Functional overview of integration of AIML with 5G and beyond the network

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***Abstract*—4 G/LTE mobile networks resolved this issue. Strong physical layer and adaptable network design enable high-capacity mobile broadband Internet. Despite this, the prevalence of bandwidth-intensive technologies like virtual reality, augmented reality, and others has grown. In addition, the rising popularity of new services places astrain on mobile infrastructure. Applications requiring high availability and low latency, such Internet-of-Vehicles or communications between vehicles (IoV). With the advent of the new 5G technology with its massive MIMO radio interface, these problems are no longer a concern. Networks protected by software-defined networking (SDN)and NFV have added a new level of flexibility that allows network operators to serve services with very high requirements across several industries. Network operators must increase and diversify their intelligence to fully comprehend the operational environment, user behaviours, and user demands. A further goal is to become(self-) networkable proactively and effectively. This chapter will look at how AI may help us in the modern world. Next-generation mobile networks that are both efficient and adaptable may benefit greatly from machine learning in the 5G era and beyond. The evolution of AI and ML in networkapplications.**

Keywords*—5G, Artificial intelligence, Machine learning, Neatwork controlling system

I. Introduction

Evolving communication network architecture for varied devices with specific network parameter needs has complicated network security. 5G Networks and beyond are helping immersive growth. By increasing data rates speeds. Data traffic has skyrocketed. Linked gadgets increase risks, dangers, and assaults causing massive financial, societal, and personal losses. Examining and can not do Big Data suspicious activity analysis solely via conventional means. AI and ML are relevant here. ML [1], [2] will be crucial. tackling NP-hard, complicated problems optimization. Self-Organizing networks, clever and adaptable algorithms in different network architecture sections enabled AI and ML with larger performance increases cheaper. The ITU also has a standard. Y.3172, the architectural structure and future ML use case needs IMT 2020 networks. Digital bandits may also penetrate. By exploiting flaws. Vulnerabilities allow data theft. cyberattacks, infrastructure destruction, ransom demands, blackmail, significant service interruption, threats to democracyand life-threatening news breaking. Thus, investingin safer andmore secure communication channels with clear user regulations, trust models, and E2E visibility.

5G+ paradigm change in future network design dedicated network resources for specialized network functions to dynamic virtualization, cloudification, orchestration, automation, and software nation of common/shared network functions [3]. These increase danger. Regarding network security and user data, unable to identify threats and assaults and prohibit real-time (with minimum delay). Such real-time threat/anomaly detection in terabytes need AI/ML help. Data gathering points in various network locations core network and supplied real-time threat detection to ML/AI engines.

Massive LTE (4G) mobile network rollout has overcome one of wireless communications' biggest problems: high capabilities for true broadband mobile Internet. This was mostly doable. via a powerful physical layer based on OFDM and MIMO, among others and adaptable networking. New bandwidth-intensive services reached capabilities. Mobile networks are confronting new services like vehicle communications or Internet-of-Vehicles that need great dependability and near-zero latency (IoV).

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II. AIML WITH MOBILE COMMUNICATION SYSTEM

Ericsson, a top mobile system manufacturer, researched the state-of-the-art and A.I. adoption by mobile carriers and worldwide service providers. The study found operators mostly use A.I. to migrate to 5G and to [8]. 4G/4.5G also has greater complexity in managing several devices and massive data. Operators hope AI/ML will lessen this. Complexity. [8]:

• Networks are using A.I. primarily to minimize capital expense, optimize network efficiency, and develop new revenues. Global operators are benefiting. A.I. integration's advantages. 50%+ of service providers (56%). 2020[16].

• A.I. will improve "Quality of Experience (QoE)" and customer service. A.I. To enhance network quality, customize services, and assist providers in improving customer experience. A.I. will help communications service providers recover their investments (CSPs) implementing 5G networks. Cost reduction Service providers prioritize network investment returns and utilizing A.I. 3 depicts priority areas for A.I. integration to minimize costs as network management. Network 5G, IoT, and industrial digitalization need intelligence and automation. Operators must adapt to 5G technology. Capacity. However, increased capacity increases complexity.

• A.I. is introducing new data issues while simplifying networks. Network providers agree that they need better ways to gather, structure, and analyze massive amounts of data. A.I. gathers.

A. Advantage of the AIML with Mobile communication system:

Mobile communication has changed throughout time. One in 30 years. Before moving to the next generation, i.e. 5G mobile network operators must comprehend existing conditions. The MNO must investigate subscriber demographics, traffic patterns, needs, the capabilities of each form, and potential future trends. Market persons like communication network operators, equipment manufacturers/providers, solution providers/receivers, suppliers/customers, etc., are interested in incorporating AI into their communication services' planning, implementation, and management. AI will mainly provide MNOs. Ability to learn about their network and consumer needs of knowledge and reasoning to make the best decisions/actions for divers situations, environmental circumstances, and eventually, collaboration high-heterogeneous, densely expanding network infrastructures. Operators must make astute judgments to handle complex and changing resources. Traffic. No model can adequately model yet. Network traffic. AI has penetrated cognition, fortunately. Age and deep learning. Deep learning enables machine systems can handle big data sets using training data mining. AI can also understand data flows, administration, and controls.

Network management automatically improves analysis accuracy with other traits and masters operational expertise to improve communication management and services networks. [9] describes. The state information of a network node is very dynamic. The network management system may receive a modified resource. Thus, network management only knows local state information. ML is capable; Like fuzzy logic and uncertainty thinking, deep learning creates a multi-hidden state to simplify classification and prediction. Layer model and transforms features using a hierarchical network structure as described in the chapter's beginning. AI's most significant benefit is that it doesn't correctly represent the system's mathematical model, handles ambiguity and "unknowability." As network infrastructure expands and densifies, Communication networks are large and complicated. Specifically for the future generation. Ideas like Network management discusses hierarchy and distribution. Governance and controls are dispersed throughout the network to avoid data-intensive management centralization problems. Thus, network operators face difficulties like job allocation, management communication, and cooperation nodes. Distributed AI multi-agent cooperation into Network administration will enable network collaboration. However, such an association demands excellent interoperability across the various networks forming full connectivity. Network interoperability is also limited of the many additional environmental conditions needed to take place AI's benefits above.

Other considerations enabling full use Figure 1 shows AIML potential. High-quality data enables lucrative AI integration. High-performance computer resources. 5G systems aim to give high- ultra-low-latency communication services to enhance users QoE. Deep learning could provide 5G systems intelligence to meet costly. Due to solid hardware and software. Needed for complicated training and inference. Several tools as addressed in [10]. The authors highlighted deep learning's hierarchy of sophisticated computing technologies. Systems, deep learning, optimization techniques, and cloud computing.

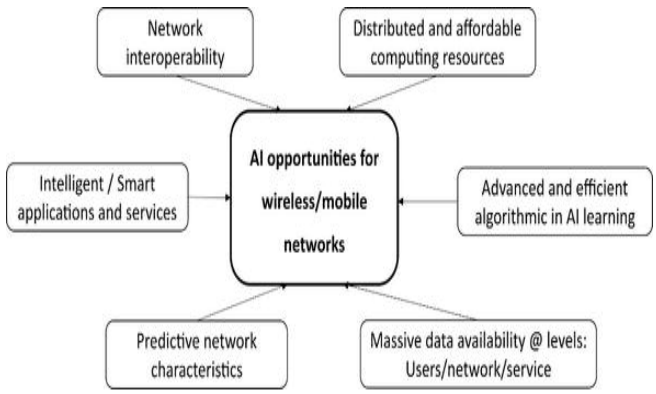

Figure 1. Figure 1: AIML potential

B. AIML components in 5G:

The expansion and improvement of 4G/LTE mobile data speeds were a driving force, but the complex and varied requirements of 5G networks provide significant challenges. Table 1. 5G networks to improve the user experience will provide tremendous throughput and ultra-low communication latencies (QoE). 5G plans to evolve along three dimensions to meet emerging requirements. Technologies include autonomous cars and driving, industrial automation and intelligent factory production.

Table 1: Major need of 5G communication system

Need	Required value	Application
Rate of the data	Upto 10GB	VR need
Volume of data used	250GB/ month	Use in office/ home any busy area
Latency	Not more than 5-8ms	Safe usage/ usage at traffic time
Battery usage and lifetime	10-15 years	Sensors are developed rapidly
Connected elements/ devices	More number of devices	More number of sensors used rapidly

New bandwidth-intensive applications may now use high data rates across a consistent coverage area, thanks to enhanced mobile broadband (eMBB). Streaming in 4K and virtual/augmented reality are two such examples. Media transport layer caching (5G MTC): Communication services increase the need for network connections.

The Number of wireless devices with efficient small- data transmission wide-ranging coverage. Smart houses, BANs, Drone and IoT traffic will cause this. MTC needs to enable large new and future applications. These apps emphasise quality. Dependability, minimal latency, and mobility over data rates. 5G systems utilise several modern technologies, including new PHY and MAC layers, SDN, and others, to reach the following goals. NFV. Figure 2 organizes these enablers.

Figure 2. Figure 2: Classification of 5G mobile communication

The lists of technologies and paradigms include further information. Three technologies enabled the extraordinary capacities: massive MIMO, which permits new bit rates and millimetre-wave that finally provide the promise ofovercoming spectrum scarcity, and network densification.

Because 5G systems should function in all environmental conditions and diverse bands, the Emotional range needs may increase. Thus, power amplifiers must fulfil tighter linearity requirements while keeping system efficiency reasonable. Aiming high Constantly feeding power amplifiers improves efficiency. At its high-power linear limit, unrealistic for 5G base stations. Station because the peak-to-average power ratio is unfeasible. 5G enablers directly impact the network. Performance, but a fully functional 5G network is not possible. AI-free. 5G allows simultaneous IoT connectivity. Devices create vast volumes of data to be analyzed by ML and AI. AI. Wireless carriers can:

Forecast how your users distribute by analysing patterns of change over time. history,

- optimise and fine-tune network settings for capacity expansion;
- predict peak traffic, resource utilisation, and application types;

III. CASE STUDY AIML LIFE CYCLE- CONTROL THE NETWORK:

Dynamic network slicing for diverse QoS use cases, End-user ML/AI-as-a-service, etc. High automation from distributed AIML framework at the edge. According to application, heterogeneous access network traffic issues and combination networks. Case study AIML lifecycle to control the network:

Communication networks begin with planning, dimensioning, and implementation. The network operator optimizes investment, CAPEX, and design requirements. Particularly end-user service quality. Continuous control and management should ensure service continuity, quality, and dependability throughout the network's second phase. Network optimization must help management maintain service quality by upgrading network hardware/software to adapt to operating environment changes— Factors include increased bandwidth demand, new services, and expanding user bases. ITU-Figure T's 3 depicts the network intelligence pillars needed to implement a certain level of AI in workflow operations (planning, dimensioning, etc.). As a result, the intelligence of the workflow necessitates large data sets, such as demand mapping (forecasting for the future years) and a continuous collection of significant data volume for optimization activities over the network's life cycle. For AI to make good decisions and provide valuable results, it has to be supported by intelligent subsystems that can digest and make sense of large amounts of data. Zero-Touch Network and Service Management (ZSM) for self-optimizing and self-repairing networks with varying degrees of control and management complexity. There are three scenarios in which ITU-top T is used, and they are as follows:

• High-reliability performance guarantee and economical radio resource use. The network should provide continuous data gathering, network slice behavior analysis, and resource use trends.

Automating application service needs to network parameters. Big data sets are needed again. Thus, networks must allow data models for service needs and automated network setup.

• Predictive detection, root cause investigation, and automated recovery decisions. Real-time performance data and testing-environment-generated training data are needed.

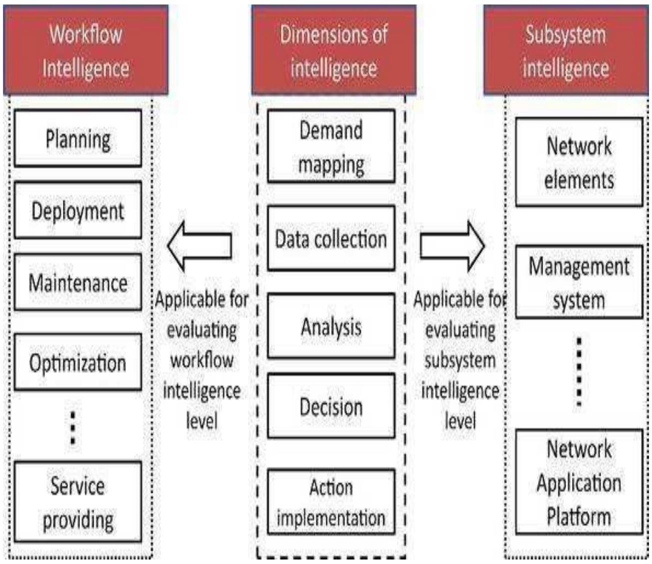

Figure 3: intelligence pillars required in the network

However, moving to a fully intelligent network will be difficult. Thus, ITU-U has classified network intelligence into five dimensions (Table 2). The network operator sets its strategy by prioritising investment, new services, etc. The operator must attain "L5: Full Intelligence" in all five dimensions to fully profit from AI. Telcos must also align migration with business strategy and ROI.

A. AIML planning and optimization process for network performance:

Technical and financial success depends on how well the initial design of a mobile network is thought out. The performance of a network that has been inadequately sized requires continual and extra control and management operations. Infrastructure, spectrum, parameters and configuration settings, energy consumption, network capacity to fulfil worst-case scenarios, bandwidth demand development over time, etc., are all factors that must be considered. The development and rollout of a 4G LTE mobile network will not be a "greenfield" endeavour. The point-of-presence, base station, optical fibre for critical network components, data centre, etc., should all be accounted for in this planning endeavour.

Artificial intelligence (AI) may assist manage complexity and provide efficient solutions in the difficult optimization problem of network planning when several input parameters are uncertain random variables or distributions. Integrating AI into the planning process is shown in Figure 4 [1]. Automated learning module:

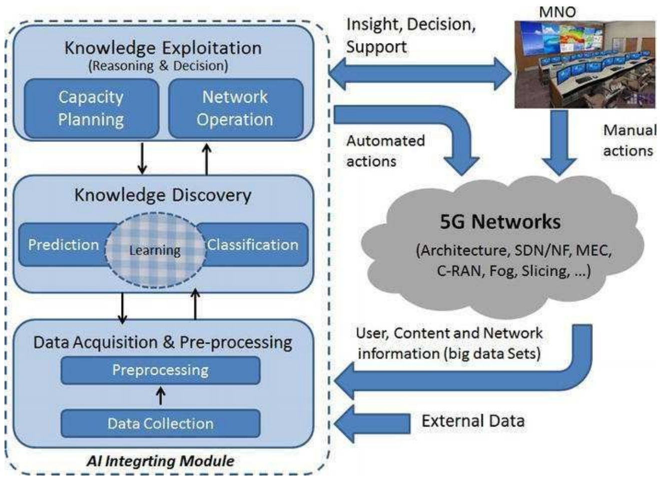

Figure 4: AI integration in planning.

• **Data collection and scrutiny Processing:** Mobile Network Operators (MNOs) use a wide variety of systems, such as Operation and Management Systems (OMS), invoicing systems, inventory, network components, Customer Relationship Management (CRM) systems, etc., all of which generate complex, disparate sets of data containing crucial information. To create high-performing mobile networks in the future, MNOs will need to deploy effective big data solutions to merge all relevant and profitable data sets. Artificial intelligence-based planning systems should thoughtfully investigate and connect several data points. To effectively manage data, it is necessary to collect, clean, filter, connect, and uncover what it is you're looking for.

• The network's efficiency may be improved by discovering new information such as traffic and congestion hotspots, user habits, resource allocations, quality of service, potential future sites, and issue or defective nodes. At this point, the network should be able to analyse its performance and quality of experience, find anomalies, optimise itself, predict its performance, disruption, and needs, and carry out several management and operation tasks automatically, including self-configuration, self-optimization, and self-healing.

• Utilizing the gleaned information (time/frequency/spectrum analysis of traffic patterns, user behaviour recognition, etc.) to determine the next steps for a network element or configuration. These measures may address systemic issues or boost performance in response to changes in the operational environment. Therefore, here, we manage slicing, virtualization, edge computing, network growth and resource use strategies, and corrective actions.

B. AIML development with network management system:

4.5G operators faced an exponentially expanding number of end devices, especially in M2M and NB-IoT LTE, as demand for capacity and coverage increased. Thus, regardless of access technology, AI integration in mobile architecture (4Gor 5G). presented a functional architecture for AI integration toutilise and support SDN, NFV, and network control/monitoring. The authors suggested a future intelligent network framework (FINE). Intelligence, agent, and business planes comprise the framework architecture.

Figure 5 shows how the intelligence plane, the framework'sbrain, integrates AI into SDN/NFV and network management. Thus, FINE is an AI-powered network. The intelligence plane comprises basic, core, platform, application/terminal, and solution layers.

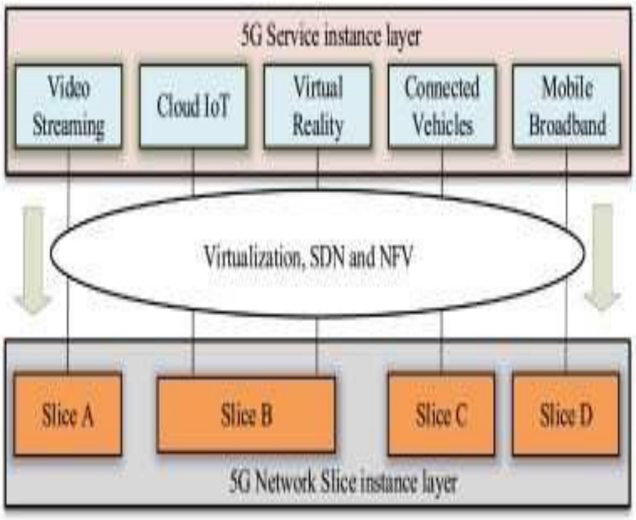

Figure 5: , integrates AI into SDN/NFV and network management

IV. Conclusion:

Network operators provided 600 Mbps mobilebroadband after establishing 4G networks. However, service and subscriber demands for improved quality have grown to unprecedented levels. Internet of cars and virtual reality need ultra-reliable connections and minimal latency. Mobile network providers began 5G migration due to this. Through a new radio interface, massive MIMO, beamforming, etc., 5G reached bit speeds of 1Gbps. However, operators must also develop network intelligence to understand their operational environment more and foresee its evolution to maximise resource consumption and adapt and configure automatically to handle the vast range of services. We demonstrated this in this chapter by integrating artificial intelligence and machine learning. We highlighted intriguing use cases that enable operators to design self-healing and self-upgrading networks.

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