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Future prospects: AI and machine learning in cloud-based SIP trunking

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Abstract. The relevance of the study lies in the consideration of artificial intelligence and machine learning as one of the most important technologies that determine the future of the telecommunications industry. Integration of artificial intelligence and machine learning into cloud-based Session Initiative Protocol trunking solutions can potentially significantly improve the efficiency, performance, and security of these solutions. The purpose of the study was to analyse the possibilities of integrating artificial intelligence and machine learning in cloud-based Session Initiation Protocol trunking solutions. The analysis and the case study methods were applied. The study found that in the modern world, artificial intelligence and machine learning can no longer be considered separately from many aspects of human activity. These technologies are widely used in the telecommunications sector. The integration of artificial intelligence and machine learning in this sector is a key to solving various problems. The findings underline that artificial intelligence and machine learning have the potential to significantly improve the efficiency, performance, and security of cloud-based Session Initiation Protocol trunking solutions. In particular, it was found that these technologies can be successfully used for intelligent call routing, optimising resource allocation, and providing a higher level of security. The results of the study are an important contribution to improving intelligent call routing, optimising resource allocation, and improving the level of security for data and network protection. In addition, the results of the study have the potential to increase the competitiveness of telecommunication companies and ensure the sustainable development of this industry

Keywords: telecommunications; network monitoring; quality of service; routing; dynamic management; integration and capabilities

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INTRODUCTION

The modern stage of development of the telecommunications industry is marked by constant changes and continuous improvement of the infrastructure of communication networks. The integration of artificial intelligence (AI) and machine learning (ML) in cloud-based Session Initiation Protocol (SIP) trunking solutions is recognised as one of the most relevant and technologically advanced paradigms. These advanced technologies have the potential to revolutionise many industries, including telecommunications. In the context of SIP trunking, they open up opportunities for solving important tasks such as management automation, optimising resource allocation, improving security, and intelligent call routing. Integration of AI and ML into SIP trunking is at the early stages, but it has great potential. The future promises even deeper integration of these technologies in cloud-based SIP trunking solutions, which will further improve the efficiency, reliability and security of this industry. This integration will open up new opportunities for the development of the telecommunications industry, ensuring its greater adaptability and ability to meet the growing needs of users.

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Researchers in the field of telecommunications are actively considering the integration of AI and ML in SIP trunking, analysing such aspects of integration as automation of resource allocation, improving security, control automation, intelligent call routing. The analysis of existing publications once again confirms the relevance of the subject matter. The study by N. Kashuba (2023) considered the possibility of using AI to optimise cloud SIP trunking solutions and evaluates the effectiveness of using AI in this area. The results of the study showed that AI can significantly improve the efficiency of cloud-based SIP trunking solutions. Basically, according to the researcher, this applies to automating real-time decision-making based on analysing a large amount of data coming from SIP trunking. For example, an AI system can independently respond to changes in network load and adapt settings to optimise performance. The possibility of using ML for call recognition in cloud-based SIP systems is also discussed by K.S. Rudenko (2021). The researchers suggested using ML to recognise the type of call, speech recognition, and subscriber number. Based on the results of this study, it was concluded that the accuracy of call recognition for various parameters has improved, which significantly affects the quality of services provided.

Much attention is paid to the problems of AI integration in cloud SIP trunking solutions by T.M. Sylka (2021). The researcher proposes a general approach to integrating AI in cloud-based SIP trunking solutions and gives some examples of implementing this approach. In particular, this refers to the use of intelligent analysis methods to identify errors in SIP trunking and automate the process of managing them. I.S. Tyunder (2022) reviewed trends in AI and ML integration in cloud-based SIP trunking solutions. The researcher analysed the potential opportunities and benefits of using these technologies in this area. Consequently, ML algorithms can detect abnormal activity and potential security threats, which improves network security. In addition, according to the researcher, AI-based systems can adapt to changes in network conditions, which makes them more flexible about changes in traffic volumes.

The possibilities of using AI and ML to improve the quality of customer service in cloud-based SIP trunking solutions are also considered in the paper by L. Nikitina *et al*. (2023). They offer a number of AI and ML methods and algorithms that can be used to solve problems such as predicting network load, detecting network anomalies, and providing personalised services to subscribers. Thus, ML algorithms, such as classification or clustering, can group subscribers by common characteristics. However, despite the significant contribution of Ukrainian researchers to the investigation of this issue, there are some aspects that were not considered in these publications. These aspects include the ethical issues of using AI and ML in cloud-based SIP trunking solutions, the resource intensity of the AI infrastructure, and the ability of AI and ML to adapt to changes.

The purpose of this study was to explore the possibilities and potential of integrating AI and ML in cloud-based SIP trunking solutions to improve productivity, and to analyse trends and challenges in the field of SIP trunking and determine the role of AI and ML in solving these problems. The objectives of the study include exploration of the possibilities of using AI and ML to optimise resources and improve SIP trunking performance, identifying specific challenges that arise when integrating AI and ML in the SIP trunking industry, and exploring examples of successful implementation of AI and ML in cloud-based SIP trunking solutions and their impact on performance and security. These goals and objectives are the main benchmarks of this study, aimed at unlocking the potential and prospects of AI and ML in the field of cloud-based SIP trunking solutions. Analysing and answering these questions will help to understand how these technologies can change the face of the telecommunications sector and how their implementation can help improve efficiency and security in this area.

LITERATURE REVIEW

AI has become a key in modern telecommunications industry, where cutting-edge technologies such as 5G make innovation critical. According to research by J. Burg (2023), the global AI market in telecommunications could reach USD 14.99 billion by 2027. AI applications address key challenges such as network management, data analytics, efficiency, and competitiveness. Examples include optimising the network by analysing data from sensors and automating customer service through chatbots.

Companies that already use AI include Vodafone, WCTel, Orange Spain, and Verizon for alleged repairs and fraud prevention. An Accenture study found that AI can increase profitability by 38% and drive the growth of telecommunication companies (Are AI innovations…, 2023). To ensure competitiveness, modern enterprises need programmable networks that adapt to customer requirements. The speed of AI adoption and automation is crucial to avoid the limitations of innovation, as happened with the transition from 4G to 5G. This is exactly what is stated in a study by STL Partners (Progress in telco…, 2023).

A. Castro *et al*. (2018) noted that AI and ML are becoming increasingly important in modern telecommunications. They help optimise networks, improve customer service, and ensure the security of network operations. AI and ML are used to monitor the network in real time, identify potential problems, and predict resource costs. They help to avoid congestion and ensure network reliability. These technologies automate routine processes, including customer service and hardware deployment, which increases efficiency and reduces costs. ML analyses network load data, helps to predict peak loads, and flexibly respond to changes in customer needs. AI and ML are also used to detect scammers and prevent fraud in telecommunications, and to improve customer service by creating virtual assistants and chatbots.

According to T.M. Sylka (2021), the use of AI and ML in telecommunications contributes to network optimisation, improved service, and greater security of network operations. These technologies are already being successfully applied to network optimisation, customer service, marketing, anti-fraud, and cyber security. The study by Ch.X. Wang *et al*. (2023) examined the use of AI to optimise the 5G network and subsequent generations. The researchers consider network monitoring, anomaly detection, load forecasting, resource optimisation, and the benefits and challenges of using AI in telecommunications. It is noted that training AI models requires large data sets, which can complicate their collection and processing by telecommunications operators. AI models can be complex and time-consuming to train, which can slow down their implementation. The research also pointed to the vulnerability of AI models to attacks, so telecommunications operators should take measures to protect them. C. Zhang *et al*. (2019) focused on the use of AI for customer service in telecommunications. The researchers discussed aspects such as creating chatbots, automating customer service tasks, and personalised customer service. This study is the most applied, as it examines specific examples of the use of AI for customer service in telecommunications.

MATERIALS AND METHODS

This study used a comprehensive approach to research, combining theoretical analysis with case studies and practical applications. This allowed the authors to present an in-depth study of AI and ML in cloud-based SIP trunking. The methods of scientific cognition included theoretical analysis of open sources, study of scientific publications, and conducting a case study to evaluate practical applications. The analysis was used to learn the basics of AI and ML, and the structure and principles of cloud SIP trunking solutions, and played a key role in learning the basics of AI and ML integration in the context of SIP trunking and in understanding the functioning of cloud solutions in this area. During the analysis, special attention was paid to the theoretical foundations of automated processing of large amounts of data, given their importance for SIP trunking in cloud computing. The analysis provided the basis for further steps of the study, where AI, ML, and cloud solutions were applied practically to solve specific problems in the field of SIP trunking.

The analysis of open sources and scientific publications helped to collect up-to-date information about modern trends and challenges in the field of SIP trunking and became a key stage of the study, as it helped to systematise and evaluate modern trends and challenges facing the SIP trunking industry. The analysis covered a wide range of sources; including research papers conference materials, technical reports, and documentation from leading industry players. During the analysis, several key topics that are relevant for modern SIP trunking were identified. Firstly, it is a matter of efficiency and optimisation of resources in the context of increasing data volume and quality of service requirements. In the course of the study, various equations for estimating call routes were considered. One of the key formulae is the utility function equation (*U*), which allows evaluating each possible route for a call in terms of its suitability. Utility function equation (1):

$$U = \alpha - \beta, \tag{1}$$

where α – bandwidth consumed; β – route delay.

General view of the utility function equation (2):

$$(U) = \sum(W_i * X_i), \tag{2}$$

where W_i – weighting factor that reflects the importance of each route selection factor; X_i – value of each factor that is considered when choosing a route.

The second significant topic was data security and confidentiality in SIP trunking networks. Research and scientific publications have revealed the risks associated with potential threats and attacks on the SIP trunking network, and proposed methods for intelligent detection and protection against such threats. The third key topic was the integration of AI and ML in cloud-based SIP trunking solutions. Through open source analysis, successful examples of implementing these technologies to improve productivity and provide real-time intelligent services were identified. In general, the analysis of open sources and scientific publications helped to understand ongoing problems and opportunities in the field of SIP trunking, which forms the basis for further research and implementation of innovative solutions.

However, the main part of research was case studies and real-world implementations. The case study stage included a detailed analysis of specific cases of AI and ML use in cloud-based SIP trunking systems and a study of existing solutions and their impact on the effectiveness of SIP trunking services. The materials used for the study included documentation for various SIP trunking systems, software tools for data analysis, and equipment for creating a test environment. The materials used were selected based on their compliance with the research goals and opportunities for creating realistic scenarios. The results of the study will be useful for industry professionals and researchers who want to use the potential of AI and ML to transform and optimise cloud-based SIP trunking services. In addition, the ethical component will be highlighted to ensure responsible and sustainable implementation of AI in the telecommunications industry.

RESULTS

Artificial intelligence and machine learning techniques to improve productivity. The modern stage of development of the telecommunications industry is characterised by constant changes and continuous improvement of the infrastructure of communication networks. In this context, the integration of AI and ML in cloud-based SIP trunking solutions is recognised as one of the most relevant and promising technological paradigms. AI benefits not only businesses in the consumer sector, but also affects all sectors of the economy and aspects of public life. Regardless of the type of application or service, AI collects and analyses different types of data, and then uses the corresponding results to perform a specific action or set of actions. AI is primarily used as cloud AI, which means that the underlying network is used to transfer data to the cloud, where the underlying intelligence responsible for data processing and output is located. Standard SBC devices offer a number of advantages, including simplicity, scalability, and low cost. However, they have certain limitations, such as the inability to scale to large networks and the lack of security features. The additional use of AI in SBC addresses these limitations and provides a number of additional benefits (Table 1).

Table 1. Comparison table of network operation using SBC with the addition of AI

Characteristics	SBC	SBC with AI
Operating principle	Network transmits data directly between endpoints.	SBC performs routing, flow management, and security functions. AI is used to improve network efficiency and security.
Advantages	Simplicity, scalability, low cost.	Efficiency, security, and personalisation.
Disadvantages	Inability to scale to large networks.	Cost and complexity of implementation.
Usage	Small and medium-sized enterprises.	Large enterprises and telecommunications companies.

Source: compiled by the author

In the future, the network and AI are expected to merge. The general scheme of the infocommunication network architecture, which provides support for embedded AI functions, is shown in Figure 1.

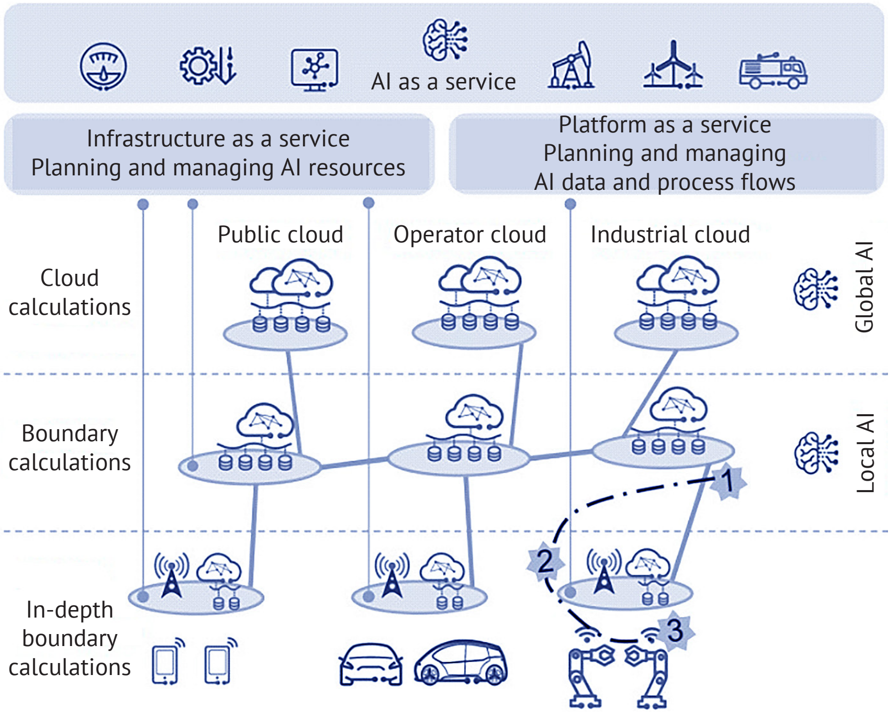

Figure 1. Architecture of the infocommunication network segment with AI support
Source: M. Vasylkivskyi *et al.* (2022a)

In the telecommunications industry, it is important to ensure stable and reliable network operation in real time and detect possible anomalies in time. AI and ML allow creating monitoring systems that analyse data flows and detect congestion, connection problems, and other anomalies that may affect network performance. Much research is aimed at preventing anomalies and detecting network performance degradation, with Software-Defined Networking (SDN) playing a special role in this, which can be modified by software. Researchers classify traffic and prevent possible problems using ML methods. Difficulties arise due to constant changes and scaling of network traffic (Romanchuk, 2022).

AI and ML are powerful tools for automatically detecting anomalies in networks, they analyse and study network parameters (Abbasi *et al.*, 2021). After building a "healthy" network model, AI and ML constantly monitor network performance in real time and notify administrators of any unusual deviations. This approach ensures network security, reliability, and early detection of problems (Alzahrani & Alenazi, 2021). It is AI and ML that help network operators predict the costs and resources needed to keep the network running. This helps to optimise resource allocation and reduce costs (Network performance monitoring..., 2023). Various AI and ML techniques are used to achieve these goals, including neural networks, time series analysis, and data clustering and classification methods. Such combinations of methods allow creating powerful systems for monitoring and detecting anomalies.

Predictive maintenance and Quality of Service (QoS) optimisation are important for virtualised networks. There has been an increase in research aimed at using ML to solve complex problems in a virtualised Network Virtualisation (NV) environment (Shafin *et al.*, 2020; Vertuam Neto *et al.*, 2021; Vasylkivskyi *et al.*, 2022a). Analysis of key performance indicators (KPI), such as expected latency and alarms, plays an important role in solving virtualised network and service management tasks (Vasylkivskyi *et al.*, 2022b). However, KPI measurement can increase costs by creating the need for adaptive measurement schemes that dynamically adjust the speed of monitoring and determine the volume of controlled parameters.

ML techniques, including regression, improve adaptive monitoring and prediction of telemetry data that would otherwise require measurements. One of the important tasks is to develop mechanisms for measuring the KPIs of virtualised networks with high quality of service requirements, especially for ultra-low latency services. ML-based predictive maintenance ensures smooth operation of virtualised networks (Zhang *et al.*, 2020). It is necessary to identify the causes of performance degradation, such as incorrect configuration or failure, which may affect KPIs. With a large amount of telemetry data and the stochasticity of network events, this task becomes difficult. ML-based research helps to solve these problems.

To ensure network reliability and efficiency, especially in SDN, a load balancing strategy is important to optimise resources and ensure network sustainability, especially in a distributed environment. Analysing the traffic of large SDN networks is difficult due to the distributed nature of the system and the variety of traffic types. Resource optimisation is difficult due to the distributed nature of the network, the large number of nodes and segments, and the variety of traffic types. To achieve optimal network performance, it is necessary to develop algorithms and strategies that take these problems into account and ensure a balance in network management. Scalability is a problem in SDN networks as they become larger and more complex. Developing adaptive algorithms to optimise load distribution is a key requirement in such conditions.

There are various approaches and strategies for solving load balancing problems in large networks. Load balancing algorithms include metric-based algorithms that estimate traffic conditions and dynamically adjust loads to optimise network performance. Additionally, dynamic load balancing algorithms automatically adjust load balancing based on the traffic structure for even load distribution. Configuring the network topology and resource allocation strategy helps to control traffic routing and ensure optimal flow.

The use of virtualisation techniques provides flexibility and resource optimisation in large SDN networks, while cloud computing platforms can be used to handle growing traffic and ensure scalability. Analytics helps to collect and analyse system performance data and develop more efficient algorithms and load balancing strategies. The use of ML and AI methods in this context opens up new opportunities for optimising large SDN networks and solving load balancing problems in rapidly developing networks. The continuous development of these technologies allows creating more accurate and efficient algorithms and strategies for optimal network performance.

Integration of machine learning and artificial intelligence techniques for security and fraud detection. The use of statistical methods and ML in the field of commercial cybersecurity systems has a long history. The trend in this area is that virtually all cybersecurity vendors include ML and AI in their products or services. Even companies of different scales prefer to create specialised data processing teams that are actively working to improve ML and deep learning technologies. However, an important topic is the effectiveness of such investments and the achievement of positive results (Yan *et al.*, 2020).

The use of ML and AI methods in cybersecurity includes detecting and analysing malware, spam, and phishing attacks, and prioritising vulnerabilities for further response to them. They are also used to respond to cyber incidents, including analysing network traffic data and system logs, identifying potential security threats, and automatically responding to detected issues. ML and AI techniques help improve detection, response, and prevention of potential threats, increasing the level of security for networks and systems.

However, there are two key issues. First, it is accuracy due to the lack of large amounts of marked-up data and the dynamic and unstable nature of cyber threats. Second, it is a matter of scaling, because integrating and scaling deep learning systems into real-world cybersecurity systems can be costly and complex. Despite these challenges, the use of ML and AI in cybersecurity is an important step in ensuring Internet security and identifying new threats, and the development of these technologies continues to improve their effectiveness and capabilities in the future. In the telecommunications industry, AI is actively used to detect and prevent fraud (Fig. 2).

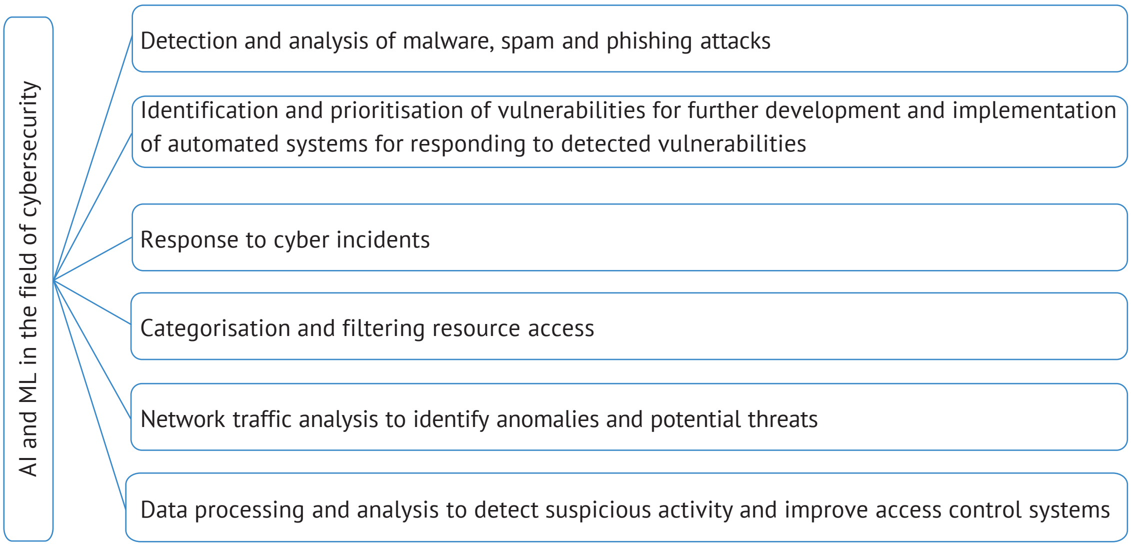

Figure 2. Aspects of using ML and AI methods in the field of cyber security
Source: compiled by the author

AI-based fraud detection systems allow companies to get a more complete and accurate view of customer activity, and respond to suspicious activity faster and more efficiently than ever before. They detect a variety of fraudulent activities, including identity theft, unauthorised access to accounts, and manipulation of financial transactions. These systems identify fraudulent calls, text messages, and emails, and detect anomalies in customer behaviour and changes in habits. Using AI to detect fraud helps companies to reduce false signals and accurately distinguish between legitimate and fraudulent activity, which reduces the number of incorrect signals that require additional investigation and saves companies time and money. The use of AI-based fraud detection systems is strategically important for telecommunications companies and contributes to ensuring the highest level of cybersecurity in the face of ever-growing threats.

One of the key advantages of using AI is the speed of response to potential threats and the ability to adaptive detection of fraudulent activities. The development of AI-based fraud detection technologies continues, which allows creating more effective cybersecurity solutions.

Intelligent call routing and session management. Intelligent call routing and session management in modern telecommunications systems makes it easier to optimise call processing and session management. With the growing volume of data and the development of networks, there is a need for more efficient approaches. One promising area is context-sensitive call routing based on user behaviour, which uses AI and ML techniques to optimise routing based on individual user behaviour. The key to context-oriented call routing is to provide the optimal route for each call based on the user context, which includes parameters such as geolocation, device type, user activity, time of day, previous calls, and other factors. Using this context, the system decides to choose the optimal route to maximise user satisfaction and network efficiency.

Complex call routing problems can be solved by mathematical modelling and calculations, using calculation formulae and algorithms to optimise the use of network resources and meet user needs. One of the key ones is the utility function equation (U), which allows evaluating each possible route for a call in terms of its suitability. The equation for the utility function can look like this (3), for example:

$$U = \alpha * (\mathit{Consumed\ bandwidth}) - \beta * (\mathit{Route\ delay}), \quad (3)$$

where α and β – weighting factors that determine the importance of throughput and latency in calculations; *Consumed bandwidth* – amount of bandwidth that a route consumes to transmit a call; *Route delay* – average delay time on the route.

In addition, the following mathematical equation (4) can be used to calculate the utility function when choosing the optimal route:

$$\text{Utility function } (U) = \sum(W_i * X_i), \quad (4)$$

where U – value of the utility function for this route; $\sum$ – sum for all alternative routes considered; W_i – weighting factor that reflects the importance of each route selection factor; X_i – value of each factor that is considered when choosing a route.

Factors (X_i) may include parameters such as route throughput (measured in bits per second (bps); route latency (measured in milliseconds (ms); route cost (defined in monetary terms); route reliability (can be measured as a percentage), and other factors that may be important for a particular routing. Each of these factors (X_i) is estimated for each possible route, and their weighting factors (W_i) are established based on the importance of each factor for a particular case. After calculating the values of all factors for each route, the utility function (*U*) helps determine the optimal route for a call that maximises user satisfaction and meets network requirements.

The context-oriented routing system in telecommunications, using AI and ML, adapts to the changing context of users to optimise call routing. It is important to continuously improve ML algorithms and ensure a high level of security and transparency for the future development of this technology, which can become the standard for telecommunications companies, improving the quality of service, and reducing costs. AI and ML play a role in personalisation and adaptive call processing, analysing customer data, creating personalised scenarios, and detecting anomalies in real time. They are also used for traffic forecasting, session routing, troubleshooting, and optimising resource allocation in telecommunications, improving the quality of service and reducing costs in the face of increasing traffic and complexity. The use of these technologies for fraud detection and prevention was considered by V.A. Savchenko and O.D. Shapovalenko (2020).

The use of AI in the context of SIP trunking management has advantages such as optimisation and automation of processes, but creates problems with data privacy and ethical aspects that require careful analysis and consistent approaches. One of the key tasks is to ensure the confidentiality of users' corporate and personal data when analysing large amounts of data, including call traffic and metadata. This can be achieved by recognising and anonymising data, restricting access to data, ensuring transparency of AI algorithms, combating bias, and complying with relevant data protection laws. Effective management of data privacy and ethical aspects requires careful consideration, development of appropriate policies and technologies to ensure data protection and compliance with ethical standards to maintain user trust and comply with legal requirements.

Implementing AI and ML in a SIP trunking network requires overcoming barriers and challenges. The main challenges include data security, the need for scalability, and efficient data processing. Optimised algorithms and specialised hardware contribute to efficient data processing, and the right investment strategy helps to reduce costs and achieve high ROI (return on investment). Retraining of personnel is necessary to work with new technologies. Overcoming these challenges requires the right approach and strategy to optimise telecommunications services and improve their efficiency. Overcoming these barriers and challenges requires the right approach and strategy to help companies implement AI and ML to optimise telecommunications services and improve their efficiency. Implementing AI systems in the telecommunications industry requires significant computing power and can create real-time delays. These limitations can be overcome by using cloud computing to access additional resources and develop specialised hardware. It is also important to develop AI algorithms with minimal latency and place computing resources closer to users. For efficient use of resources, it is advisable to implement dynamic resource management, data caching, and prediction systems. The development of optimised strategies and technologies will help ensure efficient operation of AI systems in telecommunications without significant computing power limitations and real-time delays.

Machine learning and artificial intelligence in the cybersecurity and telecommunications system: application examples, impact on the security and quality of services, and personnel training. In modern conditions, more and more companies are starting to use AI and ML in their activities (Table 2).

Table 2. The use of AI by leading telecommunications companies

Company	Customer care	Marketing&CRM	Networking&IT Ops	Fraud&security
Afiniti	✓			
AlBrain	✓			
Anodot	✓		✓	✓
Arago			✓	
Aria Networks			✓	
Avaamo	✓			
B. Yond			✓	
Cardinality		✓	✓	
Guavus	✓	✓	✓	✓
Intent HQ		✓		
IPsoft	✓			
Nuance	✓			
Skymsnd			✓	✓
Subtonomy	✓		✓	
Tupl	✓		✓	
Wise Athena		✓		✓

Source: compiled by the author

Implementing AI and ML in cloud-based SIP trunking solutions helps to improve efficiency, reduce costs, and ensure network and data security by detecting threats in real time, according to V. Vasilyshyn (2022). Fortinet has developed FortiAI, a highly efficient real-time threat detection system for protecting SIP networks and user data. FortiAI uses AI and ML to analyse traffic, recognise patterns, detect anomalies, and respond immediately to potential threats. This approach provides reliable protection of the network and privacy of user data, and the ability to respond to previously unknown threats. Twilio uses ML to optimise call routing in its cloud-based telecommunications services. AI analyses network parameters, predicts optimal routes, selects the best path to call, and dynamically adapts to network changes. This improves the quality of service and optimises communication costs, making ML an important part of telecommunications systems. Zendesk Talk uses AI and data analysis to create an efficient and personalised call processing system. This allows operators to provide personalised support, reducing response time and increasing customer satisfaction. Verizon uses ML to analyse and predict consumer activity, which allows them to optimise resources, improve the quality of service, and respond to changes in demand.

Real-world examples of the use of AI and ML in SIP trunking highlight their importance for the telecommunications industry. They improve the safety, efficiency, and quality of services. These examples also point to the potential of AI and ML for the future development of telecommunications technologies. The introduction of AI and ML in SIP trunking requires systematic measurement of their business impact and staff training. Employee training should include learning the basics, learning specific topics that cover the use of algorithms, data analytics, and working with appropriate tools. This can be done through lectures, seminars, online courses, practical assignments, trainings, workshops, and mentoring. AI and ML in the telecommunications industry open up opportunities for automating processes, detecting anomalies, and optimising real-time solutions. However, to achieve the best results and maximise the benefits of these technologies, it is necessary that staff have the understanding and skills to use them.

Staff training includes learning the basics of AI and ML, and practical skills and their application in specific work scenarios. This process begins with a carefully designed curriculum that includes both theoretical and practical aspects of using these technologies. Staff training can be conducted internally within the company or involve external experts and trainers. An important part of the process is practical exercises and projects that allow employees to put their acquired knowledge and skills into practise. This approach to training allows companies to maximise the benefits of using AI and ML in the field of SIP trunking, increase operational efficiency and maintain competitiveness in the telecommunications services market.

5G and SIP Trunking: integrating artificial intelligence and machine learning – opportunities and implications for the industry. The introduction of 5G revolutionises SIP trunking networks, providing resource optimisation, improved service quality, and reduced power consumption. For example, Nokia and Ericsson use AI to optimise real-time 5G networks. Data analytics on 5G networks helps to detect anomalies, optimise call routing, and personalise call processing, which is key to improving the quality of service (Fig. 3).

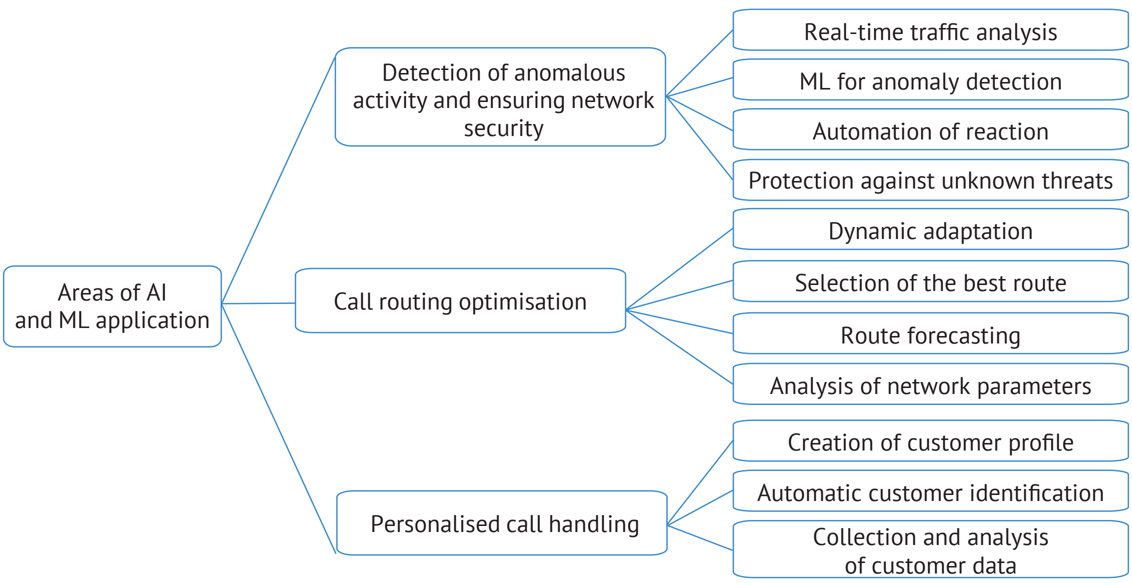

Figure 3. Areas of AI and ML application in cloud-based SIP trunking solutions
Source: compiled by the author

Google Fi uses AI to automatically determine the optimal carrier for each call or message based on the user's location and communication quality, providing a personalised service (Bohn, 2018). Verizon's 5G network (Citizen Verizon) uses ML to analyse consumer activity and user interests, recommending service packages that best suit their needs. T-Mobile (Digital Responsibility) personalises advertising services for its customers by analysing their usage data and sending ads that match their interests. These examples illustrate how AI and ML transform SIP trunking services into customised 5G networks for users. The use of AI and ML on a 5G network improves security and ensures threat detection and prevention. Fortinet Sase Extends Security to Protect Microbranches developed the FortiAI system, which uses ML to detect previously unknown threats in real time on a 5G network, ensuring the security of data and services in SIP trunking. Cisco (latest products and innovations across Cisco) analyses the behaviour of 5G network users to ensure network security and protect user data.

AT&T uses AI to detect attacks on the 5G network, such as DDoS (distributed denial-of-service attack) attacks, and automatically block fake traffic before causing damage. Nokia uses ML to analyse traffic patterns and detect anomalies in 5G networks. Ericsson uses AI to analyse the state of equipment in real time, and Huawei uses ML to optimise network load by reallocating resources to ensure the best possible quality of service. Verizon uses AI to identify problems in 5G coverage, analyse data on communication quality and latency, and provide recommendations for optimising antenna and node performance. Samsung uses ML to predict the load on 5G base stations to ensure stable network operation these examples illustrate how the use of AI and ML in 5G networks leads to significant improvements in monitoring and management processes.

Using edge computing in telecommunications networks where AI and ML optimise SIP services helps to reduce real-time latency, improve service quality, and ensure data security. Cisco uses this approach to handle calls on 5G networks, while Huawei and Nokia use it for various tasks on SIP trunking networks. Edge computing is an important component for the successful implementation of AI and ML in these networks, contributing to reliability and improving the quality of service.

DISCUSSION

The use of AI and ML in modern SIP trunking systems is becoming a key factor for improving the performance and reliability of telecommunications services. This is also confirmed by M. Alauthaman *et al*. (2018), who analysed AI and ML in the context of telecommunications services. The introduction of AI and ML methods in the field of monitoring, optimising the quality of service, security, and intelligent routing can improve the efficiency and quality of service for users. In addition, with the development of 5G networks and the transition to cloud environments, edge computing becomes necessary to ensure low latency and optimise network resources. According to D. Carrillo Melgarejo (2023) the 5th generation mobile network (5G) is not yet able to work with mission-critical applications that require low latency and high reliability, which gives grounds for further research in this area.

The problems of using AI and ML to optimise routing in 5G networks are also considered in the paper by S. Aljawarneh *et al*. (2018). They developed a new routing method that uses ML models to predict the best route. Many studies on the use of AI and ML in telecommunications show that AI and ML have significant potential to improve the efficiency and reliability of telecommunications networks. These technologies will continue to play an increasingly important role in the development of telecommunications networks in the future. N. Ameen *et al*. (2020) investigated methods for optimising resource allocation in 5G networks. The continuous development of these technologies helps to create more accurate and efficient algorithms and strategies that contribute to the optimal functioning of growing networks.

Equally important is the issue of data security and threat detection. Much attention is paid to the issue of security and threat detection in the paper by S. Amuru *et al*. (2016). They developed a new assessment method that uses ML models to identify potential security threats. Through these developments and the introduction of innovative solutions, the telecommunications industry is preparing for the upcoming challenges of 5G and delivering high-quality services to customers. The examples presented above clearly confirm and emphasise the conclusions and results obtained in this paper. The use of AI and ML in telecommunication systems leads to a noticeable improvement in the efficiency and quality of service. However, along with the benefits of using AI and ML in telecommunications, many researchers are concerned about ethics and responsibility. They consider the ethical aspects of using these technologies, in particular, in terms of transparency, privacy protection and possible socio-cultural consequences. This discussion is becoming increasingly relevant and requires careful consideration in the context of the widespread adoption of AI and ML in telecommunications systems.

The ethical aspects and management of AI and ML in the field of SIP trunking are an important aspect that requires serious consideration and attention. Achieving successful results in implementing AI and ML in SIP trunking networks requires high standards of ethics, fairness, accountability, and transparency. The transparency and accessibility of decision-making algorithms using AI and ML allow experts and the public to understand exactly how decisions are made and why. This is important for checking for fairness and identifying possible distortions. It is these issues that are discussed by L. Batra and H. Taneja (2020). The authors of this paper proposed approaches to assessing the fairness and accountability of such algorithms.

Privacy and data protection are key aspects in the context of using AI and ML on a SIP trunking network. Since this network processes large amounts of personal data, such as calls, messages, and other communication information, maintaining high standards of privacy protection is an extremely important task. Ensuring the privacy of users and the confidentiality of their personal data is not only a legal requirement, but also a key aspect from the standpoint of users' trust in the SIP trunking system. In addition, it is important to determine what data can be used to analyse and improve services, and ensure that this analysis is anonymous and impersonal, considering all regulatory requirements for the processing of personal information. Transparency in data collection, storage, and use should come first, and users should be able to control how their data is used and processed on the SIP trunking network. This is stated in the study by P. Bernal (2020). The researcher discussed issues such as privacy, transparency, and bias. He also offers recommendations for managing the ethical risks associated with the use of AI in SIP trunking systems.

Universal ethical standards and regulations can serve as important guidelines for developers and network operators in matters of privacy protection and data processing. According to M.H. Bhuyan *et al*. (2013), this approach will help create an ethical and responsible SIP trunking system that meets the highest standards of AI and ML ethics. Considering possible biases in the use of AI and ML helps to avoid discrimination and negative consequences for certain groups of users. In this context, the term "bias" refers to possible deviations or directivity in AI and ML algorithms, which may occur due to incorrect or insufficient training data or due to incorrect definition of model parameters. This bias can lead to incorrect decisions or distortions in solving problems, and discrimination or negative impact on certain user groups. Thus, ensuring fairness in AI and ML algorithms involves identifying and correcting possible biases to prevent negative consequences.

Accountability and responsibility in the context of the use of AI and ML in the SIP trunking network are essential components for ensuring the ethical and responsible operation of these systems. According to L. Batra and H. Taneja (2020), companies and organisations that use AI and ML in the SIP trunking network should establish clear internal procedures and policies that define the rules for using these technologies. This policy should include principles and norms related to the protection of user privacy, and requirements for the ethical processing of data. Companies should also appoint responsible individuals who are tasked with monitoring and enforcing these policies. This includes not only monitoring data collection and processing, but also identifying and addressing possible ethical issues that may arise when using AI and ML. In addition, an important aspect is the creation of mechanisms for reporting to regulators and the public on the use of AI and ML in the SIP trunking network. This will provide greater transparency and trust in such systems and make companies more accountable for their actions.

Universal ethical norms and regulations serve as important guidelines for defining standards and requirements for the use of AI and ML in the SIP trunking network, ensuring a high level of ethics and responsibility in this area. Ensuring fairness, accountability, and transparency helps maintain user trust and ensures efficient use of AI and ML on the SIP trunking network. Ethical guidelines for AI-driven SIP services play a critical role in ensuring high performance standards and maintaining user trust. Since these technologies can affect various aspects of users' lives and safety, compliance with ethical principles becomes an extremely important task.

CONCLUSIONS

This study examined various aspects of the use of AI and ML in SIP trunking systems and their impact on the telecommunications industry. The introduction of AI and ML in SIP trunking systems opens up wide opportunities for improving telecommunications services, ensuring security and optimising resources. AI and ML allow optimising call routing, identify security threats, improve resource management, reduce latency, ensure privacy and fairness, and combine solutions from different vendors. In general, the use of AI and ML in SIP trunking systems opens up broad prospects for improving telecommunications services, ensuring security, and optimising resources. It is important to adhere to ethical principles and standards when using these technologies in order to maximise the benefits for society and business. The introduction of AI and ML into cloud-based SIP trunking systems promises to be a key factor in the development of the telecommunications industry. This innovation has the potential to transform telecommunications and improve the quality of service.

With the development of 5G networks, the amount of data and processing speed requirements are increasing. AI and ML open up opportunities to solve these problems, ensuring low latency and high quality of service. The expanded use of AI will automate many processes in SIP trunking, including monitoring, management, testing, and data analysis. This will improve efficiency and reduce costs. AI and ML also play an important role in personalising services. They will allow creating services that meet the individual needs of users and predict their requirements, increasing the level of customer satisfaction. By using AI and ML to optimise resources and route calls in the cloud, businesses will be able to use infrastructure more efficiently and reduce costs. AI will become an important part of ensuring security in SIP trunking systems, and ML will help identify new threats and protect user data. Overall, the future of AI and ML in cloud-based SIP trunking promises to be an impressive innovative path to improve telecommunications services and provide more efficient solutions for businesses and users. However, along with all the benefits, ethical and security issues arise that require careful consideration and compliance with relevant standards and norms. It is necessary to continue research and development of these technologies, considering their ethical and safe use.

Future research in this area should focus on further developing AI and ML techniques and technologies that would allow for even greater levels of automation, optimisation, and security in SIP trunking networks. Understanding the ethical aspects and impact of these technologies on society also remains a relevant topic for further research.

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CONFLICT OF INTEREST

None.

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Майбутні перспективи: ШІ та машинне навчання в хмарному SIP-транкінгу

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Анотація. Актуальність дослідження полягає у розгляді штучного інтелекту та машинного навчання як одних із найважливіших технологій, що визначають майбутнє телекомунікаційної галузі. Інтеграція штучного інтелекту та машинного навчання у хмарних рішеннях Session Initiation Protocol-транкінгу потенційно може значно покращити ефективність, продуктивність та безпеку цих рішень. Метою дослідження було проаналізувати можливості інтеграції штучного інтелекту та машинного навчання в хмарних рішеннях Session Initiation Protocol-транкінгу. Були застосовані метод аналізу та метод кейс-стаді. За результатами дослідження встановлено, що в сучасному світі штучного інтелекту та машинного навчання вже не можуть бути розглянуті окремо від багатьох аспектів людської діяльності. Ці технології широко використовуються в телекомунікаційній сфері. Інтеграція штучного інтелекту та машинного навчання в цей сектор є ключовою для вирішення різноманітних завдань. Отримані результати підкреслюють, що штучного інтелекту та машинного навчання мають потенціал значно підвищити ефективність, продуктивність та безпеку хмарних рішень Session Initiation Protocol-транкінгу. Зокрема, виявлено, що ці технології можуть бути успішно використані для інтелектуальної маршрутизації дзвінків, оптимізації розподілу ресурсів та забезпечення вищого рівня безпеки. Результати дослідження є важливим внеском у покращення інтелектуальної маршрутизації дзвінків, оптимізації розподілу ресурсів, підвищення рівня безпеки для захисту даних та мереж. Окрім того, результати дослідження мають потенціал для підвищення конкурентоспроможності телекомунікаційних компаній і забезпечення сталого розвитку цієї галузі

Ключові слова: телекомунікації; моніторинг мережі; якість обслуговування; маршрутизація; динамічне управління; інтеграція і можливості