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Network Optimization Using Learning and Distributed Intelligence through Cognition-Based Networks

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Abstract

Network optimisation can be achieved with the incorporation of sophisticated technology and advanced algorithms to achieve efficiency and scalability. Optimisation of the entire network with learning and distributed intelligence through cognitive-based networks is investigated in the paper. A cognition-based network enhances the capacity for network optimization and designing processes to offer better services to the customers appropriately. With the rapid growth of users, the network distribution channels are required to adopt cognitive-based architecture for optimised capacity, capable of providing secure data transmission to a wider user base. 5G network construction with SDN and NFV, along with AI and machine learning algorithms are considered to be the most efficient cognitive-based approach for network optimisation. The application of NFV helps to develop network functions in operating open hardware platforms, reducing Capex, and OpenX and improving network design efficiently. On the other hand, SDN is capable of separating the control plane and the data plan with a defined interface for programming, providing an entire view of the network with centralised control.

Keywords

AI, machine learning, cognition-based networks, network optimisation, NFV, SDN.

INTRODUCTION

Network optimization helps to apply industrial leading technology in the network life cycle for developing network performance with the strategic objective and develops the return on the investment. This factor helps communication service providers to gain an edge with the help of data-given optimization technology in developing scale and complexity in the network process. The cognition network is defined as a type of data network that helps to utilize cutting-edge technology from different research areas such as machine learning prediction computer networking network management [1]. This factor helps in resolving problems in the current network related to the design and operation of communication networks. Cognition network access to apply cognition process for deciding an act on the addressed current issues with the help of network learning from the consequences of actions in the communication network. This factor creates a look at the network environment and provides an action plan according to the input obtained from the sensor and the network policies.

In India, 47% of internet penetration indicates the need of developing a cognition-based network in maintaining communication networks effectively. This factor helps to develop the learning and distribution process of intelligence with the usage of the internet through providing better service to the users [2]. The cognition process helps the devices the ability to transmit huge amounts of data with a reduction of energy consumption and efficiently use the available bandwidth. This factor helps the operational parameters to respond to the user's need for addressing the environmental condition that exploits the knowledge obtained in the execution of decisions for the further process. The system architecture of the "International Organisation of Standardization" (ISO) or "Open System Interconnection" (OSI) is an essential part of network design for its modularity in building optimization of individual groups of functionalities and developed scalability. This structure helps to increase the amount and variety of services developed over the network and efficiency of the internet service provider to continue enhancing the quality of service provided to the customers.

This factor shows that the current network architecture suffers from challenges due to the inefficiency of the underlying infrastructure and does not offer the capability of scaling up with the growing complexity of the communication networks. This growing complexity highlights the challenges in maintaining security and privacy to understand the connection with the network properly. The cognition learning process helps to provide the capability of continuous learning by optimising its performance and controlling the loopholes of the different services and resources in the network system [3]. This factor helps to monitor the environment under control and analyse the collected data effectively for developing the decision-making process in managing the cellular network effectively. The analysis of the collected data helps to perform the decided actions on the environment to get better results in network optimization and designing processes to offer better services to the customers appropriately. The objective of the study is to identify the influence of network optimisation in learning and distributing intelligence with the help of cognition base

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networks.

LITERATURE REVIEW

Significance of network optimisation in the cognition base network

Network optimization helps to identify and predict the network data with the help of technology for pushing the network to provide maximum potential in resolving the performance issue. This activity of monitoring and predicting potential issues helps to technology plan for evaluating the future network demand and identify the expansion capacity for developing the returns effectively. This factor helps to understand the capture value of the 5G area and develop communication service-providing processes for adapting to the constant change of demands and expectations in emerging 5G cases. Network benchmark criteria help to expand the dynamics of communication services by identifying the key merits to focus on and the way of evaluating them effectively [4]. This factor helps AI Power Technology to identify the gaps through the downfall of the key merits in the root cause and resolve the issues with the help of an end-to-end network.

Network optimization helps to develop traffic forecasting and performance prediction for determining critical congestion areas that cannot be resolved through the optimization process. This factor helps to develop the User experience by 15% and improve the external benchmark by 90% in the operating process of communication services with the help of internet services.[5] The cognition network techniques help to offer better protection from security attacks and network intruders and provide better services to the service operators and customers. This factor helps to focus on the development of network optimization in learning and distributing knowledge about the obligation in communication network services. The cognition-based network helps to analyse the network state and usage patent for recursion of network design and planning in enhancing the approach of communication services. This development helps to mice the network equipment for the reduction of network rollout of carbon emission and speeding the site acceptance for developing the subscriber's experience in a better way.

The cognition network helps to motivate by the observance of the lack of spectrum under the current network management policies that allow for combining new perception with the previous perception. This factor helps to understand the circumstances and determine the best line of action in resolving the current situation through maintaining policy and regulation of network management. This learning process helps to identify the patterns in the source usage and develop action in optimising the quantity network for achieving a high level of automation in operating network management and configuration tasks efficiently [6]. This factor has to instruct the way and the process of managing the system to control the interfaces in achieving the organizational goal in a short period. The automation process helps to manage it and manage specific parts of the network through the development of knowledge and thinking about the operator and the environment process.

This intended automation helps to control system operations by stating the operation goal through detailed configuration performed by the management system in controlling the network distribution and designing [7]. Distributed intelligence helps to apply smart algorithms of the network operations and procedures to distribute and centralize AI in developing the performance in the continuous learning process.

Challenges of the cognition-based network in learning and distributed intelligence

The cognition-based network assists to develop the trend of the 5th-generation mobile systems in maintaining the communication services for the users. This system creates challenges in the device capability and traffic that develops functions in managing scalability and identifying the parameters in a single node number utilized in the system infrastructure. The network optimisation process helps to identify the efficiency of the resources such as bandwidth and energy in effective management of the quality of experience of the users through cognition networks [8]. The current cellular network is designed to serve a small number of users at a high bit rate with the help of downlinks that can create challenges in the massive access.

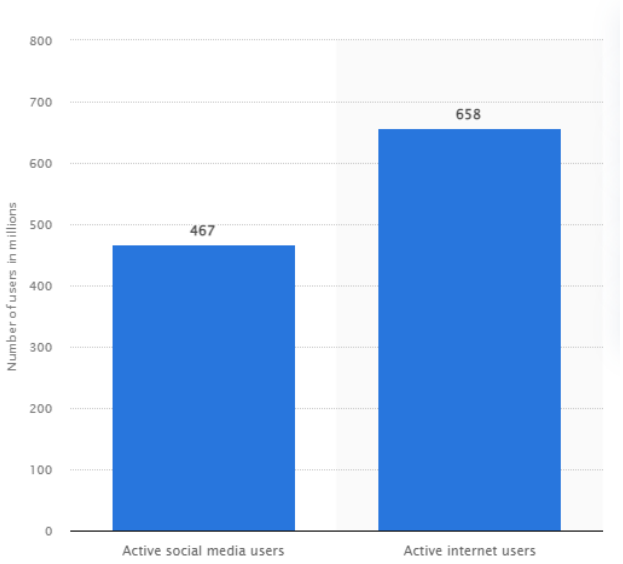

Figure 1: Number of Internet and social media users in India [9]

The above figure shows 658 million internet users in India and resulting in massive access to devices that prevalent uplink scenarios in the transmission process of short packets. The utilization of social media and cloud services at the same time can cause the generation of signalling overhead and lead to service outages in the current technology and protocols. The development of services increases the high-speed connectivity that increases in the near future and with the issue of placing the Festo base stations in the microcell.

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These stations are known as “Heterogeneous Networks” (HetNets) and provide better coverage and higher connection speed to mobile users and network operators.[10] Different density of the best station and backhaul connectivity causes new technical challenges that affect the design of efficiency handover policies, resource utilization, and service migration strategy. This factor causes challenges in introducing 5G services to the consumers and maintaining the user's experience with the cellular network process.

The high demand for wireless access points leads to the requirement of spontaneous multiple video connection at a dynamic rate through scalability coding and different quality requirements in maintaining communication services. This factor creates a problem generating a communication system for differentiating services and also includes per-flow in each class in providing content-based service optimization. The increment of topological and functional complexity in the networks leads to an automated mechanism in the cellular network for managing fundamental network operations that reflects self-configuration in the system parameter [11]. This factor helps to identify the self-optimization of the network performance through its coverage capacity, energy, and consumption for recovering the network personality and service fault in maintaining the cognition network effectively.

Self-X mechanism periods celebrity and full automation and also open challenges in managing network systems effectively that did not affect the design implementation of practical network-wide learning framework for network optimization. This factor creates a problem to maintain the learning approach of the network optimization due to the lack of infrastructure in the network management process. On the other hand, machine learning tasks lead to the performance of deep networks in the suitability of learning and adaptation of network optimization [12]. This factor builds difficult to provide effective service to the customers in maintaining the network services and traffic in providing internet services. The SDN tool did not utilize the network optimization process that creates a large-scale testbed in corporate with deep learning concepts in the network management process. This factor causes problems in maintaining the Indian cellular network among consumers and introduces fifth-generation services to Indian consumers. This challenge helps to identify the traffic and service infrastructure impact on the service-providing process and network management in India and developed the network engineering process efficiently.

Strategies to enhance the learning and distributed intelligence of network optimization

Recent trends show that the cross-boundary of layering architecture helps to develop more efficiency than the orthodox layered model in the network optimization process. This costly approach helps to provide good results in the resource challenge environment that helps the individual to collect knowledge about the correct time and the way to use cross-layered techniques. On the other hand, newly emerged network designs and capabilities involve software-defined network (SDN) and network function virtualization (NFV) for exploring the opportunities in the system and application [13]. The utilization of SDN helps to offer real-time visibility in the network performance and engineering the ability to reroute networks through developing reliability on the automation.

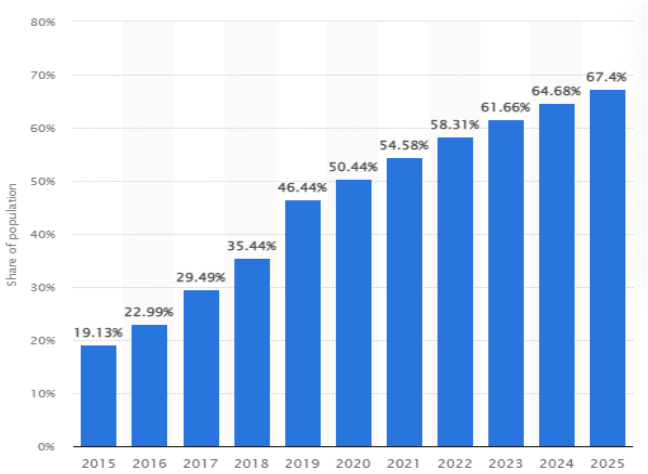

Figure 2: Usage of social networks in India population [14]

The above figure shows that the usage of social networks increased day by day that needs network optimization in managing cellular networks. The application of NFV helps to develop network functions in operating open hardware platforms, reducing Capex, OpenX and improving network design efficiently. This factor helps to apply network applications for reducing the maintenance and hard work costs in providing cellular networks. As per the CRISIL report, India has a 4G subscriber base of over 800 million by March 2022 that opens new opportunities for cellular networks [15]. 76% of respondents increased their spending time online on the backdrop of remote working, remote running, and entertaining themselves that reflects the effectiveness of network optimization. This factor provides a clear indication that India has successfully adopted 4G services in rural and urban areas and also has a welcoming approach towards the 5G services.

The usage of “user to edge" helps to deliver services in the current legal full structure for scaling up high CAPEX and time investment in developing the planning process of computer capacity and stored data leverage automation effectively. The network Optimisation process utilise open APIs for vendor agnostic for levelling up automation software in enhancing the simplicity of the network. The system integration helps the Telecom operators for developing their strategies in adopting network architecture for long-drawn processes and provides a fast-forward relook at the current availability in the regulatory allocation process [16]. This factor helps the network service providers to construct network plans in network strategy for the end users and develop the customer experience effectively. The emerging application requires more bandwidth with lower

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latency for meeting the requirements of quality experience and maintaining the expectation of the consumers that helps to develop the network architecture properly. The network helps to work as the virtualization capability for creating a close loop into automation in advance in the analytics and intelligence in self-configuration multi-layer infrastructure of the network management.

The cognition network assists applied AI in understanding the conservation surgery of the telecom operator for delivery of an uninterrupted experience to the end user and developing the legacy system. This factor helps to provide proper delivery methods through the development of division processes according to the previous datasets related to network management for fulfilling customer needs. In the Indian telecom services, operators are developing the brand with hunger in requirements with the help of serving closer to the edge services, expanding edge cloud strategy, and automated open lean network [17]. Conveyance optical and IP Network provides real-time multi-lead views of the network that play an important role in optimizing the utilization of network and cloud resources. This factor helps to centralize the data centres of the hardboard explanation for balancing the system and monitoring the collected edges data in developing cloud strategy effectively.

METHODOLOGY

Study design

The cross-sectional study design helps the researchers to compare different variables related to network optimization in discovering the user's behaviour-related data in the communication services. This factor assists to learn more cognition-based networks in the learning and disturbing knowledge-related user experience any difficulty related to community service effectively. This study design helps to track the progress offered in a cross-sectional study in determining the network market in India that is efficient in network optimization with the help of cognition network services. The utilization of available resources helps to resolve technical challenges in mobile users and network operators in improving the designing process in enhancing the handover policies [18]. This factor guides to offer of content-based service optimization for enhancing the communication system approach in different services for maintaining scalability.

The network optimization helps to fulfil the growth for 5G services maintaining increased video consumption and reliable internet connectivity for fulfilling the requirements of study and work. This factor helps to apply cognition systems for interacting with the closed loop and understanding the system's needs and the way it happens helps to automatically resolve any resulting conflict. This system helps to understand the learning system and user behaviour in moving from reactive to proactive management for mitigating the future problem of network systems in advance.

Data collection

Effective data collection helps researchers to direct scarce resources related to the research topic in determining the service area for developing the data-driven decision in improving the research work. The secondary data is collected from online journals and articles related to network optimization and its influence on learning and distributed intelligence. The random sampling process guides to remove the bias from the gathered data for developing the quality of the research work for measuring the network optimization with the help of cognition networks. The conceptual design and practical implementation in maintaining a cognition-based network for advancing machine learning for understanding deep unsupervised learning networks in resolving difficult classification issues. This factor guides identifying the commercial diffusion in the parallel computing architecture in determining large-scale deep learning models in the cellular network [19]. The application of SDN and NFV assists to overcome the underlying issues of the internet and improves the flexibility management of the network.

This factor helps to operate high-level operation goals in the continent network by outlining the Indian base automation for well-defined formal language in managing the network system. Cognition network involves explainable AI and trustworthy AI for developing the intelligence system in providing principles and values in managing cellular networks appropriately. This factor helps to knowledge representation and machinery in intent-based networking processes for enhancing the approach in network optimisation and designing processes that provide details about network issues.

Data analysis

The data analysis assists to present accurate and reliable data with the help of the secondary collected data for fulfilling the research objectives and answering the question related to the research topic efficiently. The secondary data analysis process is utilized in describing and explaining the gathered data related to network optimization in learning and distributing intelligence among the network user. This gathered data helps to connect networks wirelessly with the help of electronics and software in the cognition network in observing the environment and drawing conclusions from the acquired data u that helps in evaluating alternatives effectively. This factor helps to provide level of freedom in choosing their action for controlling the expectation of requirement and goes into constructing technical systems for controlling the interfaces and managing the multi-intended distribution across the network [20]. The cognition network technology has to enable zero-touch development and operation in real-time performance improvement through self-learning in the scale and interaction with the environment.

This technology has to be combined in building cognition systems for working together in the operating process and

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participants in the low-level network tasks to end-to-end operation effectively. This factor helps to develop the decision-making process through smart data collection and exposure to develop the efficiency of data given network architecture and manage the life circle and integrate the training process that enhances pipelines properly.

RESULT AND DISCUSSION

Cognitive-based networks help to secure performative abilities within a secondary network with the utilisation of physical layer security. However, limitations regarding fading channels and power transmission can reduce optimisation. A cognitive "unmanned aerial vehicle (UAV)" is utilised to mitigate these issues through the exploitation of a highly flexible communication network, and establishing line-of-sight links [21]. On the other hand, robust optimisation of UAV trajectory over its transmitting power is considered for averaging the secrecy rate within the secondary network. Nonconvex problems are mitigated with an iterative algorithm of an S-Procedure while Bernstein-type inequalities are also proposed for cases of outage-constrained. In essence, security in communication can be achieved with adequate cognitive-based networks.

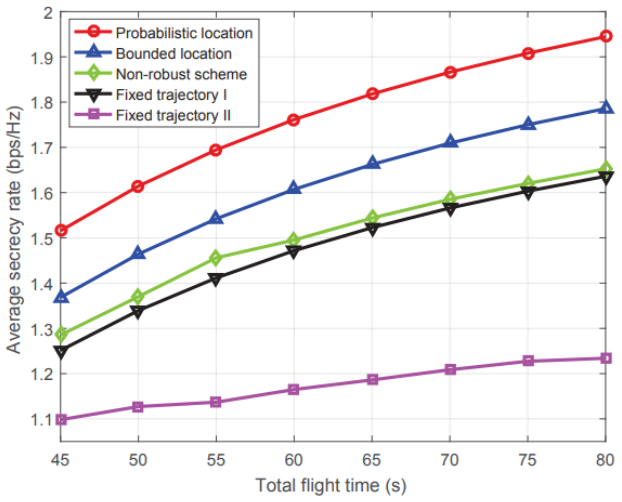

Figure 3: Average rate of secrecy versus total flight time in UAV network [21]

Network virtualization and softwarization are the new directions taken for evolving the network and gaining communicative efficiency. Scalability, reliability and flexibility are aimed to be incorporated with a cognition-based network. network function virtualization (NFV) and software-defined networks (SDN) are currently viewed as optimum solutions for establishing an efficient network [22]. SDN is capable of separating the control plane and the data plan with a defined interface for programming, providing an entire view of the network with a centralised control [22]. On the other hand, NFV operates by decoupling the network functions from the physical equipment with the aid of virtualisation technology [22]. These two helps to optimise the network by complementing each other, identified as key technologies for op[timing the 5G networks, used in various spaces such as cloud data centres, IoT, mobile-edge computing and cognition-based networks.

Technological development is also witnessed regarding emotional awareness and the Internet of Medical Things (IoMT) which was especially effective during the covid-19 pandemic. The establishment of a cognitive model based on IMoT has helped during the pandemic by connecting and monitoring the network through information sharing, patient tracking, supervision, data collection and analysis, healthcare optimisation and so on [23]. Remote operations and decision-making in the medical field are enabled by the novel IMoT network, contributing to the development of emotion-aware services for healthcare. As a dynamic and cognitive-based technology, the development of a distributed and learning network can be established, for mitigating the challenges of remote operational processes.

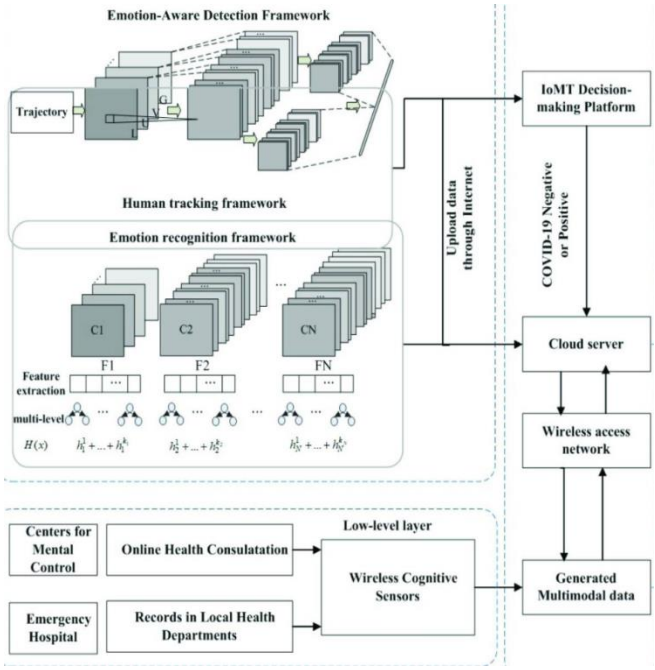

Figure 4: IMoT framework for a cognition-based, emotion-aware network in healthcare [23]

AI and machine learning currently hold significant importance in resolving complex challenges in various fields such as network distribution and communication. Implementation of AI and machine learning for NFV and SDN networks helps to establish a self-adaptive, self-configuring and self-managed network architecture, ensuring higher efficiency and scalability [24]. A Future Intelligent NEtwork-FINE is established based on a collaboration between SDN and NFV, consisting of different planes such as agent planes, intelligence planes and business planes. Each plane operates on different levels of the network, portraying cognitive networks, and accommodating both AI and ML. In essence, the compatibility between NFV and SDN confirms the scope for a wide-scale network that promotes transparency and efficiency yet adequate security to establish a reliable network framework.

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Discussion

The potential for cognitive-based networks is recognised in the age of digital transformation, ensuring the mitigation of issues related to network scalability, reliability and operational optimisation. AI and machine learning technology have been identified as the most efficient tool for establishing a cognitive-based network for optimisation. Furthermore, using SDN and NFV conjointly within a network architecture with AI and ML helps to create a distributed and wide network range. NFV and SDN networks help to establish a self-adaptive, self-configuring and self-managed network architecture, ensuring higher efficiency and scalability with AI and ML [24]. Network optimisation is also considered based on the critical factors related to the security and accuracy of data transmission. It also helps to mice the network equipment for the reduction of network rollout of carbon emission and speeding the site acceptance for developing the subscriber's experience in a better way. In essence, the cognitive-based network establishes automation within the network architecture, enhancing communicative approaches. Distributed intelligence helps to apply smart algorithms of the network operations and procedures to distribute and centralise AI in developing the performance in the continuous learning process. Therefore, based on the above discussion, it can be stated that the development of a 5G network with SDN and NFV and AI and ML algorithms can establish a beneficial, scalable, adaptable and efficient network with high optimisation.

CONCLUSION

The prospect of network optimisation enables the network to provide maximum potential for scalability, transparency, adaptability and security during the management of communication. In essence, the optimisation of networks based on cognitive designs and AI technology helps in creating a learning and distributed intelligence network that is effective and operational for different industrial sectors. Cognitive-based automation for network optimisation enhances performance ability with the application of smart algorithms based on machine learning and artificial intelligence. Development of the 5G network is also identified as one of the potential uses of cognitive-based networks that helps to maintain secure and efficient communication services for the users. SDN and NFV network models are considered to be the most efficient and effective network frameworks, currently capable of mitigating the challenges of expansive and dynamic network circles, both regionally and globally. As the current cellular network is designed to serve a small number of users at a high bit rate with the help of downlinks that can create challenges in the massive access, safe expansion of the current network with cognitive-based optimisation can elevate the experience of users. Therefore, a learning and distributed intelligence model for network optimization is possible with a cognitive-based approach, ensuring that security and operational efficiency are maintained with the capacity to expand and accommodate the growing rate of users effectively.

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