosyo-ekonomik faktörler de dikkate alınmalıdır. Gelecekteki araştırmacılara başlangıç noktası olacak bu çalışma, 6G'nin başarısını belirleyecek ve geleceğin iletişim ağlarını şekillendirecek önemli bir adımdır.

Anahtar Kelimeler: Yapay Zeka, Blockchain, Havacılık Ağı, 6G

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1. INTRODUCTION

Telecommunication technology entered our lives with mobile devices that provide voice communication over analog signals, starting with 1G in the 1980s. Then came services such as 2G, digital encryption and SMS. 3G increased data transmission speed, making internet access and video calls possible. 4G enriched the user experience with high-speed internet and advanced mobile applications. 5G technology supports innovations such as the internet of things (IoT), smart cities and autonomous vehicles with its ultra-low latency and high data transfer speeds. Now, 6G promises to further expand the boundaries of telecommunications with terahertz (THz) bandwidth, artificial intelligence integration and advanced network topologies [1].

Non-Terrestrial Networks (NTN) are systems that provide communication from the earth to high altitudes, usually through suborbital platforms and satellites. NTN is critical for providing connectivity in regions where traditional ground-based networks cannot reach or are inadequate. This technology is used to strengthen communication infrastructure, especially in remote, rural and challenging geographies [2-5]. Aeronautical networks use aviation technologies to provide communication services in areas where ground-based networks cannot reach or are inadequate. These networks include a variety of platforms such as Unmanned Aerial Vehicles (UAVs), High Altitude Platforms (HAPs) and Low Orbiting Satellites (LEO Satellites). Aeronautic networks offer advantages such as fast deployment, high mobility and wide coverage. While 6G technology promises ultra-high speed, low latency and wide coverage, the integration of NTN and aeronautical networks plays a key role in realizing these promises. 6G's terahertz bandwidth and advanced network topologies are designed to enable more efficient and effective use of NTN and aeronautic networks. Integration of NTN and aeronautic networks with 6G has the potential to push the boundaries of future communication networks and provide uninterrupted communication worldwide. This integration is vital to the success of 6G.

In the transition from 5G to 6G, 5G-Advanced, built on the foundation provided by 5G, has taken important steps in improving performance and enabling new use cases. 6G aims to go further than the speed and reliability offered by 5G, offering terabyte/second speeds and millisecond-level latencies. The development of 6G networks is closely related to the integration of Artificial Intelligence (AI) and Blockchain technologies. These two revolutionary technologies are considered the cornerstones of 6G and have the potential to transform the performance, security and services of networks. Artificial Intelligence is used in various areas such as data analysis, network optimization and service personalization in 6G networks. AI can process complex data sets, learn user behavior, and manage network resources in real time. AI's advanced learning algorithms also play a critical role in detecting cyber-attacks to improve network security. Blockchain increases network security by ensuring data integrity and user privacy. Smart contracts and distributed ledger technology facilitate automated service agreements and transactions. With its decentralized nature, blockchain reduces the risk of single-point failure and increases security on the network. The integration of Artificial Intelligence and Blockchain technologies into 6G networks has the potential to make future communication networks more secure, flexible and efficient [6-9]. This integration is a turning point that will determine the success of 6G and provide innovative solutions to societal challenges.

6G networks have the potential to shape the future of telecommunications and provide innovative solutions to societal challenges. This study discusses the integration of aeronautical networks, artificial intelligence and blockchain technologies, which are the key components of 6G, and the challenges this integration may face, and highlights innovations in this field. This study examines in depth the innovations brought about by the integration of these components into 6G networks and the social and economic impacts of these innovations. Integration is key to realizing 6G's promises of ultra-high speeds, low latency and wide coverage. This study highlights that the development and implementation of 6G networks requires a multifaceted and interdisciplinary research effort. It reveals that innovative components and integration are important steps that will determine the success of 6G and shape the communication networks of the future.

The remainder of this paper is organized as follows: Section II discusses the aeronautical network architecture in 6G. Section III presents the AI in 6G. Section IV presents the Blockchain in 6G. Section V presents the integration of aeronautical network, AI and blockchain in 6G. Section VI is the challenges and future directions. Section VII discusses conclusions.

2. AERONAUTICAL NETWORK ARCHITECTURE IN 6G

6G networks of the future expect everything to be connected, which will combine terrestrial and nonterrestrial networks. However, in order to achieve better resource sharing and spectral efficiency, as mentioned in [10], an intermediary layer—the aeronautical layer—between the satellite and terrestrial layers is needed. As a result, to provide high bandwidth, mm-wave networks will be used in conjunction with civil aircraft, UAVs, and HAPs. According to [11–21], this is a three-dimensional network architecture comprising terrestrial networks, such as Radio Access Networks (RANs), non-terrestrial networks, such as satellites, and aeronautical networks. Fig. 1 depicts an extensive description of the architecture. In contrast to past network generations and ongoing research in aeronautical systems, a novel concept is introduced focusing on network consumers. These consumers encompass traditional User Equipment (UEs) as well as UEs within aircraft seeking In-Flight Entertainment and Connectivity Services (IFECS). Additionally, aircraft themselves may require services such as weather predictions, sensing, and localization data, making them consumers as well. Traditional satellites may also require processing capacity or intelligence to execute advanced algorithms necessitating SDN, Network Function Virtualization (NFV), and AI capabilities. Throughout this paper, the services provided to consumers will be referred to as applications. To align 6G features with our architecture, the crucial elements are the communication, processing, and storage resources of all components in the aerial domain. Both terrestrial and aeronautical networks must be equipped with servers capable of enhancing network performance, endorsing the concept of federated in-network computing. Proximity to consumers is categorized from cloud to edge and

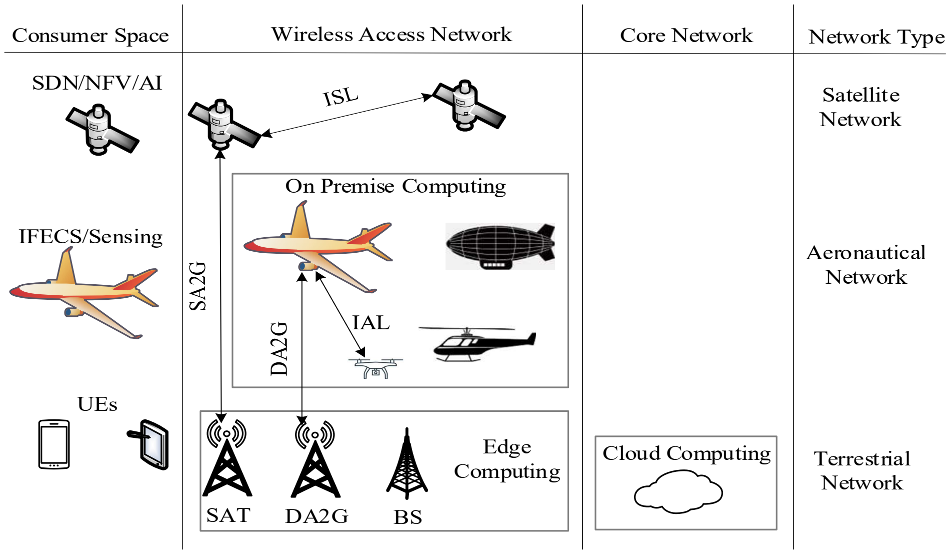

Figure 1. An example of aeronautical network architecture.

premise computing, with these servers serving as the processing and storage resources. Communication resources in the sky include Inter-Aerial Links (IALs) for communication among various aeronautical components, Inter-Satellite Links (ISLs) for communication among satellites, Direct-Air-to-Ground (DA2G) links, and Satellite-to-Gateway links (SA2G). Alternatively, Air-to-Satellite mmWave links can be employed given the specific limitations of DA2G links. Establishing integration between satellite and aeronautical components with the terrestrial network involves placing Satellite Gateways (SATs), DA2G gateways, and Base Stations (BSs) in what is referred to as the wireless access network. This network then connects to the core network, where we will delve into how resources can be aggregated and allocated to consumers to deliver the necessary applications through a federation entity in the sky.

A novel paradigm for the network customer is introduced, which differs from earlier generations of networks and current research for aviation systems. From our vantage point, a consumer might include both conventional users and users wanting connectivity and in-flight entertainment aboard flights. Additionally, aircraft may be seen as consumers if they need sensors, localization, and weather forecasts, among other things. Conversely, conventional satellites might imagine having the intellect or processing power to execute complex algorithms that call for SDN, NFT, and AI capabilities. Consumer services shall be referred to as applications for the rest of this article.

All components in the sky have communication, processing, and storage capacity, which are essential for mapping 6G capabilities to our design. In order to promote the idea of federated in-network computing, not only terrestrial networks but also aerial networks must be outfitted with servers that may be used to enhance network performance. They are categorized from cloud to edge and premise computing based on how close they are to the consumer. The processing and storage resources are made up of these servers. The sky's communication resources include Direct-Air-to-Ground (DA2G) links,

Table 1. Aeronautical Network Architecture in 6G.

Architectural Component	Functions	Its Role in 6G Networks	Potential Challenges
UAVs (Unmanned Aerial Vehicles)	Local network services, emergency communications, data collection	Extends the coverage area of ground-based networks, enables rapid deployment	Energy management, air traffic control, security protocols
HAPs (High Altitude Platforms)	Long-term service at fixed points, wide area coverage	Provides wide coverage at high altitude, supports ground-based networks	Impact of weather conditions, energy efficiency, maintenance challenges
LEO Satellites (Low Orbit Satellites)	Global coverage, high speed data transfer	Provides uninterrupted communication worldwide, access to remote areas	Orbit management, signal delay, space debris
Ground-Based Networks	Basic network access, data routing, user connectivity	Underpins 6G, connecting ground-based users	Density management, infrastructure costs, update requirements
Wireless Access Network	Network access, data transfer, service distribution	Connects air- and space-based layers to the ground-based network	Frequency management, interference control, energy efficiency
Core Network	Data centers, servers, network management	Manages and coordinates all network layers	Security, scalability, high performance requirements

Satellite-to-Gateway (SA2G) links, Inter-Aerial Links (IALs) for communication between different aeronautical components, and Inter-Satellite Links (ISLs) for communication among satellites. As an alternative, Air-to-Satellite mmWave links can be used, considering the particular limitations of DA2G lines [22]. Base Stations (BSs), DA2G gateways, and Satellite Gateways (SATs) are deployed in what is known as a wireless access network in order to provide the integration of the satellite and aeronautical components to the terrestrial network [23]. The core network is further connected to the wireless access network. In the latter, we will go into further detail about how resources might be collected and distributed to users via a federation entity in the sky in order to deliver the necessary applications.

Table 1 summarizes the various components of aeronautical network architecture in 6G networks, the functions of these components, their roles in 6G networks, and the potential challenges they may face. Each component plays an important role in the high-speed, connected world that 6G promises and can deepen the social and economic impacts of the technology.

Various metrics are used to evaluate the performance of the aeronautical network architecture. These metrics measure important aspects of the network such as throughput, latency, reliability, and energy efficiency. These performance metrics and equations form the basis for the design and optimization of 6G aeronautical network architecture.

- Throughput: Data transmission rate is directly related to the bandwidth (*B)* used and the signal-to-noise ratio (SNR). The Shannon-Hartley theorem expresses this relationship as follows:

$$R = B\log_2(1+SNR) \tag{1}$$

This equation shows what the maximum data transmission rate could theoretically be at a given bandwidth and signal-to-noise ratio.

- Latency: Delay time (D) consists of the sum of processing time (T_p), transmission time (T_t), and travel time (T_r):

$$D = T_p + T_t + T_r \tag{2}$$

This equation is used to calculate how long it will take for a packet to reach its destination from the source.

- Reliability: It is expressed in terms of successful packet delivery rate (P_s) and error rate (P_e):

$$R = P_s(1-P_e) \tag{3}$$

This equation indicates how reliably the network can transmit packets without errors.

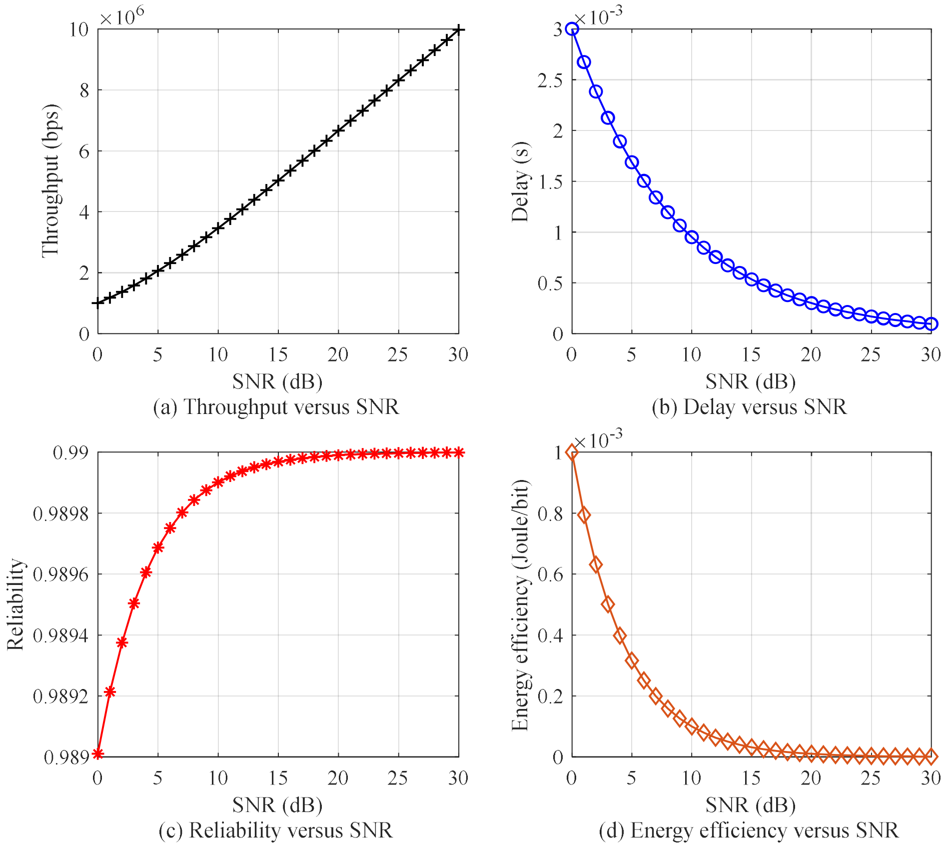

Figure 2. Performance metrics of the aeronautical network versus SNR.

- Energy efficiency: Energy efficiency (E) is calculated by the amount of energy per transmitted bit (E_b) and the total energy consumption (E_t):

$$E = \frac{E_b}{E_t} \tag{4}$$

This equation is used to optimize the energy consumption of the network.

Figure 2 shows how performance metrics such as throughput, latency, reliability, and energy efficiency change over a range of SNR values. Throughput increases logarithmically with increasing SNR. Higher SNR values indicate greater data transmission capacity. The Shannon-Hartley theorem expresses this relationship mathematically. Higher SNR values mean faster data transmission. However, it cannot be said that this speed increases unlimitedly; bandwidth and other factors also play a role. The latency graph shows a decrease with increasing SNR, as latency generally depends on the physical characteristics of the transmission medium and network protocols. Factors such as processing time, transmission time, and travel time affect the total latency. Reliability increases with increasing SNR. High SNR means fewer errors, leading to a higher successful packet delivery rate. Reliability indicates how reliably the network can transmit packets without errors. Energy efficiency decreases as SNR increases. Higher SNR allows more bits to be transmitted with the same amount of energy, increasing efficiency. Energy efficiency is important to optimize the energy consumption of the network. Lower energy consumption is important for sustainability and long battery life.

3. AI IN 6G

AI is considered one of the cornerstones of 6G networks. AI has the potential to revolutionize areas such as data analysis, network optimization and service personalization [24-27]. This section examines in detail the role of AI in 6G networks and how this technology can address future challenges.

- The Role of AI in 6G Network Management: In 6G networks, AI can optimize data flow and resource distribution by instantly analyzing network traffic. By learning user behavior, machine learning algorithms can continuously improve network performance. AI is also critical for network security; It can use advanced pattern recognition capabilities to detect and prevent cyber-attacks.
- AI-Powered Services and Applications: AI also plays an important role in developing the services and applications that 6G will support. For example, AI-powered healthcare could revolutionize real-time patient monitoring and diagnosis. In smart cities, AI can provide effective solutions in areas such as traffic management, energy conservation and public safety.
- AI and Industrial Automation: 6G will shape the future of industrial automation and AI will play a central role here. By optimizing production processes, AI can predict malfunctions and automate maintenance processes. This helps reduce costs while increasing production efficiency.
- The Role of AI in Education and Learning: By personalizing education and learning processes, AI can offer appropriate learning paths according to the needs of each student. 6G's high-speed connectivity can increase equality of opportunity in education by providing richer and more interactive experiences in distance education.

Implementing AI in 6G networks brings challenges such as data privacy and ethics. Transparency and fairness of AI algorithms will increase society's trust in these technologies. Additionally, AI's energy consumption and sustainability are an important factor in efforts to reduce the environmental impact of 6G.

Table 2. AI Technologies in 6G.

AI Application Field	Explanation	Potential Impacts on 6G
Network Optimization	AI algorithms can improve network performance by analyzing data traffic and optimizing resource allocation.	Faster and more efficient network operations, improved user experience.
Security	AI-powered systems can be used to detect and prevent cyber-attacks.	Strengthened network security and reduced cyber risks.
Service Personalization	AI can provide personalized services by learning user behavior.	Services that better adapt to user needs.
IoT Integration	AI can manage communication and transactions between IoT devices.	More effective device management in smart homes and cities.
Energy Management	AI can improve the energy efficiency of networks by monitoring and managing energy consumption.	Sustainable network operations and reduced environmental impact.
Health Service	AI can be used for real-time patient monitoring and diagnosis.	Improvements to remote health monitoring and emergency responses.
Traffic Management	AI can reduce traffic problems in smart cities by analyzing and managing traffic flow.	Less traffic congestion and increased public safety.
Industrial automation	AI can increase industrial efficiency by optimizing production processes and predicting failures.	Higher production efficiency and reduced operational costs.

AI in 6G is key to improving network performance, developing new services and applications, and finding solutions to societal challenges. Effective integration of this technology will determine the success of 6G and shape the communication networks of the future.

Table 2 summarizes various aspects of AI in 6G networks and potential applications of this technology. AI is used in a wide range of areas, from network optimization to security, from service personalization to IoT integration. While network optimization stands out as an area where AI improves network performance by analyzing data traffic and optimizing resource allocation, in security, AI-supported systems are used to detect and prevent cyber-attacks. AI also provides personalized services by learning user behavior and manages communication and transactions between IoT devices. In energy management, AI can improve the energy efficiency of networks by monitoring and managing energy consumption. In healthcare, AI can be used for real-time patient monitoring and diagnosis, while in traffic management, AI can reduce traffic problems in smart cities by analyzing and managing traffic flow. In industrial automation, AI can increase industrial efficiency by optimizing production processes and predicting malfunctions. AI can improve network performance by automating network management and providing real-time performance optimization. Additionally, AI-powered security systems can provide faster response to threats and better threat mitigation. The predicted high speeds and low latencies of 6G may require AI to take on

Table 3. Blockchain Technology in 6G.

Blockchain Application Area	Explanation	Potential Impacts on 6G
Security and Privacy	Blockchain increases network security by ensuring data integrity and user privacy.	Strengthened data security and enhanced user privacy.
Smart Contracts	Automatically executed contracts simplify service agreements and transactions.	More efficient service management and reduced legal complexity.
Distributed Management	Decentralized network management reduces the risk of a single point of failure.	More durable and flexible network structures.
IoT Integration	It is used for secure data exchange and transactions between IoT devices.	Secure and transparent IoT ecosystems.
Authentication	Securely manages the authentication of users and devices.	Preventing fraud and reducing the risk of identity theft.
Copyrights and Licensing	Protection of copyrights of digital content and management of license agreements.	Better rights management and revenue distribution in the creative industries.
Supply chain management	It ensures traceability of products from their source to the consumer.	Transparent and reliable supply chains.
Financial Services	Fast and secure payment systems and financial transactions.	More efficient financial transactions and reduced transaction costs.

more complex tasks in network management. For example, AI can detect security threats by analyzing traffic patterns and comparing them with historical data.

4. BLOCKCHAIN IN 6G

Blockchain technology has the potential to transform the security and transparency aspects of 6G networks [28-34]. This section will discuss how blockchain can be integrated in 6G networks, the innovations that this integration will bring, and the challenges that will be encountered.

Blockchain is a distributed ledger that stores data in an immutable and transparent manner. Each block is linked to a cryptographic hash of the previous block, ensuring data integrity. With its decentralized nature, blockchain reduces the risk of single-point failure and increases security on the network.

In 6G networks, blockchain can be used to protect the privacy of user data, implement automatic service agreements through smart contracts, and verify network transactions. It also contributes to the expansion of the internet of things (IoT) by securing transactions between IoT devices. Blockchain has various uses in 6G-enabled applications:

- Financial Transactions: Fast and secure payment systems.
- Supply Chain Management: Traceability of products from source to consumer.
- Smart Cities: Effective management and automation of public services.

Implementation of blockchain technology brings challenges such as scalability and energy consumption. It also needs to be aligned with existing legal and regulatory frameworks. With the development of 6G, blockchain is expected to become more efficient and sustainable. Integration of blockchain technology in 6G networks can significantly improve network security and user privacy. This technology has the potential to make the communication networks of the future more secure, transparent and efficient. Blockchain technology can play an important role in ensuring security and privacy in 6G networks. In particular, blockchain-based radio access networks can offer a reliable and secure 6G network structure. Blockchain can help networks become more efficient and secure by improving resource sharing, data interaction, and access control.

Table 3 presents a wide range of potential impacts of the use of blockchain technology in 6G networks, from security and privacy to financial services. Blockchain increases network security by ensuring data integrity and user privacy, while smart contracts facilitate automatic service agreements and reduce the risk of single-point failure with decentralized network management. It enables secure data exchange between IoT devices, enabling more effective device management in smart homes and cities. It securely manages user and device authentication, protects the copyright of digital content, and ensures traceability of products in supply chain management. Additionally, it makes financial transactions more efficient with fast and secure payment systems.

5. INTEGRATION OF AERONAUTICAL NETWORK, AI AND BLOCKCHAIN IN 6G

The revolutionary communications network promised by 6G requires the integration of aeronautical networks, AI and blockchain technologies [35-38]. This section will discuss how these three basic technologies will be integrated into 6G networks, the innovations that this integration will bring, and the challenges that will be encountered.

Aeronautical networks aim to provide communications even in regions where ground-based networks cannot reach, using aviation tools such as UAVs, HAPs and LEO satellites. In 6G, integration of these networks is critical to provide wide coverage and uninterrupted communications. Aeronautic networks can be used to extend network reach and strengthen emergency communications, especially in rural and remote areas [39].

Table 4. Integration of Aeronautical Network, AI and Blockchain in 6G.

Integration Area	Explanation	Potential Impacts on 6G	Challenges
Aeronautical networks	Wide coverage areas and uninterrupted communication are provided by using aviation tools such as UAVs, HAPs and LEO satellites.	Expanded coverage and advanced emergency communications.	Effect of weather conditions, energy management and air traffic control.
AI	AI is used in areas such as network optimization, security, service personalization and IoT integration.	Faster and more efficient network operations, improved user experience.	Development of AI algorithms, data privacy and ethical issues.
Blockchain	It is used for operations such as security, smart contracts, distributed management and authentication.	Strengthened network security, transparent and reliable transactions.	Scalability, energy efficiency and regulatory compliance.

By taking over the management and optimization of aeronautical networks, AI can improve network performance. AI can manage network traffic on an ad-hoc basis by analyzing data flow and optimizing resource allocation. Additionally, AI is critical for network security; It can use advanced pattern recognition capabilities to detect and prevent cyber-attacks.

Blockchain can be used to conduct network transactions securely and transparently. When integrated with aeronautical networks and AI, blockchain can protect the privacy of user data and enforce automatic service agreements through smart contracts. This contributes to IoT expansion, especially by securing transactions between IoT devices.

This integration enables the development of new services and applications while increasing the flexibility and reliability of 6G networks. For example, AI-powered healthcare could revolutionize real-time patient monitoring and diagnosis. In smart cities, blockchain-enabled public services can enable efficient management and automation.

The integration process presents technical and regulatory challenges. Scalability, energy consumption, and regulatory compliance are major hurdles in implementing these technologies. Additionally, for this integration to be successful, standards and protocols must be developed to ensure that different technologies work in harmony with each other. The integration of aeronautical networking, AI and blockchain in 6G has the potential to make the communication networks of the future more secure, flexible and efficient. This integration is a turning point that will determine the success of 6G and provide innovative solutions to societal challenges.

6. CHALLENGES AND FUTURE RESEARCH DIRECTIONS

The development of 6G networks presents a number of challenges. These challenges include technological barriers, security issues, regulatory frameworks, and ethical issues. Below, some of these challenges and future research directions are detailed:

- Technological Barriers

Table 5. Challenges and Future Research Directions.

Field	Challenges	Future Research Directions
Aeronautical networks	- Low latencies for flight safety: Ensuring low latencies in aviation networks is critical.	- Optimizing communication protocols with aircraft for the transition from 5G to 6G - Researching new methods for security and data integrity in aviation networks
Artificial intelligence	- Data abundance and complexity of learning algorithms: Big data and complex algorithms are required for artificial intelligence applications.	- Development of artificial intelligence-based automation in 6G networks - Research of artificial intelligence methods for data security and privacy
blockchain	- Scalability and speed: Scalability and transaction speed of blockchain networks are important.	- Research on blockchain-based secure data sharing in 6G networks - Development of new blockchain protocols for energy efficiency

- High Frequency Bands: 6G is expected to operate in the terahertz (THz) band. These high frequencies can cause problems such as signal attenuation and path loss. Researchers must work on new antenna technologies and waveform designs to overcome these obstacles.
- Network Topology: 6G will need to support heterogeneous network topologies. This requires seamless integration between different network layers and technologies.
- Energy Efficiency: The energy efficiency of 6G devices and infrastructure is critical to sustainability. Researchers should develop technologies that will reduce energy consumption and increase energy recovery.

- Security problems
  - Cyber Security: While 6G networks offer greater connectivity and higher data speeds, they may be more vulnerable to cyber-attacks. Security protocols, encryption methods and cybersecurity policies must be updated for these new generation networks.
  - Privacy: Privacy of user data is an important factor affecting user acceptance of 6G. Researchers should work on data anonymization and privacy protection techniques.
- Regulatory Frameworks
  - Spectrum Management: 6G's use of high frequency bands may require reviewing existing spectrum management policies. International regulatory bodies should update spectrum allocations to support these new technologies.

- Standards and Protocols: International standards and protocols should be developed to ensure global compatibility of 6G technologies.

➢ Ethical Issues

- Technological Inequality: The innovations that 6G will bring may increase technological inequality. Researchers must work to ensure that these technologies are accessible to the broader community.
- Automation and Employment: The level of automation that 6G will provide may lead to changes in the labor market. Researchers should examine the socioeconomic impacts of these changes and develop policy recommendations.

To overcome these challenges and fully realize the potential of 6G, collaboration between academics, industry experts and policymakers is essential. Future research should address these challenges and focus on maximizing the positive impacts of 6G networks on society. Table 5 summarizes the future challenges of 6G networks and research directions for these challenges.

7. CONCLUSION

This study discussed three important technologies that will shape the future development of 6G networks – aeronautical networks, AI and blockchain – and the challenges that the integration of these technologies may face. AI is transforming network management and service customization, while aeronautical networks provide extensive coverage areas and uninterrupted communications. The execution of smart contracts and the protection of user data are made possible by blockchain, which offers security and transparency. Integration of these technologies is key to the successful implementation of 6G. 6G can offer a wide range of societal benefits, from education to health, from industrial automation to smart cities. However, research should also be conducted to reduce the environmental impact of these technologies and optimize energy consumption. 6G networks have the potential to shape the future of telecommunications and provide innovative solutions to societal challenges. This study has provided a roadmap to help overcome the challenges 6G will face and maximize the societal benefits of this technology. Serving as a starting point for future researchers, this study is an important step that will determine the success of 6G and shape the communication networks of the future. In the future, we aim to develop customized communication infrastructures for the aviation industry in 6G networks. This is of great importance for flight safety, data transfer and air traffic management.

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