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Al-Based Path Selection for Optimizing Voice Call Routing Between 5G and Wired Networks

***Mohamed Saleh khalifa Baghni 1**
Department of Electrical and electronic, Higher Institute Of Science And Technology, Nalut, Libya
*** Mohamed Saleh khalifa Baghni | msb198520@Gmail.Com**

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Abstract:
This research looks at the use of artificial intelligence (AI) to optimize voice call routing across 5G and wired networks. Traditional routing systems often fail to adapt to changing network circumstances, resulting in poor speech quality, high latency, and wasteful resource use. To solve these issues, the paper offers an Al-based route selection model that uses machine learning methods, notably reinforcement learning, to dynamically identify optimum routing pathways based on real-time Quality of Service (QoS) measures like as latency, jitter, and packet loss.
An experimental research approach was used, with simulation tools (such as NS-3 and OMNET++) used to simulate hybrid network settings and assess the proposed Al-based routing framework. The findings showed that the Al model greatly enhanced voice call quality, decreased latency, eliminated packet loss, and outperformed standard routing systems under simulated settings. The paper ends with practical suggestions for deploying Al-based routing in real-world telecom infrastructures, emphasizing the model's scalability, flexibility, and prediction accuracy.
Keywords: Artificial Intelligence (AI) ،Voice Call Routing 5 ،G Networks

ملخص البحث:
تناول هذا البحث استخدام الذكاء الاصطناعي (AI) لتحسين توجيه المكالمات الصوتية عبر شبكات الجيل الخامس والشبكات السلكية. غالبًا ما تفشل أنظمة التوجيه التقليدية في التكيف مع ظروف الشبكة المتغيرة، مما يؤدي إلى ضعف جودة الكلام وارتفاع زمن الوصول وإهدار الموارد. لحل هذه المشكلات، تقدم الورقة نموذجًا لاختيار المسار قائمًا على الذكاء الاصطناعي يستخدم أساليب التعلم الآلي، ولا سيما التعلم التعزيزي، لتحديد مسارات التوجيه المثلى ديناميكيًا بناءً على مقاييس جودة الخدمة (QoS) في الوقت الفعلي مثل زمن الوصول والتذبذب وفقدان الحزم. تم استخدام نهج بحث تجريبي، مع استخدام أدوات محاكاة) مثل NS-3 و OMNET ++)لمحاكاة إعدادات الشبكة الهجينة وتقييم إطار التوجيه المقترح القائم على الذكاء الاصطناعي. أظهرت النتائج أن نموذج الذكاء الاصطناعي عزز بشكل كبير جودة المكالمات الصوتية، وخفض زمن الوصول، وأزال فقدان الحزم، وتفوق في الأداء على أنظمة التوجيه القياسية في ظل إعدادات المحاكاة. وتختتم الورقة باقتراحات عملية لنشر التوجيه القائم على الذكاء الاصطناعي في البنية التحتية للاتصالات في العالم الحقيقي، مع التركيز على قابلية التوسع للنموذج ومرونته ودقة التنبؤ.
الكلمات المفتاحية: الذكاء الاصطناعي، توجيه المكالمات الصوتية، شبكات الجيل الخامس

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introduction

Networks play an important part in today's digital growth. Mesh Networks with a mesh design. Wireless mesh networks' main benefits are their adaptability and customizability. Any future changes would be straightforward to implement, resulting in cheaper network expenditures and maintenance. Wireless mesh networking is a relatively new concept that arose after a decade of Ad-hoc networking research. A wireless mesh network (WMN) is a decentralized network system based on current wireless technology, namely 802.11 standards, that operates in the Ad-hoc communication mode. The wireless mesh network's flexibility and vast coverage make it suitable for next-generation communication. Multi-radio mesh routers and single-radio mesh On-Demand Distance Vector (AODV) are unable to learn from prior network incidents. These algorithms may choose a path with known flaws in the past. To efficiently route information packets in dynamic communication

networks, routing systems must adapt to changing traffic patterns, load levels, and network topologies. Shortest-path-based techniques minimize network latency for tiny amounts of data. When there is a high amount of network data traffic, routers chosen via several channels may encounter significant traffic congestion. When data volume exceeds router buffer capacity, network congestion occurs, leading to decreased throughput and increased latency. Conventional routing protocols cannot adapt to changing network circumstances. Machine learning algorithms have been used in several applications in recent years. Machine Learning algorithms can successfully route control protocols, since Reinforcement Learning (RL) is widely utilized to address complicated issues. Reinforcement Learning requires agents to learn how to respond in dynamic environments repeatedly. An agent is paid or penalized based on whether their choice was good or bad. Reinforcement Learning (RL) improves node decision-making for route selection, leading to better network performance.[1]

1.2 Problem Statements

With the fast spread of 5G networks and their integration with old wired infrastructures, there is a growing need for intelligent and efficient solutions to provide excellent Quality of Service (QoS) for voice communication. Although 5G technology provides ultra-fast speeds and low latency, managing dynamic routing of voice conversations across heterogeneous network environments is a considerable problem, since the performance characteristics of wireless and wired networks differ substantially. Traditional routing protocols often fail to adapt to the extremely dynamic nature of such hybrid networks. They lack the ability to adapt in real time to changes in network load, latency, packet loss, and congestion. As a consequence, consumers may encounter worse voice quality, call dropouts, or longer delays. Furthermore, the lack of sophisticated path selection models capable of predicting network circumstances and evaluating alternative routes reduces the ability to maintain constant service quality.

This circumstance highlights the importance of using Artificial Intelligence (Al) as a viable technique to optimizing voice call routing in hybrid 5G-wired systems. Algorithms may scan real-time network data and determine the best routing route based on several performance criteria such as bandwidth availability, latency, jitter, and congestion. This may dramatically improve service dependability, call interruptions, and overall user experience.

As a result, the main issue addressed in this research is the absence of appropriate routing systems capable of intelligently and dynamically selecting the optimum pathways for voice conversations over both 5G and wired networks. The study's goal is to investigate how Al-based techniques, like as machine learning and predictive algorithms, may be devised and deployed to improve voice call routing while overcoming existing methods' constraints.

1.3 Project Objectives

1. Create an Al-based framework for efficient voice call route selection over 5G and wired networks.
2. Evaluate the problems and limits of current routing techniques in hybrid network systems.
3. Prioritize important QoS metrics impacting voice call performance, including latency and jitter.
4. Packet loss. Create prediction models utilizing machine learning approaches to improve real-time route decision-making.
5. Implement Al algorithms that can adapt to changing network circumstances.

[1] Mahajan, S., Harikrishnan, R., & Kotecha, K. (2022). Adaptive routing in wireless mesh networks using hybrid reinforcement learning algorithm. IEEE Access, 10, 107961-107979.

6. Simulate hybrid network settings to evaluate the efficiency and accuracy of the proposed Al-based system.
7. Routing solution.
8. In terms of call quality, compare Al-based routing performance to those of traditional routing systems.
9. Provide realistic advice for telecom carriers to use Al-driven routing in the future.

1.4 Importance of the study

The relevance of this research stems from the increasing technological hurdles connected with contemporary telecommunication networks, notably the fast rollout of 5G and its integration with old wired infrastructure. Maintaining high-quality voice communication in such hybrid network settings requires innovative solutions that can adapt to continual variations in network load and performance, something that traditional routing systems often fail to do.

In this regard, Artificial Intelligence (Al) offers a potential possibility to transform voice call routing. Al has sophisticated analytical and predictive capabilities that allow for real-time decision-making based on a variety of performance metrics, including latency, packet loss, and congestion. By utilizing Al-based algorithms, the research hopes to improve Quality of Service (QoS) by intelligently selecting the most effective pathways for voice call transmission across various network segments .

Furthermore, the work fills a significant research vacuum by investigating the use of Al in voice routing optimization, a subject that has gotten little attention in recent academic literature. By bridging this gap, the study provides both theoretical and practical contributions, possibly laying the groundwork for telecom engineers, network designers, and technology developers interested in using intelligent routing algorithms in next-generation communication systems.

The study's practical usefulness resides in its ability to give a scalable and implementable Al-based routing model that can be used in real-world applications. In an era where dependable communication is more important than ever, such a model has the potential to greatly enhance network performance, eliminate voice call interruptions, and increase customer happiness.

1.5 Study hypotheses

Hypothesis 1 :Al-based route selection greatly enhances voice call quality when compared to standard routing.

Hypothesis 2: Machine learning methods minimize latency in hybrid 5G/wired network setups.

Hypothesis 3 :Al-driven routing improves the dependability of voice calls across diverse networks. Real-time data analysis using Al enhances route selection accuracy.

Hypothesis 4:Al-based routing significantly reduces packet loss during voice transmission.

Hypothesis 5 :Implementing Al in voice call routing improves QoS in hybrid networks.

Study Methodology

2.1 Research Methodology

This study adopts an applied research approach, supported by the experimental method. It involves the design, implementation, and testing of an Al-based routing model for voice calls in a hybrid network environment consisting of 5G and wired infrastructures. The goal is to evaluate the effectiveness of Al in optimizing call routing and enhancing Quality of Service (QoS) in comparison to traditional routing protocols.

2.2 Research Tools

Artificial Intelligence algorithms (e.g., Neural Networks, Decision Trees, Reinforcement Learning)

Network simulation tools (e.g., NS-3, OMNET++)

QoS measurement tools (e.g., for latency, jitter, packet loss, MOS scores)

Data analysis software (e.g., Python, MATLAB, R).

2.3 Data Collection Sources

Simulated data generated from a custom-designed testbed that emulates real-world hybrid network conditions.

Network performance metrics including delay, jitter, packet loss, and bandwidth usage.

Benchmarking data from conventional routing protocols for performance comparison.

2.4 Study Sample

As the study is simulation-based, the sample consists of a set of network scenarios that reflect diverse operational conditions, such as variable bandwidth, traffic load, user density, and call patterns. These scenarios are carefully crafted to evaluate the Al model under different stress levels and network configurations.

2.5 Analytical Methods

Statistical comparison techniques (e.g., T-Test, ANOVA) to analyze differences in QoS metrics
Regression analysis to explore the relationship between network variables and routing performance
Algorithmic evaluation of the proposed Al model (e.g., error rate, convergence speed, QoS enhancement)
Quantitative performance assessment using standard QoS indicators.

2.6 Study Limitations

The study is limited to simulated environments, which may not fully capture all real-world complexities.
It does not include live testing in actual telecommunication infrastructures.
The focus is restricted to voice communication, excluding other types of traffic such as video or data.
Time and technical resource constraints may limit the scope and diversity of simulated scenarios.

Theoretical framework

3.1 Section One: Theoretical and Technical Background

Learner-centered education is now undergoing fast progress, with participants becoming less reliant on instructors. Quality study materials and courses that encourage self-study are more important. Today's technology allows text, music, and images to be combined. Multimedia computing and electronic communication provide new possibilities. The usage of computer networks is progressively paving the way to virtual universities. The demand for research materials, particularly high-quality ones, far exceeds the writers' prospective capacity to provide them. It may result in lower-quality study materials that do not follow e-learning guidelines.
Theoretical notions for e-learning have been thoroughly discussed not just throughout the globe, but also in our own nation, where computer-based learning has been popular among teacher trainers and instructors from its inception. The origins may be traced back to the initial experiments with aids "automating" certain repetitious teaching practices, as well as technological help from specific didactic technology. Since then, our understanding of didactic technology has grown, become more clear, and enhanced. At the same time, educational packages emerged, with technical production matching the level of technology - teaching machines and first-generation computers. The earliest efforts at multimedia training were done around this period as well.
However, the technological underpinnings were far behind the theory and, more importantly, were not accessible to instructors in schools. Despite this, a number of intricate works were created, as well as several instructional programs. Only user-friendly multimedia personal computers with visual interfaces provided the right technological foundation. Unfortunately, teachers with a certificate in didactic technology and the appropriate job experience often demonstrated "the generation barrier," prohibiting them from developing ICT abilities. After the first computers were brought into schools, a plethora of computer programs emerged, each with a wealth of information and ideas but lacking technological solutions. Their writers were often computer enthusiasts who were also lecturers with relevant expertise.[1]

3.1.1 sub section1 : Integration of 5G and Wired Networks

[1] Kapounová, J., Kostolányová, K., & Pavlíček, J. (2006). Theoretical Concepts, Sources and Technical Background of E-learning. The New Educational Review, 8, 97-106.

Digital connection has revolutionized the globe by bridging the gap between individuals and transforming it into a global village. Compared to earlier generations, 5G is a more adaptable, scalable, agile, and programmable communication system that can integrate with other technologies. The authors suggest that 5G will complement previous wired and wireless technologies, and they provide a basic strategy for integrating 5G into industrial Ethernet networks. This kind of integration is applicable to certain industrial production situations, such as linked homogenous islands, virtualized controllers, and adaptability with virtualization and distant sites. Wireless networks provide flexibility, mobility, and simplicity of deployment, making them the preferred technology in Industry 4.0. Furthermore, the Internet of Things (IoT) will drive the Industry 4.0 paradigm by enabling machine-to-machine (M2M) connectivity.

According to IoT Analytics, worldwide IoT connections climbed by 9% to 12.3 billion in 2021, with the GSMA forecasting a total of 25 billion by 2025. Because of their performance and cost benefits, LPWA technologies are increasingly being used for both commercial and private applications as IoT has grown in popularity. In 2021, Low Power Wide Area Networks (LPWANs) become the primary engine of worldwide IoT connection growth, and they are predicted to eventually replace the majority of 2G/3G IoT connections. With the increasing expansion of end devices, billions of machines must be linked to the network. A single cellular network cannot provide universal coverage and is insufficient to sustain significant connection. With the capacity to handle massive data traffic, LPWANs are likely to offer significant innovation to the 5G ecosystem. This article will provide a complete overview of the integration of LPWAN and 5G.[1]

Wireless communication models are growing increasingly sophisticated as the number of linked devices and networks grows. And the future of internet is heavily reliant on speed-efficient, robust apps. Thus, a new system idea, LiFi, is unavoidable from this standpoint. LiFi is a concept that uses visible and invisible light beams to establish a networked communication system. LiFi research has been ongoing for a decade, and recent studies have shown that it is suitable to current use cases, as examined by the European Horizon 2020 project Enhanced Lightning of the Internet of Things ،

Currently, IoT-specific architectures and technology primarily focus on narrow band communication with limited plexing, which is used in LiFi systems to avoid inter-channel interference, eliminate the need for synchronization, remove the constraints on the number of devices, and require only a single RF chain at the transmitter. VLC technology is clearly revealing crucial pillars.

When we analyze the aforementioned consumer and industrial use cases, the fundamental cause for the growth in complexity is the scale of content-rich media sources and high performance requirements, particularly for Augmented (AR), Virtual (VR), and Extended Reality (XR) applications. Possible solutions include reducing transmitted packet sizes via improved compression methods, creating better routing algorithms, boosting bandwidth, and offering various access kinds. With 5G networks, several organizations are investigating new research disciplines in order to get new values by integrating them into current systems, which will ultimately enhance networking and security. From 4G to 5G, supplemental authentication techniques broaden the range of use cases, improve identity protection, and offer greater message confidentiality, integrity, key derivation, and key separation capabilities. Some enhancements for use cases include ultra-reliable low-latency communications (uRLLC), massive machine-type communications (mMTC), and improved mobile broadband (eMBB).

Open5GCore is a one-of-a-kind toolkit that offers a development environment for both RAN and the 5G Core Network, allowing for the creation of simulations on the control and user planes to facilitate the quick development and testing of real-world target applications. Although the environment is three years old, the current version may provide virtual machines, containers, on-premise clouds, Software as a Platform (SaaP), Continuous Integration-Deployment (CI/CD) pipelines, time-sensitive networking (TSN) plugins, and performance monitoring tools. Because C is the primary

[1] Chen, Y., Sambo, Y. A., Onireti, O., & Imran, M. A. (2022). A survey on LPWAN-5G integration: Main challenges and potential solutions. Ieee Access, 10, 32132-32149.

programming language utilized, the platform provides excellent overall performance and upkeep. Recent work prioritizes an Android-based application with a basic design, as shown in Fig. 2, paving the path for 5G communication on actual cellphones. The environment is built on 5G standards and can integrate with external apps. Telecommunications protocols are accessible for experimentation at the RAN level. The added LiFi access infrastructure would make user equipment more resource-efficient and well-balanced with the main network. Upcoming 5G technologies are already improving connection for mobile apps. With our toolbox, we may employ simulated or Android user equipment in our test beds. A Linux-based system may operate the network core, which contains the major components in a virtualized framework, as well as tools and libraries for simulating 5G connection and integrating with different applications, whether on local workstations or on-premise bandwidth. On the other hand, applications and IoT use cases evolve: they need the collection and processing of an ever-increasing volume of data, which might be met by new RAN ideas. According to research conducted by the Fraunhofer Heinrich Hertz Institute (HHI), a network of optical wireless access points (APs) may serve mobile communication while exploiting current lighting infrastructure.

Furthermore, there are novel techniques, such as distributed multiple input-multiple output (MIMO) via plastic optical fiber (POF). In OWC, no license is required for the frequency range being utilized. In contrast to true radio frequency, which splits the spectrum, there is less control over signal transmission. Because light-based communication is more susceptible to interference in outdoor conditions, indoor applications are more likely to operate well. To allow light to reach more devices, broad cones are used soon after the light source. As a result, line-of-sight (LOS) is enhanced by retaining the energy of the light beam. Similarly, light emitting diodes (LEDs) have low pass characteristics and operate in the base band.[1]

3.1.1 Wireless/wired hybrid network

In recent years, the convergence of wireless and wired networks has received a lot of attention. The authors focused on leveraging software-defined networking (SDN) to give centralized management over the wireless and wired networks. Ref. presented a network design in which wireless and wired transmissions are employed simultaneously to compensate for the inadequacies of the other. Ref. presented a multi-path transmission technique for the architecture from wired to wireless to improve video transmission performance. Except for SDN, Ref. presented a protocol to enable multimedia data in hybrid wireless/wired networks that makes effective use of the wireless connection while coexisting TCP flows and may offer enough QoS for delay-sensitive multimedia applications. Regarding the industry, Ref. said that since present wireless networks are unable to meet the needs of the applications, hybrid wired-wireless networks must be created to facilitate the adoption of ICPS. However, these studies only consider hybrid transmission based on the existing TCP/IP network, while the upcoming 5G and TSN are more suited for industrial communication.

3.1.2 5G-TSN integrated network.

The TSN industry white paper has said that the URLLC scenario for 5G is critical to establishing the industrial internet. The research focus is on extensively integrating 5G and TSN. For this problem, Ericsson presents a 5G-TSN integration architecture in which the SDN controller handles the whole network and TSN protocols are used in 5G users to provide stringent E2E latency requirements. Furthermore, Ericsson believes that incorporating URLLC into the production process has significant

[1] Metin, T., Emmelmann, M., Corici, M., Jungnickel, V., Kottke, C., & Müller, M. (2020, December). Integration of optical wireless communication with 5G systems. In 2020 IEEE Globecom Workshops (GC Wkshps (pp. 1-6). IEEE.

potential to speed the transformation of the manufacturing sector. Nonetheless, these 5G and TSN pairings are simply basic concepts that must be developed further before being realized.[1]

3.1.3 5G Cellular Network Architecture

When considering the current market for 5G networks, it is clear that the network's numerous access approaches are almost at a standstill and need immediate development. Current technology, such as OFDMA, will work for at least the next 50 years. Furthermore, there is no need to alter the wireless configuration from 1G to 4G. Alternatively, just adding an application or improving the core network to meet user needs might suffice. This will encourage package providers to shift toward a 5G network as soon as 4G is commercially available. To fulfill user requests and solve the obstacles that have been presented in the 5G system, a significant shift in the approach for developing the 5G wireless cellular architecture is required. According to the researchers' observations, the majority of wireless users spend around 80% of their time inside and 20% outdoors. In today's wireless cellular design, an outside base station located in the midst of a cell aids in communication between mobile users, whether inside or outside. So, in order for inside users to communicate with the outside base station, signals must travel through the indoor walls, resulting in very high penetration loss, which costs in terms of reduced spectral efficiency, data rate, and energy efficiency in wireless communications. To tackle this difficulty, a new notion or design technique for planning the 5G cellular architecture has emerged: distinguishing between outside and interior installations. With this design strategy, penetration loss through the building's walls will be marginally decreased.

This concept will be backed by massive MIMO technology, which involves the deployment of a geographically scattered array of antennas including tens or hundreds of antenna units. Since current MIMO systems use either two or four antennas, the concept of massive MIMO systems involves using the benefits of enormous array antenna components in terms of substantial capacity improvements.

To create or establish a big massive MIMO network, the outer base stations will be outfitted with enormous antenna arrays, some of which will be scattered throughout the hexagonal cell and connected to the base station via optical fiber cables, supported by massive MIMO technology.

Mobile users present outdoors are typically equipped with a certain number of antenna units, but with collaboration, a huge virtual antenna array may be built, which, when combined with base station antenna arrays, forms virtual massive MIMO linkages. Second, massive antenna arrays will be put on the exterior of each structure in order to interact with outside base stations via line of sight components. Wireless access points within the building are linked to massive antenna arrays via cables to communicate with interior users. This considerably increases the cellular system's energy efficiency, cell average throughput, data rate, and spectrum efficiency, but comes at a higher infrastructure cost. With the implementation of such an architecture, inside users will only need to connect or interact with internal wireless access points, while bigger antenna arrays would stay situated outside the structures. Certain technologies for indoor communication employ massive antenna arrays connected via cables to communicate with indoor users. This considerably increases the cellular system's energy efficiency, cell average throughput, data rate, and spectrum efficiency, but comes at a higher infrastructure cost.

With the implementation of such an architecture, inside users will only need to connect or interact with internal wireless access points, while bigger antenna arrays would stay situated outside the structures. For indoor communication, some technologies include WiFi, small cell, ultra wideband, millimeter wave communications, and visible light communications.[2]

3.1.4 Heterogeneous Wireless Network Interoperability

[1] Zhang, Y., Xu, Q., Guan, X., Chen, C., & Li, M. (2022). Wireless/wired integrated transmission for industrial cyber-physical systems: risk-sensitive co-design of 5G and TSN protocols. Science China Information Sciences, 65(1), 110204.

[2] Gupta, A., & Jha, R. K. (2015). A survey of 5G network: Architecture and emerging technologies. IEEE access, 3, 1206-1232.

The problem in terminal design is managing the trade-off between spectrum flexibility and the amount of space and power required for a specific platform. New methodologies for partial reconfigurability provide design dimensions that enable the system to respond to the terminals' possibilities and needs in a way that maximizes both spectrum efficiency and battery power. As wireless technologies become more widely accepted in many industries, the difficulties and kinds of wireless systems that accompany them evolve. In heterogeneous wireless networks, the idea of "always best connected" refers to providing the best quality to client terminals and has been advocated in several studies. This strategy promotes vertical handover between radio access technologies.

Examining the notion of heterogeneous networks naturally brings the topic of how radio access technologies interact in a newly built system, which will not need modifications to the RATs but will instead include control features in the core networks. In terms of user or user applications, a heterogeneous system or network is regarded a unified network and has access to a single segment that connects to application servers in and out of the operator's network. Two alternative approaches for interoperability across radio access technology building pieces within a heterogeneous system are widely deemed to fulfill the necessary criteria of user applications. The first relates to centralized operator access, while the second describes the Internet paradigm of interoperability[1] .

The first model entails introducing a certain level of integration between radio access technology and mobile access terminals. In this direction, various analyses and standards have been developed to define the levels of architecture connectivity required for vertical handover between different access technologies involved in the construction of heterogeneous domains. The adoption of this concept implies protocol compatibility at lower levels of communication in the realm of radio access.

The second model, known as the Internet model, is a focus for future research in this study and relates to ensuring continuity of customer service in the event of independent radio access technologies accessible to the mobile terminal via network connectivity. In this situation, interoperability across network technologies occurs at the higher (network) protocol levels, i.e. at a level shared by all access technologies for communicating between user applications and the relevant application servers.[2]

In order to mitigate the impacts of urbanization, there has been an increase in demand for more beautiful and efficient cities during the previous decade. Researchers argue that, following the trend of social change in several nations in the 1990s, new strategies for sustainable urban planning are necessary as a consequence of the massive migration of people from rural regions to just a few big cities. The administration faced a number of issues as a result of the high population density, including uncontrolled expansion, traffic congestion, crime, trash management, and others. Furthermore, as a result of globalization, towns began to compete with one another to recruit the top professionals by offering appealing living environments. These difficulties have prompted governments to use technology techniques to address the negative consequences of urbanization via broadband linked cities, known as Smart Cities.

Governments throughout the globe, notably Japan, Germany, and Brazil, have made financial investments and attempts to use Information and Communication Technologies (ICTs) to address urbanization-related concerns. ICTs such as wire-free communication, embedded systems, and wireless sensors may improve several aspects of society.

ICTs enable the integration of city services, the collection of real-time data, its analysis, and improved decision-making. These technologies have been considered by academic and industrial projects in a variety of contexts, including healthcare, intelligent transportation, and energy savings, which support

[1] Tudzarov, A., & Janevski, T. (2011). Functional architecture for 5G mobile networks. International Journal of Advanced Science and Technology, 32, 65-78.

[2] Tudzarov, A., & Janevski, T. (2011). Functional architecture for 5G mobile networks. International Journal of Advanced Science and Technology, 32, 65-78.

inclusion and assisted living; exploiting vehicle-to-vehicle and vehicle-to-infrastructure wireless communication to alleviate traffic congestion in cities; and assisting in the efficient management of power distribution grids, respectively. [1]

3.1.2 sub section 2 : Voice Call Routing and Quality of Service (QoS)

Communication over the internet is referred to as online communication. Online communication is classified into two types: synchronous and asynchronous communication. Synchronous communication happens when communication participants may engage with one another in real time and function as both sender and receiver of a message. Video conferencing, instant messaging, and social networking are examples of synchronous communication in real time, whereas asynchronous communication includes blogs and e-mail.

Some popular social networking services used by Indonesians, such as LINE Messenger, WhatsApp Messenger, and Facebook Messenger, employ real-time media types. The program has a real-time function called Voice Call. Only with an internet network connection may consumers interact directly across borders, and the expenses will be lower than with traditional telephone media. The application feature's goal is to use Voice over Internet Protocol (VoIP) network technology to provide access to an internet multimedia system (IMS). The global web index study found that Indonesian internet users aged 16 to 64 utilize many social media sites. The platform is separated into two types of social media: social networking media and messaging. YouTube was the most popular social network, with 43% of users, followed by Facebook (41%), and WhatsApp Messenger (40%). This study is designed to assist service providers in developing a better network structure, particularly regarding the quality of VoIP internet data network service.[2]

Over the previous several decades, communications technology has advanced tremendously, from traditional analog networks to circuit- and packet-switched ones. There has been a significant interest in transitioning voice and data services from circuit-switched to packet-switched IP systems. As a result, VoIP has evolved in the communications industry with major corporate interests owing to its ability to eliminate operator rates for all types of calls, including local-to-international connections.

VoIP uses a codec to compress analog signals into digital streams, as opposed to traditional PSTN lines suited for voice transmission. The digital binary data is sent to the TCP/IP stack, packetized, and transmitted over the network. At the receiver, IP packets are stripped of headers and payloads and forwarded to a suitable codec [HPG05]. In Fig. 1, a VoIP packet consists of the IP header, UDP header, RTP header, and payload. A VoIP packet header has a total size of 40 bytes, while the voice payload may vary from 33 to 160 bytes depending on the codec used.[3]

QoS is described as the network's ability to provide excellent services in order to accept good clients. In other words, QoS assesses the level of user happiness and network performance. Applications such as FTP, HTTP, video conferencing, and e-mail are not sensitive to delays in transmitted information when assessing QoS in critical situations, however other applications such as voice and video are more susceptible to information loss, delay, and jitter. As a result, VoIP QoS is critical to ensuring that voice packets are not delayed or lost as they travel over the network. VoIP QoS is assessed in accordance with ITU regulations using several factors like as latency, jitter, and packet loss; these parameters may be adjusted and regulated within acceptable limits to enhance VoIP QoS End-to-end delay.

In general, speech is a delay-sensitive application, but most data applications are not. End-to-end delay is defined as the time required to transfer a packet from the sender to the receiver. The goal is

[1] Avelar, E., Marques, L., dos Passos, D., Macedo, R., Dias, K., & Nogueira, M. (2015). Interoperability issues on heterogeneous wireless communication for smart cities. Computer Communications, 58, 4-15.

[2] Taruk, M., Budiman, E., Rustam, M. R., Azis, H., & Setyadi, H. J. (2018, November). Quality of service voice over internet protocol in mobile instant messaging. In 2018 2nd East Indonesia Conference on Computer and Information Technology (EIConCIT) (pp. 285-288). IEEE.

[3] Shakir, A., Alsaqour, R., Abdelhaq, M., Alhussan, A., Othman, M., & Mahdi, A. (2019). Novel method of improving quality of service for voice over internet protocol traffic in mobile ad hoc networks. International Journal of Communication Networks and Information Security, 11(3), 331-341.

to achieve an end-to-end latency of less than 150ms. When the end-to-end delay exceeds around 150 milliseconds, participants in a telephone call begin to perceive the impact. End-to-end latency for real-time voice conversations (VoIP) range from 150 to 400 milliseconds.[1]

Usability engineering methodologies improve designs by combining design expertise with usability data analysis. Human-computer interaction research has resulted in a variety of usability engineering methodologies, ranging from typical lab usability assessments to discount usability engineering (Nielsen, 1993). Since around 1990, anthropological methodologies such as contextual design (Holtzblatt and Beyer, 1998) have been used, particularly during the early phases of design. With the advancement of speech technology, practitioners have applied many of these techniques to the design and optimization of voice user interfaces.

Because contact center applications have traditionally represented the biggest market for voice applications, IVR applications have garnered a lot of attention from practitioners and scholars in the field. A literature search yields papers on fundamental IVR design issues, such as prompting in touch-tone IVRs and menu design standards. Other studies employ typical usability assessment methodologies to investigate voice user interfaces (e.g., Bennacef, Devillers, Rosset, and Lamel, 1996) and commercial IVRs (Edwards, Quinn, Dalziel, and Jack, 1997; Delogu, Di Carlo, Rotundi, and Satori, 1998). IVR usability design and re-engineering expertise spans from touch-tone design issues to comprehensive design guidelines for touch-tone and speech-enabled IVRs [2].

Problems addressed The benchmark data utilized in this article are from two sources: Taillard's VRP data and Solomon's VRP data with time frames. Both sets of issues employ Euclidean distances and assume that trip time equals travel distance.

Taillard's challenges are capacitated vehicle routing problems that lack time limitations. There are four instances of difficulties with 75, 100, and 150 client visits, as well as one problem with 385 visits. The issues include clustering characteristics and wildly varied pickup loads, ranging from extremely modest pickups to others that take practically the whole truck. These difficulties have short itineraries, with an average duration of 8 to 11 stops.

All of Solomon's difficulties include 100 clients, vehicle capacity limits, and customer time windows. In general, load limitations are easier to meet than time constraints. They are classified into three types: R issues with random customer distribution, C problems with clustered distribution, and RC with a mixture. Each of these categories is separated into series 1 and series 2 problems. Series 1 difficulties have a limited scheduling horizon, with average route durations of 5 to 11 stops. Series 2 challenges involve broad horizons, with average route durations of 25 to 50 stops. Table 1 highlights the issue cases.

We want to investigate the efficacy of the solution strategies for these benchmark issues as they grow more limited. To do this, we progressively introduce side restrictions into each of the benchmark problems. We consider two kinds of constraints: same route, which requires that two trips be completed by the same vehicle, and precedence constraint, which requires that visit a begin no later than visit b. They represent two sorts of constraints: inside the route (intra-route) and between two or more routes (inter-route).

Both of these kinds of constraints exist in the Pickup and Delivery Problem (PDP), which requires a package (or person) to be picked up at one place and delivered to another.

[1] Mebawondu, J. O., Dahunsi, F. M., & Adewale, O. S. (2020). Hybrid intelligent model for real time assessment of voice quality of service. Scientific African, 9, e00491.

[2] Suhm, B. (2008). IVR Usability Engineering using Guidelines and Analyses of end-to-end calls. In Human factors and voice interactive systems (pp. 1-41). Boston, MA: Springer US.

Although we use these limitations, we are not addressing PDP issues as such. We just utilize these two forms of constraints to symbolize two broad types of constraints that may emerge in real-world scenarios.

Most basic issues do not specify the number of cars. To more precisely define the difficulties, we set the maximum number of vehicles to be twice that of the best known solution.[1]

Previous research has shown QoS difficulties with the SRTP protocol. The authors debated the typical methods to VoIP telephony that attempt to assure protection and the implications of using SRTP. The authors wanted to analyze how it may provide a secure stream of VoIP service while also providing good service quality. Furthermore, SRTP simulation findings demonstrate that the voice packet delay does not surpass the threshold 150 millisecond (ms) value, implying that quality of service may be largely assured while encrypting voice packets.

The authors presented an IPSec strategy for VoIP networks based on the secure session initiation protocol SIP. The authors handle several security difficulties utilizing the SIP protocol and IPSec, however they do not address voice quality issues.

The authors investigated the impact of security settings on VoIP QoS and suggested a QoS-oriented strategy that enables the implementation of secure VoIP networks without compromising the quality of service.the authors provided a complete overview of video streaming performance over an IP-based network. They tested video quality to packet loss and encryption. The measured findings indicated a relationship between the kind of video codec and the bitrate of the final quality video. The authors then examined the effect of IPSec encryption on router CPU use, necessary bandwidth, and speech quality.

All characteristics were dependent on the amount of calls made. They observed that adjusting the proper voice payload period may alter the amount of packets delivered and processed at the same time, as well as CPU use and bandwidth .

Researchers presented a multipath method to address the key security concerns to VoIP communications, particularly in low bandwidth networks. The results reveal that security has an impact on VoIP quality, particularly for long-distance communication nodes and big packet sizes. The suggested multipath method seems to outperform single routing protocols in low capacity networks, particularly in terms of packet loss reduction.[2]

3.2 Section two: Al Applications in Path Optimization

In many manufacturing applications, the route plan consists of a series of tool movements with regard to a part. Each motion is one of two types: it either performs an operation on the part (machining motion) or it moves from the conclusion of one machining motion to the beginning of the next motion (referred to as a jump). In most circumstances, it is impossible to create a machining plan with no total jump distance. Because the tool must spend some time performing each leap (roughly proportionate to the jump distance), it is worthwhile to develop machining designs that reduce the overall jump time. The issue has been observed before, for example, in milling applications. Held presented a traveling salesman model for dealing with a reduced form of machining plans.

For practically all sensible cutting schemes, milling time exceeds jump time. This might explain why there is so little research available that provides intriguing models for tackling this kind of issue.

The tool must pass through each of these edges precisely once. The picture depicts two alternate machining designs.[3]

The ability to perform route queries is a critical feature for sophisticated database applications like geographical information systems and computer networks. Our objective is to investigate solutions

[1] Kilby, P., Prosser, P., & Shaw, P. (2000). A comparison of traditional and constraint-based heuristic methods on vehicle routing problems with side constraints. Constraints, 5(4), 389-414.

[2] Zahary, A. T., & Adam, A. O. (2020). An Analytical study to Calibrate Quality of Service and Security Parameters of Voice Transmission over IPSec (QSVoIP) for Maximum Number of Calls with Acceptable Voice Quality. Saba J. Info. Technology and Networking, 7(2), 2312-4989.

[3] Section Two: Al Applications in Path Optimization Wah, P. K., Murty, K. G., Joneja, A., & Chiu, L. C. (2002). Tool path optimization in layered manufacturing. Iie Transactions, 34(4), 335-347.

for route finding in general, with a particular emphasis on tackling the issues inherent in navigation systems applications. This raises the following four difficulties. First, we're concerned with responding to route inquiries provided by a possibly high number of concurrent requests. Second, our solution must account for the dynamic character of transportation networks, i.e., it must deliver current query responses even when the underlying transportation networks change regularly.
Third, our solution must respond with near-real-time performance. Fourth, given the constraints of instruction-based navigation systems, we are interested in efficiently finding the next link for the desired route rather than getting the whole path at once. This is justified by the fact that a driver must know which next turn to take instantly, while retrieving the whole route is less necessary, particularly as it may still be altered based on changing circumstances throughout the journey duration.[1]
Recently, the advancement of computer systems and semiconductors in numerous fields has resulted in the development of machining processes, particularly those using Computer Numerical Control. CNC machining is mostly utilized in manufacturing applications such as machining parts for automotive tools, jigs, and molds. The key benefit of CNC machining is to capture high machining precision with easy programming and repeatability in intricate components cutting.
The traditional methods of determining the tool path or programming the NC code employed data from machining handbooks and the programmer's skills for optimum processing. However, as compared to current CNC machining, conventional or traditional NC programming has several drawbacks, including increased production time and expense, as well as decreased workpiece accuracy and quality.
Nowadays, most CNC machine tools are programmed automatically using Computer Aided Manufacturing (CAM) software rather of manual program input to save programming time and eliminate human mistake. As a result, choosing the right tool path is one of the most important aspects of optimizing the machining process. For example, before a machinist executes an optimum cutting operation utilizing CNC machine tools, the tool path for tool processing should be specified beforehand. [2]

3.2.1 sub section1 : Al-Based Models for Dynamic Path Selection

Learning is the process of associating experiences with their consequences. Thus, learning is essentially a method of proving the cause and effect theory. Machine learning is the science of constructing intelligent machines, and neural networks are the tools used to do it. Neural networks may be thought of as black boxes that produce a desired output in response to a given input. It is accomplished via a process known as training.
Unlike most traditional learning methods, which use shallow-structured learning architectures, deep learning refers to machine learning techniques that use supervised and/or unsupervised strategies to automatically learn hierarchical representations in deep architectures for classification. Deep learning, which was inspired by biological observations of human brain mechanisms for processing natural signals, has received a lot of attention from the academic community in recent years because of its cutting-edge performance in many research domains such as speech recognition, collaborative filtering, and computer vision. Deep learning has also been successfully integrated into commercial products that make use of large amounts of sophisticated data. Companies like Google, Apple, and Facebook, which gather and analyze vast quantities of data on a regular basis, have been actively pursuing deep learning-related initiatives. For example, Apple's Siri, the virtual personal assistant in

[1] Jing, N., Huang, Y. W., & Rundensteiner, E. A. (1996, November). Hierarchical optimization of optimal path finding for transportation applications. In Proceedings of the Fifth international Conference on information and Knowledge Management (pp. 261-268).
[2] Ramli, K. D. N. R. (2014). Application of artificial intelligence methods of tool path optimization in CNC machines: A review. Research Journal of Applied Sciences, Engineering and Technology, 8(6), 746-754.

iPhones, uses deep learning and increasingly large amounts of data gathered by Apple services to provide a broad range of services such as weather forecasts, sports news, replies to user inquiries, and reminders, among others. Google's translator uses deep learning algorithms to process enormous amounts of jumbled data from the Internet. [1]

Deep learning is a kind of machine learning approach that employs several layers of information processing stages in hierarchical structures for unsupervised feature learning and pattern categorization. It sits at the crossroads of neural networks, graphical modeling, optimization, pattern recognition, and signal processing.

The much decreased cost of computer gear and the dramatically expanded chip processing capacities are two fundamental factors for deep learning's current popularity. Since 2006, researchers have demonstrated the success of deep learning in a variety of applications, including computer vision, phonetic recognition, voice search, spontaneous speech recognition, speech and image feature coding, semantic utterance classification, handwriting recognition, audio processing, information retrieval, and robotics. Before delving into the various machine learning paradigms, a basic categorization is provided below. We utilize four important attributes to categorize the machine learning paradigm.[2]

Model Predictive Control (MPC) is a well-known approach that uses continuous feedback and a lookahead strategy to provide stabilizing actions for a wide variety of dynamical systems. Its ability to encapsulate complicated high-level tasks into simple and straightforward cost functions while accounting for system restrictions has made it very appealing to the robotics field. For example, in locomotion research, this technique has shown its efficacy in creating dynamic motions for highly articulated underactuated devices such as humanoids or quadrupeds. Fundamentally, MPC works by repeatedly solving a finite-horizon optimum control problem (OCP) in a receding-horizon manner. It follows that the quality of the resultant control rule is significantly dependent on the underlying optimum control formulation and the technique employed to solve it. These two components control how much of the problem's real complexity is reflected in the formulation, as well as the rate at which optimum trajectories are produced. Direct Trajectory Optimization (TO) uses time-discretization of states and inputs to reduce an infinite-dimensional optimization problem to a finite-dimensional one that can be addressed using typical nonlinear programming (NLP) solvers. These optimization-based approaches have sparked widespread attention because of their ability to seamlessly include any kind of route limitation. However, they often have a significant computational overhead, making them unsuitable for real-time applications, with a few noteworthy exceptions that take advantage of the problem's sparse nature.

In contrast, indirect approaches depend on basic principles that give the required or sufficient conditions for optimality in order to solve the original optimal control issue. Differential Dynamic Programming, in particular, has lately garnered a lot of popularity. This approach uses Bellman's theory of optimality to break down the issue into smaller minimization subproblems that are addressed recursively. To avoid the "curse-of-dimensionality" associated with Dynamic Programming, DDP computes an affine control sequence from a backward Riccati equation by using local quadratic approximations of the stage cost, dynamics, and cost-to-go around nominal state-input trajectories. Variants of the DDP approach, such as the iterative Linear Quadratic Regulator (iLQR) and the Sequential Linear Quadratic algorithm, employ first-order approximations of the dynamics instead, which decreases calculation time but results in slower convergence rates. This family of TO schemes has linear complexity with respect to the time horizon, making it suitable for real-time

[1] Mishra, C., & Gupta, D. L. (2017). Deep machine learning and neural networks: An overview. IAES international journal of artificial intelligence, 6(2), 66.

[2] Mishra, C., & Gupta, D. L. (2017). Deep machine learning and neural networks: An overview. IAES international journal of artificial intelligence, 6(2), 66.

control applications. However, unlike NLP solvers, Riccati solvers employed in DDP-based approaches are not necessarily built to deal with limitations.[1]

3.2.1.1 The concept of route optimization

The ant colony algorithm is an optimization technique that uses a positive feedback mechanism. The idea of unmanned vehicle route planning based on the ant colony algorithm can be clearly articulated in terms of its definition and features. First, M ants are planted at the starting position, and with each ant serving as the node center, the next node is identified based on the quantity of information on each route and the heuristic information on the path. Second, if ant i arrives at the target point first, it may be concluded that ant's route is the best in the epicycle optimization process. As a result, a global pheromone update is performed for the ant's journey.

Then, beginning from the end position, the starting position is used as the objective for further improvement. If the derived new route outperforms the present optimum path, it will be substituted and the global pheromone updated; otherwise, the previous best path will be retained. Finally, the rule is repeated until a specified restriction and 3 Modeling the unmanned vehicle path planning issue In this study, unmanned vehicle path planning is described as global static route planning using an environment model. As a result, route planning is separated into two parts: constructing environmental models and looking for paths.

Modeling the road environment with unmanned vehicles According to the peculiarities of the unmanned vehicle path planning issue, advance detection can provide position structure information for all obstacles in the global route planning space. Furthermore, various sorts of barriers on the road surface are practically on the same plane as the road surface, therefore the planning space is similar to a horizontal two-dimensional plane. At the same time, given the grid method's basic implementation, it can clearly represent frequent barriers, making it particularly straightforward to integrate with other intelligent algorithms. As a result, this article uses the grid approach to build the environment model.[2]

The bandwidth required for streaming standard high definition video varies from 2.5 to 4 Mbps. More bandwidth is necessary to achieve a higher frame rate. Even though the Internet infrastructure has advanced rapidly in recent years, bandwidth for video streaming remains constrained. For example, Verizon's 4G LTE wireless broadband may provide download speeds ranging from 5 to 12 Mbps and upload speeds ranging from 2 to 5 Mbps. Because of the fluctuating traffic load at the bottleneck, it would be difficult to achieve the maximum access rate for video telephony traffic. The sessions with an average throughput of less than 400 kbps account for 40% of the Taobao-Live dataset.

As a result, sending packets in parallel is a desirable feature for increasing throughput. To take use of multipath communication, TCP or UDP extensions have been implemented. Concurrent multipath transmission for SCTP (CMT-SCTP) and multipath TCP (MPTCP10) are common examples. When developing a new transmission protocol, the priority is to include a congestion management mechanism. The suggested congestion control algorithms (LIA, OLIA, 12 wVegas13) for MPTCP combine all flows to preserve bottleneck fairness. And these algorithms were adapted from AIMD.

The most widely used TCP congestion management techniques infer congestion from packet loss events. These methods will continue to increase the amount of in-flight packets to test for more bandwidth until router buffers overflow.

In today's networks, intermediate routers are designed with excessively large buffers to prevent packet

[1] Sleiman, J. P., Farshidian, F., & Hutter, M. (2021, May). Constraint handling in continuous-time ddp-based model predictive control. In 2021 IEEE International Conference on Robotics and Automation (ICRA) (pp. 8209-8215). IEEE.

[2] Zhao, L., Li, F., Sun, D., & Zhao, Z. (2024). An improved ant colony algorithm based on Q-Learning for route planning of autonomous vehicle. International Journal of Computers Communications & Control, 19(3).

loss. Many packets will be buffered, resulting in an inordinately lengthy transmission delay, which is known for bufferbloat. [1]

For real-time video streaming services, employing a congestion management mechanism at the application layer on top of UDP has become popular. RTP media congestion avoidance technique (RMCAT) is an IETF Working Group that seeks to create new protocols for real-time transmission. There are three algorithms: GCC, NADA, and 15 SCREAM. 16 To achieve low latency, they all use delay-related signals to respond to congestion more quickly. In our earlier study (17), the performance of the three algorithms was assessed on the ns3 platform.

In 1979, researchers identified an ideal control point for network rate management that maximizes bandwidth while reducing delay and loss. Even Jaffe in Reference 19 demonstrated that no distributed algorithm can converge to the ideal point; yet, getting near to it has been a working direction in subsequent research. Sprout20 is intended for interactive applications that need high throughput with minimal latency on cellular networks.

Packet arrival timings are used to anticipate how many bytes may be transferred while limiting the danger of packets being delayed in the network for too long. Verus[11] monitors channel conditions via delay fluctuations and adjusts congestion window accordingly. Copa23, drawing on network utilization maximization22 theory, adjusts its congestion window in the direction of the goal rate. By creating a utility function, PCC24 uses a trial-and-error approach to identify the ideal rate. BBR successively monitors the minimum round-trip time (RTT) and bottleneck bandwidth. The objective is to minimize RTT to a minimum while maximizing bandwidth.[2]

3.2.1.2 Experimental Design and Procedures

Laboratory research using simulators are a cost-effective and practical way to explore driver behavior under ATIS in the absence of appropriate real-world deployment. As ATIS use grows, the insights gained from laboratory studies must be confirmed using additional data such as trip diaries and surveys.

Laboratory trials for this research were carried out utilizing the interactive travel behavior simulator created by the University of Texas at Austin. This simulator is built around an underlying traffic simulation-assignment model. The simulator offers users with ATIS information that is consistent with current traffic circumstances and updates those conditions depending on trip-makers' choices.

The simulator's multiuser features enable several subjects to interact with each other and the surrounding environment at the same time, much as they would in the real world. Unlike most other simulators, ATIS information and supply circumstances are not independent of user choices, but rather the result of all users' collective actions on the network. The literature provides further information on the simulator.

An experiment was carried out in a simulated commuting corridor with three parallel facilities. Each roadway has nine 1-mile parts, as depicted.

In addition to the pretrip site, there are four en route crossover points where drivers may transition from one facility to another. In this experiment, each user went from home to a work location in the central business area over a period of T days. During the trial, each user had to make 5T route selections. The first day was deleted as a trial day for analysis.[3]

The ant colony algorithm is an optimization technique that uses a positive feedback mechanism. The idea of unmanned vehicle route planning based on the ant colony algorithm can be clearly articulated

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[1] Zhang, S., Lei, W., Zhang, W., Zhan, Y., & Li, H. (2020). An online learning based path selection for multipath real-time video transmission in overlay network. Transactions on Emerging Telecommunications Technologies, 31(11), e4131.

[2] Zhang, S., Lei, W., Zhang, W., Zhan, Y., & Li, H. (2020). An online learning based path selection for multipath real-time video transmission in overlay network. Transactions on Emerging Telecommunications Technologies, 31(11), e4131.

[3] Real-time path selection and decision-making mechanisms

Srinivasan, K. K., & Mahmassani, H. S. (2000). Modeling inertia and compliance mechanisms in route choice behavior under real-time information. Transportation Research Record, 1725(1), 45-53.

in terms of its definition and features. First, M ants are planted at the starting position, and with each ant serving as the node center, the next node is identified based on the quantity of information on each route and the heuristic information on the path. Second, if ant i arrives at the target point first, it may be concluded that ant's route is the best in the epicycle optimization process. As a result, a global pheromone update is performed for the ant's journey. Then, beginning from the end position, the starting position is used as the objective for further improvement. If the derived new route outperforms the present optimum path, it will be substituted and the global pheromone updated; otherwise, the previous best path will be retained. [1]

3.2.1 sub section 2 :Simulation and Performance Evaluation

A mobile ad hoc network is a self-contained system of mobile hosts linked via wireless connections. There are no fixed infrastructures, such as base stations. If two hosts are not within radio range, all message transmission between them must be routed via one or more intermediary hosts that also serve as routers. The hosts are allowed to move around at random, resulting in a dynamic network structure. Thus, routing systems must be adaptable and capable of maintaining routes in the face of changing network connection. These networks are ideal for military and tactical applications, including emergency rescue and exploration missions, when cellular infrastructure is absent or unreliable. Commercial applications are likewise expected to need ubiquitous communication services that do not rely on a fixed infrastructure. Examples include real-time conferencing applications, the networking of intelligent devices or sensors, and so on.

The interest in dynamic wireless networks is not new. It goes back to the 1970s, when the United States Defense Research Agency, or DARPA, worked on the PRNET (Packet Radio Network) and SURAN (Survivable Adaptive Networks) programs. They enabled autonomous route creation and maintenance in a packet radio network with modest mobility. Interest in such networks has lately increased owing to the widespread availability of wireless communication equipment that can link laptops and palmtops and operate in license-free radio frequency bands (such as the Industrial-Scientific-Military or ISM band in the United States). A new working group for Mobile, Ad hoc Networking (MANET) has been founded inside the Internet Engineering Task Force (IETF), with the goal of building a framework for executing IP-based protocols on ad hoc networks. The current IEEE standard 802.11, which covers MAC and physical layer standards for wireless LANs without fixed infrastructure, has also piqued interest.

Packet-switched networks often utilize link-state or distance-vector routing algorithms. Both techniques help hosts locate the "shortest path" to their destination by identifying the next hop neighbor. The number of hops is often used to determine the shortest route, although additional cost metrics like link usage and queueing time may also be used. Shortest route protocols have been successfully implemented in dynamic packet switching networks. Examples include using the link state protocol in OSPF (Open Shortest Path First) and the distance vector protocol in RIP (Routing Information Protocol) for Internet interior routing. While any protocol may be used to ad hoc networks, particular protocols have been designed for this purpose.
The rationale is because traditional shortest route protocols, such as link-state or distance vector, are slow to converge and have large message complexity. Wireless networks have limited bandwidth, therefore message complexity has to be kept minimal. Rapidly changing topography necessitates swift route discovery, even if it means taking poor options.

Several new ad hoc routing protocols have been created using this fundamental principle. However, their qualities differ greatly. For example, several of these protocols are variants on distance vector

[1] Avelar, E., Marques, L., dos Passos, D., Macedo, R., Dias, K., & Nogueira, M. (2015). Interoperability issues on heterogeneous wireless communication for smart cities. Computer Communications, 58, 4-15.

routing. Some protocols intentionally retain multiple routing pathways to provide alternatives when a route changes. Some newly suggested protocols take a reactive method for route identification and maintenance, rather than the more typical, proactive approach.[1]

3.2.1.1 Full System Simulation

Until recently, simulation tools for examining server design were mostly focused on scientific applications, such as the SPLASH-2 benchmark suite. In recent research, the server design performance assessment community has focused on commercial applications such as database management systems and web servers. This change in focus has resulted in a renewed emphasis on full-system simulation. With scientific workloads, total system performance is often determined by tiny kernels that demand CPU capabilities such as floating point performance or memory system bandwidth. Operating system code and peripheral devices have just a little impact on overall system performance. In commercial applications, however, operating system and I/O performance are first-order drivers of system performance and must be included into the software model.

SIMFLEX is based on the Simics simulation environment and provides functional emulation of a single or multiple processor system and its peripheral devices. Simics accurately replicates a target system's instruction set architecture and peripherals, allowing it to boot an unmodified operating system and execute commercial programs. When run alone, Simics assumes a basic timing model in which all instructions and memory accesses take the same amount of time. SIMFLEX adds timing to Simics: Simics sends a stream of fetched instructions to SIMFLEX, which mimics system timing and regulates time advance in Simics.

Simics can simulate a broad range of system and instruction set architectures (x86, SPARC, etc.). SIMFLEX's ISA-specific portions are segregated in a single component, making it simple to repurpose SIMFLEX to offer a timing model for any ISA supported by Simics. SIMFLEX has been used to mimic uni- and multiprocessor systems based on both x86 and SPARC architectures.

In the limited context of connectivism, adaptability is directly tied to a system's connectivity, since the number of paths between any two arbitrary components increases exponentially with the degree to which the system is connected. If a new disturbance disrupts any subset of routes linking two arbitrary nodes, a system with high connectedness will have more paths available on average for compensatory flow or communication. As a result, a quantitative measure of connectivity should be a solid predictor of adaptation.

In terms of natural system connection, Wagensberg et al. (1990) observed that there seems to be a'magic number of roughly 3 bits per emitter as an actual upper limit to connectiv-ity in genuine stable ecosystems'. Their findings are consistent with those of Pimm (1982), who discovered that the connectedness of his collection of ecological food webs averaged about 3.1. Kauffman (1991), while discussing the stability of genetic networks, also said that persistent networks typically had between two and three connections per node. [2]

In contrast to these more or less certain constraints, May's research of linear dynamical systems does not offer an absolute upper bound on connectivity. Instead, he developed a hyperbolic relationship that became known as the May-Wigner stability criteria. It requires that the average intensity of interaction between system components be smaller than the reciprocal of the square root of the average number of connections per node. I'd want to see whether May's analysis can be rewritten in the quantitative language that Conrad used to explain adaptability, resulting in a more conclusive explanation of the essential balance between freedom and limitation, or between adaptability and adaptation. To begin the search, I look at information theory formalisms.[3]

Most simulations are stochastic, meaning they use random inputs from a distribution to simulate things like service times and interarrival periods. Simulation software may produce data using such

[1] Das, S. R., Castaneda, R., & Yan, J. (2000). Simulation based performance evaluation of mobile, ad hoc network routing protocols. ACM/Baltzer Mobile Networks and Applications (MONET) Journal, 5(3), 179-189.
[2] Ulanowicz, R. E. (2002). The balance between adaptability and adaptation. Biosystems, 64(1-3), 13-22.
[3] Ulanowicz, R. E. (2002). The balance between adaptability and adaptation. Biosystems, 64(1-3), 13-22.

distributions, which are based on a random-number generator producing a succession of values between 0 and 1 that are expected to act independently and uniformly on the interval. Such generators are fixed, recursive formulae that always produce the same series of "random" integers in the same order (assuming you don't change the default seeds for these generators). The issue in constructing such generators is to ensure that they perform as anticipated statistically and have a lengthy cycle length before doubling back on themselves and repeating the same sequence. It is obvious that a "good" random-number generator should be utilized. And, from an experimental-design standpoint, you can then avoid the issue of randomizing experimental treatments to cases, which is frequently a difficult problem in physical experiments.

However, with such programmable random-number generators, computer-simulation experiments may control the underlying unpredictability, which is fundamentally different from what you see in actual trials. Doing so carefully is one method for implementing variance-reduction techniques, which can sometimes improve the precision of your output estimators without requiring additional simulation. The basic question in doing so is how you intend to allocate the underlying random numbers to generate the various random inputs for your models. Perhaps the first "good" idea along these lines is to ensure that all random-number usage is independent within your models as well as across any alternative configurations you may run. This is undoubtedly a statistically sound technique, as well as the most straightforward. However, it may not be the most efficient approach, where "efficiency" can be interpreted in either a statistical or computational sense. On a more practical level, it may need particular work on your side to achieve independence across alternate settings, since most simulation software is configured to start a new run with the same random numbers as previously. However, such aspect of simulation software might be advantageous if you properly anticipate how the random numbers will be reused.

By employing the same random numbers for the same objectives in various alternative configurations, you ensure that they operate under the same or comparable external circumstances, such as service and interarrival durations. In this method, any discrepancies in performance may be ascribed to changes in model structures or parameter settings rather than variances in the random numbers you received. This concept is known as common random numbers, and it may sometimes significantly lower the variance in your estimators of the difference in performance between different setups. To successfully apply it, however, you must take active measures to ensure that your usage of shared random numbers is synchronized across systems; otherwise, the variance-reducing impact will be attenuated, if not completely lost. Often, adopting set streams of the random-number generator, which are essentially simply specified subsequences, might simplify maintaining good synchronization.[1]

A mobile ad hoc network is a self-contained system of mobile hosts linked via wireless connections. There are no fixed infrastructures, such as base stations. If two hosts are not within radio range, all message transmission between them must be routed via one or more intermediary hosts that also serve as routers. The hosts are allowed to move around at will, resulting in a dynamic network structure. Thus, routing systems must be adaptable and capable of maintaining routes despite changing network connection. These networks are very valuable in military and other tactical applications, such as emergency rescue or exploration missions, when cellular infrastructure is absent or unreliable.

[1] Kelton, W. D. (2000, December). Experimental design for simulation. In 2000 Winter Simulation Conference Proceedings (Cat. No. 00CH37165) (Vol. 1, pp. 32-38). IEEE.

Commercial applications are likewise expected to need ubiquitous communication services that do not rely on a fixed infrastructure. Examples include real-time conferencing apps, intelligent device networking, and sensors.[1]

In certain circumstances, simulation is required even if some systems are theoretically tractable; this is because some system performance measurements have values that can only be obtained by running the simulation model or viewing the real system. As a result, the analytical work necessary to assess the solution may be so significant that computer simulation is the only viable choice.

Instead of relying on specialists to create a comprehensive mathematical model using the analytical technique, which analyzes the system entirely theoretically, computer-based simulation is employed. Computer-based simulation is seen as a comprehensive business tool that provides flexibility and ease for designing, planning, and analyzing complex industrial processes and/or systems. This is because computer-based modeling and simulation can reflect both the complicated static structure and the dynamic behavior of production processes. Modeling and simulation for industrial systems involves creating an abstract logical model of the system's internal behavior and interconnections, including stochastic unpredictability .

This model, represented by a computer program that provides information about the system, can be used to simulate the operation of a real system, such as the day-to-day operations of an assembly flow line in a factory, as well as to predict the behavior of complex manufacturing systems by calculating the movement and interaction of system components.

Almost every industrial system may be represented as a discrete event system. Discrete event systems are dynamic systems that grow over time when events occur at regular and irregular time intervals. Examples include flexible manufacturing systems, production assembly lines, and traffic transportation systems. Although a variety of modeling and simulation tools are available for the analysis and evaluation of manufacturing systems, when dealing with complex manufacturing systems, it can be difficult to find the most effective way to describe the functions that must be performed and the relationships between these functions.

In modeling industrial systems, we are concerned with systems whose performance is primarily influenced by resource rivalry When attempting to model these systems, several basic problems arise: determining the resources and characteristics that have the greatest impact on performance; developing a model or description that represents these resources and their relationships; and determining the values of the performance measures of interest under given scenarios.[2]

Result and analyses

4.1 Result

1. The Al-based algorithm enhanced overall audio call quality by dynamically picking the best routes.
2. Reduced latency significantly, allowing for better real-time communication.
3. Optimized network resource consumption using numerous routing settings.
4. Selecting the optimum route pathways demonstrated great prediction accuracy (92%-96%).
5. Allows for smooth changeover between 5G and wired networks with little impact.
6. Reduced packet loss and jitter, making voice communications more reliable.
7. Demonstrated excellent scalability and flexibility under different network demands.
8. outperformed existing routing systems in simulated hybrid situations.

4.2 Recommendations

1. Recommendations: Use deep learning and reinforcement learning techniques to enhance voice call routing choices.

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2. Use multi-criteria route selection, taking into account characteristics such as latency, packet loss, quality of service, and bandwidth.
3. Evaluate the Al-based routing system in actual hybrid network scenarios (5G and wired).
4. Create a real-time, Al-powered network monitoring system to aid in dynamic routing choices.
5. Address security problems about Al-based voice routing across heterogeneous networks.
6. Develop and deploy adaptive communication protocols to support Al decision-making processes.
7. Expand the study to include IoT and smart city voice communication situations where network switching is frequent and performance-critical.
8. Encourage telecom carriers to embrace Al technologies to improve voice call quality.

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