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IMPACT OF AI ON CUSTOMER EXPERIENCE IN TELECOM INDUSTRY

STANDARDIZING RESPONSIBLE AI IN TELECOM: ENSURING FAIRNESS, ROBUSTNESS AND TRUSTWORTHINESS

6G USAGE SCENARIOS AND KEY CAPABILITIES

Dear Readers,

Wish you a Very Happy and Prosperous New Year 2024 with renewed hopes, aspirations and commitment to excellence.

I feel very happy while presenting this issue of "Telecommunications" journal focused on Artificial Intelligence and Machine Learning. Artificial Intelligence (AI) has become a crucial tool in managing and optimizing networks. Telcos across the globe are realizing new levels of operational efficiency, improved customer experiences, optimized network operations and cost savings by adopting Generative AI, AI and Machine Learning.

Various aspects related to AI and Machine Learning, Standardization of Responsible AI in Telecom, Use cases of AI in 5G, Application of AI in Detecting Fraudulent SIMs etc. have been discussed in this issue. Also 6G Usage Scenarios and Key Capabilities, ORAN Architecture & Interfaces and the ChatGPT Connection have been covered.

I am sure this issue of "Telecommunications" journal would provide an understating of latest trends of AI in Telecommunications and give an insight on these topics. I greatly appreciate the contributions by authors who have put in efforts to elucidate such advanced subjects in a very simple manner.

Looking forward for continued efforts towards excellence in emerging telecom technologies.

(Saurabh Gupta)
Chairman
Telecommunications Journal

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IN THIS ISSUE

IMPACT OF AI ON CUSTOMER EXPERIENCE IN TELECOM INDUSTRY – A BSNL'S PERSPECTIVE

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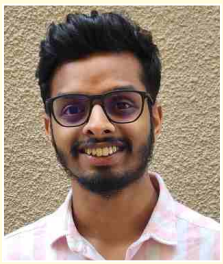
Has participated in National and International conferences as Delegate, Keynote Speaker, Chair and Panelists of both Technical and Management Areas. He had participated in the Work Group Meetings as a member of various Study Groups and Work Groups of International Telecommunications Union (ITU). He has been a part of the Indian Delegation to various forums including Ministerial Conferences, ITU Cross Regional Seminars, Training Testing & Validation teams, Evaluating Networks and Systems teams.

Has published papers on the National, International journals on various technical & management topics including the Technology, Standards, National Policy, Various Services, Planning & Rolling-out Networks for both Urban & Rural Needs, Implementation Methodologies & Deployment Strategies, Principle and challenges, QoS, Network Security & Cyber Security, IPv6, Interoperability and on Block Chain etc.



Andhan Rahul Buddhan commenced his academic journey as a master's candidate in Mathematics from IISER (Indian Institute of Science and Research) Trivandrum. After establishing a robust foundation in Mathematics & Physics, he has accumulated a year of dedicated experience in the field of Cyber security at CDAC (Centre for Development and Advance Computing) and at IISER. He has contributed to the cutting edge research in the field of Science, Mathematics, Artificial Intelligence and Cyber Security. He has published papers in the National and International journals.

The topics includes: Even Driven Multimodal Augmented Reality based Command and Control Systems for Mining Industry, Exploring Vertical Gardens for environment protection, Exploitation of Mathematical Models for identifying the shortest metrics to reach paths.

An industry which is steadily growing in terms of customer base, technology, services being offered, providing support to all other fields and sectors is the Telecom Industry. It not only exploits various technological advancements and grows exponentially but also is well received by the customers and citizens. Telecom industry world over has been evolving and so is the expectation from the customers. Once a Luxury has become a necessity to the extent that it is being considered as a part of the basic needs of living. In this competitive era, the Telecom, IT, ICT is being viewed as a complete solution for various issues. Under this context, the customer looks for an uninterrupted fault free service which is operational round the clock and remains always online ensuring the continuity of the business all across the globe. Service support plays an important role

Deploying latest state-of-the-art technology

platforms, making better models and packages and Working out best solutions is not just sufficient but the customer service and customer experience is the importance of customer service. Generally, customer service is looked at as an interaction between the buyer and the seller of product & services. Customer service is the one which starts even when the customers are not knowing about it. The customer service is any support and assistance that is provided to the customer, right from the initial interaction / engagement and till the end of the life – not just the product or service. Customer service is not just being a support platform for the customer but being a part of the customer in enjoying the service along with each and every interaction.

The coming of CORONA and the deployment of various technological solutions like AI, ML, IoT, Big Data etc. has changed the way the customer service is being implemented nowadays. Earlier, there was a need to have a person for all issues, who will call and interact with the customer to resolve their issues and provide guidance. Now many customers are finding comfort in IVRS/ Chatbots/ Virtual Assistants where somebody is resolving the issue, not necessarily the involvement of a person to attend to their queries. Though the innovations have been brought into each and every step of customer service, customer experience and the journey which are aimed at automating / optimizing customer service platforms, in some cases, the need for the human is indispensable.

Even the SMEs and Large Corporate should have a better customer service experience plan such that they take care of the customer needs proactively and ensure the utmost satisfaction of customers. The small shops and the street vendors do have a fixed customer base because of their attention to customers and their needs. With very few products they add value to their service delivery measures and they lure the customers utilizing any one or multiple methods of customer interaction. The purpose of customer service started from

- Effective interaction with customers,
- Answering queries and questions satisfactorily
- Registering & Resolving grievances
- Pursuing with the concerned to resolve the issues
- Continuously pursuing with employees till complete resolution
- Updating the knowledge base and
- Providing support system to customers for taking appropriate decisions
- Periodically updating the customers with various alternatives and new initiatives.

According to the Zendesk Customer Experience Trends Report 2023, the customer service initiatives play a vital role in customer behavior

Figure1 : Zendesk customer experience Trends Report 2023

- 66% of consumers who often interact with support staff said a bad interaction with a business can ruin their day, while 73% of those consumers will switch to a competitor after multiple bad experiences.
- 73 percent of consumers will leave for a competitor after multiple poor interactions, and more than half will bolt after a single bad

experience. Make it two negative experiences, and 76 percent of customers are out the door.

- 81% of business leaders see customer experience and support as growing priorities over the next year.
- 77 percent of business leaders recognize, deeper personalized service experiences lead to increased customer retention.
- 66 percent of business leaders believe deeper personalization lowers acquisition costs.
- Reduces costs: 60 percent say it keeps customers coming back.
- Increases revenue: 60 percent of consumers have purchased something from one brand over another based on the service they expect to receive.

Considering the importance of Customer Service, Customer Experience and Customer enrichment there is a tool getting popular in the name CX Tool which is more focused and designed to give all the parameters, key performance indicators, QOS indicators and other such guidelines which are issued from time to time from the Government and related agencies.

In every industry, customer experience, or CX, is a key instrument for gaining a competitive edge. It is a comprehensive interactive process that creates distinct, enjoyable, or unpleasant memories. It is aided by cognitive and emotional cues, tempered by consumer and contextual factors. Part of the challenge in building memorable CX is that experience is an intangible quality that is so different from one person to the next.

The Evolution and Impact of Customer Service

In the initial days, even for establishing a call, the customer had to call the operator/Customer Service Representative even to make a call to another party. The customer has to inform the operator about the called party to whom they desire to talk and the connection will be put through by the Operator, who will disconnect the connection after both the parties have terminated their communication. From there, we have gone into Analog Switching then to Digitial Switching technologies. The technology has been evolving and has given rise to the switching of calls digitally anywhere across the globe both voice and data (IP). It has branched from voice to data, wireline to wireless, narrow band to broadband and ultra band communication, copper to fibre over a period of time. Now the service provider has multiple options to reach the desired customer and to communicate with them. As the technology has been changing in Switching, Transmission, Networking areas the customer service was also evolving over a period of time.

Customer service plays a pivotal role in shaping a business success. Customer experience encompasses each and every interaction of a customer with a business entity right from accessing the portal till the delivery of the customer service support. The customer service can be provided through various channels which includes Over Phone, Fax, through Messaging Systems like SMS, Email, Chat applications like Telegram, WhatsApp, SnapChat, Instagram etc, Social Networking platforms like facebook, twitter, Online web sites, Self care portals, FAQs / Knowledge base etc. Apart from these the live chat platforms and providing relief / resolution in person makes a good impact as well. All the channels should be effectively utilized to reach the customer and provide a better experience to the utmost satisfaction of customers. Through the implementation of AI-powered algorithms, businesses can utilize predictive modeling and machine learning to personalize

customer interactions, predict customer needs, and provide tailored solutions. It can significantly impact brand loyalty, customer retention, and overall business performance. The service providers face lot of challenges in providing better customer service to the needy demanding customers. Providing excellent customer service, on the other hand, can help your business to:

- Run the business effectively
- Generate revenue
- Provide a sense of satisfaction to the stakeholders
- Ensure the longevity of the customers
- Generate more business ambassadors
- Increase brand Loyalty
- Have an edge over the competitors

Components of the Customer Experience Process.

The customer service is defined by the way the customer is treated by the service provider at all times. Customers want to resolve their problems yesterday and without any excuses. Though the occurrence of a problem / complaint shall be new or the first of its kind, the customer wants a better service with stringent Service Level Agreements. Delivery of good customer service that keeps your customer coming back requires certain characteristics.

i. **Personalization:** It is no secret that customers prefer to be regarded as real humans rather than just numbers in a queue. In order to retain customer loyalty, you need to be able to provide them with customized experiences. Data research, consumer segmentation, and targeted marketing initiatives can all help create personalization.

ii. **Empathy:** Empathy is the ability to place oneself in the position of your clients. You want to empathise with their suffering, consider things from their viewpoint, pay attention to their worries, and, if needed, extend compassion. Consumers are astute; they may detect indifferent customer service from a distance and choose to stop using the good or service as a result.

iii. **Responsiveness:** In the business world, time is a very valuable currency. It can be incredibly frustrating to have to wait hours or days to receive a response for a straight forward problem that might be fixed in ten minutes. Being prompt is essential since it improves your clients' experiences overall the faster you are able to resolve your customers' issues, the better their experience.

iv. **Product knowledge**: Excellent customer service agents are well-versed in their products, and as such, you should be prepared to field a wide range of inquiries about them. Your clients must feel confident that they have access to a guide who can help them with any queries or problems they may have with the product.

v. **Professionalism:** It's important to maintain a professional demeanor at all times. This implies treating clients with decency as well as with respect and courtesy. It also entails maintaining composure, being kind, patient, and productive, particularly when interacting with irate or disgruntled clients.

Figure 2: Components of Customer Experience Process

How can we make use of AI ?

Artificial Intelligence being a very strong and powerful tool might tempt one to use it to solve dozens or even hundreds of problems at the

same time. However, the best results will be obtained on tackling the issues that will have the greatest impact on customer experience. Strategically selecting the right forms of AI to be implemented in their products and services becomes the smartest way and fastest way to grow.

AI can provide solutions in two simple but broad categories

Automation tasks: for such tasks models can be used to automate burdensome and repetitive tasks, which can save on the human resource. For example, chatbots or robotic automation can be used to free up customers from wait times, which also reduces load on employees.

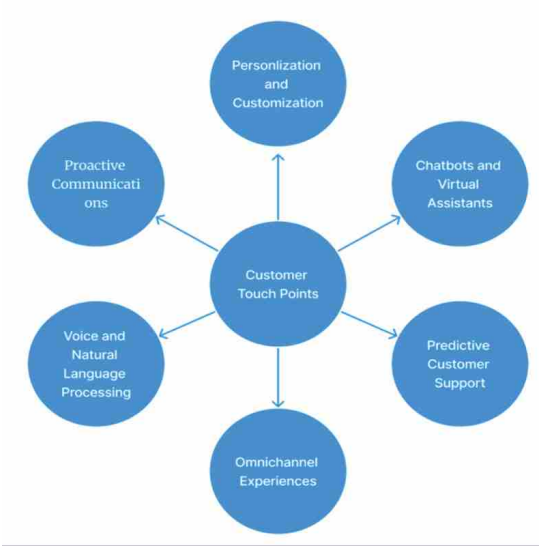
Predictive or cognitive tasks: these tasks require a more advanced intelligence and can be used to better understand the users quarries to be helpful alongside. Like, predicting which accounts and contacts are most likely to influence and buy.

AI Applications	Automation Tasks	Benefits- Instant support
Customer Service Chatbots	AI handles routine queries related to billing, account information, and troubleshooting.	- Reduced response times - Improved customer satisfaction - Cost-effective customer service
Automated Billing and Payments	AI automates billing processes, generating accurate bills, and handling transactions.	- Reduced billing errors - Seamless payment transactions - Improved billing accuracy-
Network Management and Optimization	AI automates the monitoring and management of network infrastructure.	- Real-time issue resolution - Enhanced network reliability - Minimized service disruptions
Automated Provisioning of Services	AI streamlines the process of activating, modifying, or deactivating services.	- Faster service provisioning - Improved accuracy in service activation - Enhanced operational efficiency
Troubleshooting and Diagnostics	AI automates the troubleshooting process, helping customers resolve common issues.	- Self-service issue resolution - Reduced dependence on customer support for routine problems - Improved customer empowerment

The predictive / Cognitive tasks along with benefits are listed below:

AI Applications	Predictive/Cognitive tasks	Benefits- Instant support
Customer Experience Analytics	AI analyzes interactions, feedback, and data to predict and improve customer satisfaction.	- Data-driven decision-making - Improved understanding of customer needs - Enhanced customer loyalty and retention
Predictive Maintenance	AI predicts potential faults or issues in telecom infrastructure for proactive maintenance.	- Reduced service outages - Improved network reliability - Minimized downtime
Personalized Service Plans	AI analyzes customer usage patterns to recommend personalized service plans.	- Tailored packages for individual needs - Increased customer satisfaction - Improved upselling opportunities
Fraud Detection and Security	AI algorithms predict and detect patterns indicative of fraudulent activities.	- Enhanced security for customer accounts - Detection and prevention of fraudulent activities - Protection of sensitive customer information
Network Capacity Planning	AI predicts future network usage for optimal capacity planning.	- Improved network performance - Prevented congestion during peak times
Voice and Natural Language Processing	AI-driven voice recognition and natural language processing in customer support.	- More natural and efficient interactions - Voice-activated services for enhanced user experience - Improved accessibility for customers

How can AI change the way the customer touch points are being conceived, deployed and implemented?



Artificial intelligence (AI) has considerable potential for revolutionising the design, implementation, and management of client touch points across a range of industries, including telecommunications. Here are a few ways AI may affect consumer interactions:

❑ **Personlization and Customization:**

- Artificial Intelligence (AI) analyses individual preferences, behaviours, and past interactions to enable the creation of highly personalised touch points. This results in the deployment of personalised offers, communications, and recommendations via AI-driven systems, giving clients a more personalised and interesting experience. In order to improve the entire customer journey, the implementation phase makes sure that real-time personalisation happens at every customer touch point.

❑ **Chatbots and Virtual Assistants**

- AI-driven chatbots and virtual assistants are another significant aspect of this transformation. These technologies are designed to respond instantly to common customer inquiries. Customers can interact with them seamlessly and quickly because they are available on various platforms, including messaging apps, websites, and mobile apps. Chatbot deployment increases customer touchpoint efficiency and results in a more responsive and intuitive user experience.

❑ **Predictive Customer Support**

- AI models predict potential issues before they occur, influencing the deployment of proactive customer support strategies and resource allocation. As a result, overall service reliability and customer satisfaction are enhanced. In reality, telecom companies can handle possible problems before customers encounter disruptions.

❑ **Omnichannel Experiences**

- With AI there is a seamless customer journey across various touch points and channels. AI synchronisation ensures consistency in customer interactions whether they take place in-store, on websites, through mobile apps, or on social media. This strategy is used to give clients a consistent and integrated experience through a variety of channels.

❑ **Voice and Natural Language Processing**

- Conceived to redefine how customers interact with telecom services, these technologies are deployed across touch points to create voice-activated systems and intelligent assistants. In implementation, customers engage with services using natural language, making interactions more intuitive and user-friendly.

❑ **Proactive Communications**

- The implementation of proactive communication strategies is influenced by AI models that forecast communication preferences and the best times to engage customers. Clients receive pertinent and timely communications—such as alerts, updates, and tailored offers—which improves client happiness and engagement.

Various models of AI which can make an impact?

Sl. No.	Computing Model	Description	Benefits	Challenges
1	MachineLearning (ML)	Utilizes algorithms to analyze customer data, predict preferences, and personalize interactions.	Personalized recommendations Predictive customer service Improved target in	Data privacy concerns Model interpretability challenges Data quality and bias issues
2	Natural Language Processing (NLP)	Enables computers to understand, interpret, and generate human language, enhancing chatbots and customer support systems.	Personalized recommendations Predictive customer service Improved target in	Data privacy concerns Model interpretability challenges Data quality and bias issues
3	Predictive Analytics	Analyzes historical data to identify patterns, allowing businesses to foreseecustomer behavior and preferences.	Anticipatecustomer needs Improveproduct offerings Reducec hurnrate	Data integration complexities Prediction accuracy limitations Changing customer behavior patterns
4	Data Mining	Extracts valuable insights from large data sets, helping businesses understand customer behaviors and preferences.	Identify market trends Optimize marketing strategies Customer segmentation	Data preprocessing challenges Scalability issues Extracting relevant information from vast data sets
5	Recommender Systems	Suggests products or services based on user behavior, enhancing cross-selling and upselling opportunities.	Increased sales- Personalized product offerings Enhanced customer experience	Cold start problem (new users/items) Over-reliance on past preferences Limited diversity in recommendations
6	Social Media Analytics	Analyzes social media datato gauge customer sentiment, preferences, and trends, informing marketing strategies.	Real-time feed back Improved social engagement Competitive analysis	Data privacy and security concerns Handling unstructured data- Identifying genuine sentiment from noise
7	Augmented Reality (AR) and Virtual Reality (VR)	Offers immersive experiences, allowing customers to interact with products/services before purchasing.	Enhanced customer engagement Interactive product demos Novelty factor	High development costs Hardware and software compatibility Limited use rad option and awareness
8	Blockchain Technology	Provides transparent, secure transactions, fostering trust and loyalty by ensuring the integrity of customer data	Enhanced data security Trustworthy transactions Immutable customer records	Scalability challenges Energy consumption concerns Regulatory and legal hurdles in certain regions
9	Chatbots and Virtual Assistants	AI-powered chatbots and virtual assistants handle customer inquiries, improving response time and availability.	24/7customer support Quick query resolution Cost-effective customer service	Limited understanding of complex queries Integration with existing systems User experience challenges
10	Emotion AI	Recognizes and responds to human emotions, allowing personalized and empathetic customer interactions.	Empathetic customer service Personalized emotional responses Enhanced customer satisfaction	Ethical considerations Recognition of emotional nuances User acceptance and privacy concerns
11	Internet of Things (IoT)	Connects physical devices, collecting real-time data for personalized services, predictive maintenance, and customer insights.	Personalized product experiences Proactive issue resolution Efficient resource management	Security vulnerabilities Data privacy challenges Interoperability issues between devices and platforms

Human-Machine Collaboration Models

While the models discussed earlier all have their respective impacts in different sectors of Customer Experience. One model that makes the transition from AI support to Human support

more approachable to the customers are human-machine collaborative models which represent a synergy between Artificial intelligence systems and human expertise. These models leverage the strengths of both humans and machines to achieve superior outcomes. Here are some examples:

i. Interactive Virtual Assistants:

- **AI-Driven Initial Interaction:** Virtual assistants powered by AI handle initial customer inquiries, providing quick and automated responses.
- **Human Escalation:** When queries become complex or require a more nuanced understanding, the virtual assistant seamlessly escalates the conversation to a human customer service representative.
- **Benefits:** Quick response times for routine queries.Efficient use of human resources for handling complex issues.Enhanced customer satisfaction by AI and human support.

ii. Personalized Service Recommendations:

- **AI Analytics for Usage Patterns:** AI analyzes customer usage patterns and preferences to suggest personalized service plans.
- **Human Verification and Customization:** Telecom representatives validate AI recommendations and work with customers to customize plans based on individual needs.
- **Benefits:** Tailored services that match individual preferences. Human touch in fine-tuning recommendations for a more personalized customer experience. Increased customer satisfaction and loyalty.

iii. Predictive Customer Support:

- **AI-Driven Issue Prediction:** AI predicts potential service issues based on historical data and network performance.
- **Human Intervention for Proactive Support:** Customer service teams use AI predictions to proactively address potential issues and provide assistance before customers experience service disruptions.
- **Benefits:** Proactive customer support to prevent issues. Improved customer perception through anticipatory assistance. Minimized service disruptions for enhanced customer satisfaction.

iv. Voice and Natural Language Processing:

- **AI-Enhanced Voice Recognition:** AI systems improve voice recognition for customer interactions.
- **Human Review and Fine-Tuning:** Human operators review and fine-tune AI-transcribed voice interactions, ensuring accuracy and understanding of customer requests.
- **Benefits:** More natural and efficient voice interactions. Continuous improvement through human feedback and refinement. Enhanced accessibility for customers using voice-based services.

v. Customer Feedback Analysis:

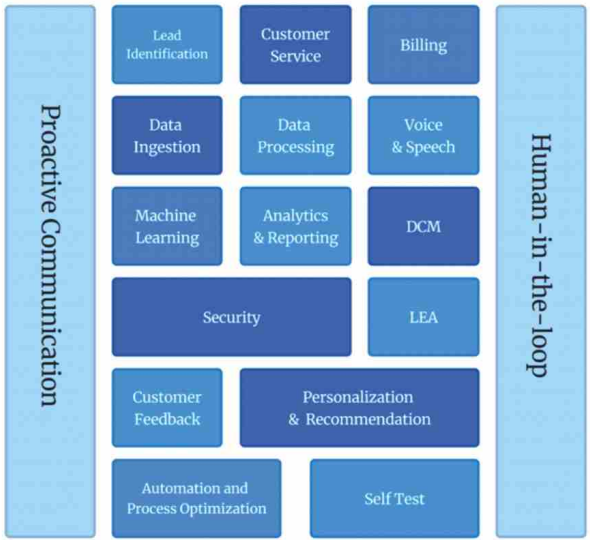
- **AI-Based Sentiment Analysis:** AI tools analyze customer feedback across various channels.
- **Human Interpretation and Action:** Human teams interpret sentiment analysis results, identify key areas for improvement, and implement changes to enhance the customer experience.

- **Benefits:** Insights into customer sentiment for data-driven decision-making. Human understanding of context and emotions for more nuanced improvements. Improved overall customer satisfaction.

vi. Human-Machine Collaboration in Service Outages:

- **AI Detection of Network Issues:** AI systems detect potential network outages or disruptions.
- **Human Coordination and Communication:** Human teams coordinate response efforts, communicate with affected customers, and provide updates during service outages.
- **Benefits:** Quick identification and response to network issues. Clear and transparent communication during service disruptions. Minimized impact on customer experience through efficient collaboration.

How can an Organization like BSNL make the best use of AI and its model



Artificial Intelligence STACK for Telecom Service Provider (BSNL):

i. **Lead Identification Layer:** This layer focuses on collecting and analyzing data related to the demographics of potential customers. This information is what will be used in targeted marketing, personalized services, and understanding the characteristics of the customer base. This layer would include packages like Demographic Data Collection Systems, Lead Scoring Algorithms and Geographic Information Systems to name a few.

ii. **Data Ingestion Layer:** This layer collects customer data from various sources, preparing it for processing and analysis. This layer would work with datasets dealing with Customer Interaction data, Billing Information, Network Performance Data

iii. **Data Processing and Storage Layer:** This layer processes and stores the ingested data for analysis and future reference. A few software are Hadoop and Spark for Big Data Processing, Amazon Redshift, Google BigQuery for Data Warehousing.

iv. **Machine Learning Models Layer:** The Machine Learning Models Layer incorporates AI models for predicting customer behavior, personalized recommendations, and other predictive analytics. Some Models that might prove beneficial are Churn Prediction Models, Sentiment Analysis Models, Customer Segmentation Models.

v. **Customer Service Implementation/ Deployment Layer:** The Customer Service Implementation/Deployment Layer is responsible for translating insights from customer inputs and model analyses into actual services and responses. This

layer ensures the deployment of services aligned with customer requirements and model recommendations. Some components present in this layer would deal with service deployment, customer interaction, workflow automation

vi. **Billing Layer:** The Billing Layer manages financial transactions, invoicing, and ensures accurate billing for telecom services. Billing systems, invoicing platforms, revenue assurance tools would contribute in this layer

vii. **Analytics and Reporting Layer:** The Analytics and Reporting Layer focuses on tools for analyzing and reporting insights from customer data, network data, billing data etc.

viii. **Chatbot and Virtual Assistant Layer:** This layer includes the AI-driven conversational interfaces used for customer interactions. NLP models and Dialogue Management systems would serve useful here.

ix. **Predictive Customer Support Layer:** This layer focuses on AI models predicting and preventing customer issues before they occur. Some predictive maintenance models and Anomaly detection models

x. **Personalization and Recommendation Layer:** AI models like Recommendation Engines and Dynamic Pricing Models present in this layer provide personalized service recommendations to customers.

xi. **Voice and Speech Recognition Layer:** This layer integrates AI models for voice recognition and processing. Voice Biometric Models and Automated Transcription Models are present in this layer

xii. **Customer Feedback Analysis Layer:** This layer involves AI-driven sentiment analysis to gauge customer feedback. Text Analytics Models and Emotion Recognition models are a part of this.

xiii. **Automation and Process Optimization Layer:** This layer includes AI tools-like Robotic Process Automation and Automated Billing and Tranaction Systems- for automating processes and optimizing workflow.

xiv. **Self-Test Layer:** The Self-Test Layer includes components that autonomously assess the performance and accuracy of AI models and systems.This layer takes care of all the tests to be conducted on the CPE, Access Network Elements, Core Equipments, Servers, Applications and other platforms which are used to provide service to customers. Model Evaluation modules, Continuous Monitoring Systems and Automated Testing Frameworks perform checks on the stack to evaluate Performance as per various protocols and standards based on which service is provided.

xv. **Human-in-the-Loop Layer:** The Human-in-the-Loop Layer involves human validation, review, and intervention where necessary. Customer service agents, Human review of AI-generated insights this kind of integration ensures that we maintain enough human feel in our customer service so as to not feel too robotic.

xvi. **Proactive Communication Layer:** The Proactive Communication Layer includes AI models predicting optimal communication strategies for proactive

customer engagement. AI-Driven Communication Platforms and Automated Notification Systems are active components in this layer

xvii. **Security Management Layer:** Security Management Layer includes the AI models analyzing the security available threat landscape and providing guidance to meet the security compliances from various agencies and guidelines issued from time to time. Working out models and implementation methodologies for complying to all the security guidelines along with alerts and conformances.

xviii. **Law Enforcement Co-ordination Layer:** Law Enforcement Co-ordination Layer includes the AI models which will identify the log generators, IPDR generators, Mediation validators, Record generators and verifiers for the format and the value of the data records. Will generate alarms and notifications in case of any non-compliance.

xix. **Re-Engagement Prompt Layer:** The Re-Engagement Prompt Layer serves as the last component, initiating targeted prompts and messages to reconnect with customers who have disengaged. This layer is designed to rekindle interest, encourage re-engagement, and bring back lapsed customers. This layer and its components are addressed in the next section of this paper

This comprehensive AI stack for Telecom Customer Service Management covers lead identification, data processing, machine learning, customer service implementation, billing, analytics, chatbots, predictive support, personalization, voice recognition, feedback analysis, automation, self-testing, human-in-the-loop, proactive communication, and re-engagement strategies.

Disconnected Customer Management or Loyalty Restoration Program (LRP)

Continuing interaction with disconnected customers, or customers who have disengaged or lapsed in their interactions, requires a thoughtful and strategic approach. Many Companies give different terms to their programs of rekindling a connection with their customers like Disconnected Customer Management, Churn Management. Here are some strategies to re-engage with disconnected customers:

Remember that successful re-engagement requires a customer-centric approach, understanding their needs, and demonstrating the value your products or services can provide. It's essential to be persistent, yet respectful, in your efforts to reconnect with customers.

Effective utilization of AI for DCM / LRP

Reconnecting with disconnected customers using AI involves implementing targeted and

personalized strategies to regain their interest and engagement. Some ways to leverage AI for reconnecting with disconnected customers includes Predictive Analytics, Customer Segmentation, Personalized Communication, Chatbot Engagement, Reactivation Email Campaigns, Customer Journey Analytics, Recommendation Engines, Social Media Engagement, Voice and Speech Analytics, Proactive Communication, win-back campaigns, Customer Feedback Analysis, Machine Learning for Issue Resolution, Dynamic Pricing Models, Continuous Monitoring and Adjustment and Human-in-the loop assistance.

Use predictive analytics to anticipate when a customer might disengage. Employ AI-driven customer segmentation models to categorize disconnected customers based on behavior, preferences, or demographics. Tailor reconnection strategies for each segment. Use AI to analyze historical data, Customer preferences, Behaviour, Customer journey, Optimal timing, Right Channel, Feedback, touchpoints and personalize crafted reconnection messages for Emails, SMS, WhatsApp or other applications. Design Reactivation campaigns with AI driven personalisation. Leverage recommendation engines to suggest products or services based on the customer's past behavior. Offer incentives or promotions to encourage a return. Use AI-driven sentiment analysis on social media platforms to gauge customer sentiments.

Implement machine learning models to predict and resolve potential issues that led to disconnection. Proactively address concerns before customers decide to disengage by using AI driven dynamic pricing models, strategies with human-in-the-loop assistance and address unique concerns to enhance reconnection efforts and make the re-engagement more attractive and heart warming.

Implementing these AI-driven strategies for customer reconnection requires a holistic and customer-centric approach. By understanding individual customer preferences, predicting behavior, and offering personalized incentives, businesses can increase the likelihood of successfully reconnecting with previously disconnected customers.

Conclusion

In the contemporary business environment, incorporating cutting-edge technologies like Artificial Intelligence (AI), Internet of Things (IoT), and Big data has emerged as a crucial driver for fostering and maintaining customer loyalty. With technological advancements being the primary driving force for innovations in switching technologies to cloud computing, this paper looks at the ocean of possibilities these technologies bring to the customer's experience. Gathering data in real-time facilitates active involvement, predictive analysis, and the provision of tailored solutions, collectively solidifying customer loyalty. Through the utilization of interconnected devices and systems, enterprises can provide a heightened personalized experience, cultivating robust connections between the brand and the consumer.

Furthermore, by leveraging AI models and techniques, businesses can anticipate customer needs, provide tailored recommendations, and offer timely support,

fostering trust and reliability. AI enhances decision-making and helps companies optimize operations, streamline processes, and provide synchronous support across any touch point the customer may choose. This study touches on the potential Big Data brings with its pattern identification and trend predictions, enabling more informed decision-making that resonates with the customer base.

Moreover, this study touches upon an integral aspect of customer service that must not be lost: the human component. This will ease the transition and help those less familiar with technology. This report also investigates an active application concerning the organization BSNL, where a thoughtful and thorough STACK has been devised. The comprehensive analysis underscores the critical role of AI, IoT, and Big Data technologies in strengthening customer loyalty and satisfaction. Finally, this paper is a stepping stone for many ideas that may sprout into more extensive projects; all the AI models are theorized and can each bring value to the overall experience.

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STANDARDIZING RESPONSIBLE AI IN TELECOM: ENSURING FAIRNESS, ROBUSTNESS AND TRUSTWORTHINESS

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The telecom sector's rapid adoption of Artificial Intelligence (AI) brings forth critical considerations regarding its responsible use. This article delves into the evolving role of AI in telecom, associated risks, and the pressing need for responsible AI practices. It highlights key attributes such as fairness and robustness, and emphasizes the necessity for standardized assessments in the telecom sector to ensure AI's responsible and reliable implementation.

AI and ML have gained significant traction across diverse domains, including Healthcare, Agriculture, Smart Cities, and Finance. Government entities also apply AI/ML for public services. The integration of AI technologies is leading to a profound transformation in the telecommunications industry. In the telecom sector, AI plays a growing role in all upcoming technologies.

Artificial Intelligence is increasingly being used in telecom, from real-time autonomous decision-making to recommender applications. In the future networks such as IMT-2030 (popularly referred to as 6G), satellite broadband, drone communication, smart optical networks, Metaverse, etc., AI will play an increasingly important role. The Bharat 6G Vision Statement [1] includes the term "intelligent," and the Vision document refers to "intelligence/intelligent" in the context of AI/ML at almost 70 places. The IMT- 2030 Framework Recommendation recently finalized by ITU-R [2] includes "AI and Communication" as one of the six Usage Scenarios of 6G. It also includes "Ubiquitous Intelligence," implying that intelligence will be present in every part of the communication system.

AI has become indispensable for dynamic spectrum allocation optimizations, orchestrating intelligent beam-forming by antennas, RAN intelligence controllers, network slicing and security, ML-aided UAV control, and enhancing network performance to deliver a superior customer experience. However, the rapid adoption of AI in telecom has introduced a new set of challenges.

The deployment of AI in the telecom sector brings with it a host of potential risks, including security vulnerabilities, reliability issues, scalability challenges, bias in decision-making, privacy concerns, data breaches, discriminatory practices, regulatory comp-liance difficulties, and more. These risks have the potential to lead to far-reaching consequences such as service disruptions, customer trust erosion, legal and regulatory complications,

inequality and discrimination, privacy violations, etc. In light of these challenges, the responsible use of AI becomes not just a preference but an imperative.

The pursuit of responsible AI raises fundamental questions: What defines responsible AI, and how can we determine the trustworthiness of AI systems? One approach to establish this trustworthiness is to assess AI based on the inherent risks associated with their use. Another approach involves evaluating critical attributes of AI systems.

However, it is evident that assessment represents a crucial initial step in the journey toward responsible AI. While guidelines outlining the requirements and recommendations for responsible AI have been put forth, they often remain at an abstract level, leaving open the question of which specific measures and methods should be employed to meet them. A notable gap exists in the absence of standardized assessment procedures that can concretize these requirements, making it challenging for organizations, regulators, and users to gauge the reliability of AI applications and systems. This article delves into the pressing need for standardized assessment procedures to ensure the responsible and trustworthy use of AI in the telecom industry.

2. Responsible AI

Responsible AI is an imperative approach that encompasses the design, development, and deployment of Artificial Intelligence systems in compliance with ethical and legal standards. The integration of new technologies like AI/ML, while offering exciting opportunities, also introduces the potential for inaccurate or biased algorithms and unethical AI applications.

Responsible AI is committed to ensuring that AI systems exhibit fairness, robustness, reliability, safety, inclusivity, transparency, and accountability. In India, the National Strategy for Artificial Intelligence [3], in conjunction with approach documents from NITI Aayog, underscores the significance of adopting Responsible AI to cultivate public trust and align with pertinent AI standards and guidelines. National Digital Communications Policy-2018 [4] mandates the synergistic deployment and adoption of AI.

TRAI, in its recommendation on Leveraging artificial intelligence and big data in the telecommunications sector [5], highlights various AI applications in telecom and associated concerns. For example, AI algorithms that curate personalized plans for users may introduce biases, potentially diverting customers toward ill-suited services, thereby increasing the likelihood of them switching to alternative service providers. The OECD's "Recommendations on AI" [6] discuss the principles of Responsible AI, which have found adoption in numerous countries. These principles, also underpinning the G20 AI standards, will serve as the basis for assessing the trustworthiness of AI, encompassing the following:

- **Inclusive Growth, Sustainable Development, and Well-being:** These principles centre around ensuring that telecom technology benefits all, bridging the digital divide, deploying infrastructure responsibly, and enhancing the well-being of individuals and communities through improved access to education, healthcare, and economic opportunities.
- **Human-Centred Values and Fairness:** Human-centred values emphasize prioritizing individual well-being, safety, and dignity. Fairness involves avoiding

discrimination in AI algorithms and service offerings based on factors like race or gender, ensuring fair competition among telecom providers.

- **Transparency and Explainability:** These principles entail disclosing AI use in telecom services, enabling consumers to understand how AI systems are developed, trained, and deployed, and providing information about AI decision factors. This empowers informed choices and fosters trust.
- **Robustness, Security, and Safety:** This principle addresses safety and security challenges, emphasizing AI system resilience, security, and the avoidance of unreasonable safety risks throughout their lifecycle. It highlights the interplay of digital security and safety.
- **Accountability:** In the context of telecom, accountability means providers are responsible for their AI systems and network operations, including addressing complaints, ensuring regulatory compliance, and rectifying adverse effects or biases in AI algorithms. It is about explaining the reasons behind decisions and actions.

Assessing Responsible AI is vital for identifying and addressing potential issues like bias. This process aids organizations within the telecom industry in ensuring that their AI applications adhere to ethical standards, legal regulations, and industry best practices.

Despite the growing recognition of the importance of Responsible AI, there is a distinct lack of universally accepted assessment procedures. This gap presents challenges for organizations, regulators, and users in their efforts to evaluate the trustworthiness of AI. As a result, the need for a standardized assessment procedure has become increasingly urgent.

3. AI Fairness

The integration of AI into existing telecom networks necessitates AI algorithms and models to be fair and unbiased to build trust among customers, a key enabler for rapid AI adoption. AI fairness assessment is vital for detecting and rectifying biases in AI systems, ensuring ethical, non-discriminatory outcomes, and preventing potential harm, legal repercussions, and reputational damage. By prioritizing fairness, these assessments enhance user trust, compliance with anti-discrimination laws, and the reputation of organizations deploying AI technologies.

Fairness assessment is a pivotal step in the development and deployment of artificial intelligence (AI) systems, involving the evaluation of AI algorithms and models' impact on various demographic groups to ensure unbiased and non-discriminatory applications. Its primary objectives include identifying potential biases, promoting equal treatment, and upholding ethical and legal standards in AI systems.

To measure fairness in AI systems, various metrics have been proposed, each suitable for different scenarios. In real-life applications, there may be multiple protected attributes, necessitating the use of multiple fairness metrics for assessment. This abundance of metric values can be confusing for evaluators. Agarwal et al. [7] have introduced two innovative and versatile combined metrics: the Fairness Score and Bias Index for measuring the fairness of supervised learning AI systems. The Bias Index proposed in this paper reveals comparative bias among the various protected attributes within the datasets, while the Fairness Score provides an overall measure of

fairness for the AI system by aggregating all fairness metrics used in the evaluation.

Reference [7] also introduces a standard operating procedure (SOP) for issuing fairness certification for data-driven applications. It offers a framework to operationalize the concept of fairness and facilitate the commercial deployment of such systems."

Standardizing AI fairness rules and benchmarks presents a significant challenge due to the multifaceted nature of AI fairness and its ethical requirements, which vary based on contextual factors, usage cases, the type of AI system, and the presence of biases at every stage of the AI's life cycle. Reference [8] introduces a seven-layer standardized approach inspired by the Open System Interconnection (OSI) model, to address AI fairness comprehensively at every stage. This model divides the AI system life cycle into seven distinct abstraction layers, each corresponding to a well-defined stage in AI model development or usage. It also provides checklists for each layer, examines potential bias sources, and suggests mitigation methodologies.

The 'Standard for Fairness Assessment and Rating of Artificial Intelligence Systems,' developed by the Telecommunication Engineering Centre (TEC) [9], seeks to facilitate bias assessment by establishing a standard procedure for bias assessment and transparent disclosure. This standard is primarily intended to aid developers in assessing their AI systems. It poses essential questions and offers a qualitative measure to determine where a given AI system stands in terms of fairness. This measure also serves as a useful tool for non-experts to gauge an AI system's readiness for deployment. The standard encompasses a framework for examining biases within different components of AI systems, facilitating fairness assessments, and offering a reference scale for comparison. It further delves into various types of AI systems and the potential biases associated with them.

The fairness assessment framework of this standard consists of a three-step approach as shown in fig.1. It includes (1) classifying bias risk within the AI system and identifying contributors to bias, (2) selecting appropriate metrics, thresholds, and benchmark values for bias, and (3) implementing a bias testing mechanism to validate and assess the extent of their impact. Throughout this process, it is assumed that both the auditee and the auditor assess bias concerning the same protected attribute(s). The approach also offers various bias testing methods based on (1) process, (2) metrics and measures, and (3) scenarios.

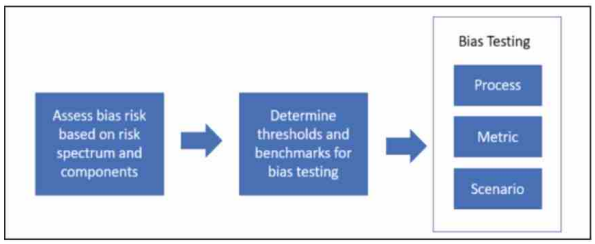

Fig1: Three-step approach to bias assessment

Additionally, the standard defines a structured fairness evaluation outcome report. It also elaborates on three distinct types of report validity: self-certification, certification by a third-party auditing agency, and certification by regulatory bodies such as TEC."

4. AI Robustness

The telecom sector, vital for information exchange and digital transformation, operates within a complex ecosystem driven by AI. Here, the utmost importance lies in robustness, which signifies AI's capability to perform consistently under diverse and unpredictable conditions.

For the telecom networks and digital infrastructure, where connectivity is indispensable, robust AI isn't a luxury; it's a necessity. Developing a Responsible AI standard in telecom is imperative to ensure the robustness and safety of AI/ML systems, encompassing an AI system's response to adversarial attacks, scalability, resilience, safety, and more. Assessing robustness is vital to ascertain the AI system's trustworthiness and responsibility.

While human safety is not typically directly impacted by telecom operations, situations like a loss of service can indirectly affect it. Adversarial attacks on AI systems can disrupt seamless connectivity and even bring down telecom networks. Telecom systems are critical for emergency communications and disaster management.

Autonomous vehicles, for instance, heavily rely on communication for safe operation. AI can enhance network robustness in these scenarios, but the AI itself must be robust. This highlights the necessity for a standardized assessment procedure for AI robustness. Such a procedure allows organizations, users, and regulators to effectively compare AI systems, ensuring the safeguarding of telecom networks against adverse conditions and promoting efficient services and sustainable AI utilization in the telecom industry.

To meet this requirement, TEC is developing a standard for assessing and rating robustness of artificial intelligence systems in telecom networks and digital infrastructure.

5. Conclusion

In conclusion, the integration of AI into the telecom sector represents a transformative leap towards a more connected and intelligent future. While AI brings remarkable opportunities, it also introduces unique challenges, from potential biases in decision making to privacy concerns and security vulnerabilities. Responsible AI, underpinned by principles of fairness, transparency, robustness, and accountability, is the cornerstone of ensuring that these challenges are met with ethical, lawful, and dependable solutions. Standardized assessment procedures are pivotal in achieving this goal, allowing organizations, users, and regulators to evaluate the trustworthiness of AI systems effectively. By fostering the responsible use of AI in telecom, we can not only enhance network robustness but also ensure that AI continues to benefit all of society, bridging the digital divide, promoting inclusivity, and driving sustainable development. As the telecom industry evolves, responsible AI will be the compass guiding us towards a future of connectivity that is safe, secure, and equitable.

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MACHINE LEARNING: IMPORTANT SUBSET OF ARTIFICIAL INTELLIGENCE

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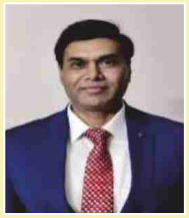


Among other AI (Artificial Intelligence) tools, Machine Learning (ML) has emerged as a transformative force, revolutionizing industries, and reshaping decision-making processes. In this article, we provide a comprehensive analysis of the foundations, advanced techniques, realworld applications, challenges, and ethical considerations of machine learning. To demonstrate the practical impact of this rapidly evolving field, we provide examples of prominent ML algorithms and case studies.

Artificial intelligence (AI) has witnessed unprecedented growth and has become an integral part of every aspect of modern life. One of the most important advances in AI has been the development of Machine Learning algorithms. Machine Learning algorithms allow AI system to learn from the dataset without being explicitly programmed. As a result, AI system can be trained to perform tasks by simply providing the data from those tasks. Machine learning has driven industries to new heights through regression analysis, outcome prediction, classification, and filtering. Artificial intelligence (AI) is a broad field of computer science that deals with the creation of intelligent agents, which are systems that can reason, learn, and act autonomously. Machine learning (ML) is a subset of AI that focuses on the development of algorithms that can learn from data without being explicitly programmed. In other words, AI is the goal of creating intelligent machines, while ML is a set of tools and techniques that can be used to achieve that goal. ML algorithms can be used to train AI systems to perform a wide range of tasks, such as image recognition, natural language processing, and fraud detection. Deep learning and ethical AI too have foundations ingrained to Machine learning. As a result of ability of Machine Learning to extract patterns from data autonomously, it has found applications in a wide variety of industries. The purpose of this article is to provide a comprehensive review and analysis of machine learning as a tool of Artificial Intelligence (AI), shedding light on the significance and practical applications of this technology.

2. FOUNDATIONS OF MACHINE LEARNING

2.1. Supervised Learning

Supervised learning involves the training of models using labelled data to predict outcomes. A fundamental algorithm in this category is the Support Vector Machine (SVM), which is widely used for classification tasks. For instance, in medical diagnosis, SVMs help identify diseases based on patient data. In service industries, this is used for classification of services as highly satisfactory, satisfactory, not satisfactory etc. Regression models like linear models, logistics regression etc forms a part of supervised learning.

2.2. Unsupervised Learning

Unsupervised learning encompasses clustering and dimensionality reduction techniques. The K-Means clustering algorithm

is a prominent example, applied in customer segmentation for marketing strategies. Principal Component Analysis (PCA) is widely used for dimensionality reduction. PCA has wide use in such industries where data with numerous features are produced and processed to predict the target outcome.

2.3. Reinforcement Learning

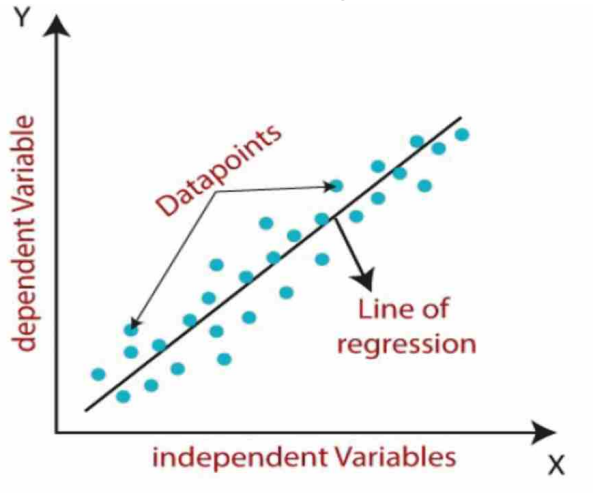
Reinforcement learning model is an advance learning model that uses algorithms like QLearning to enable machines to learn through interactions with an environment. This approach powers autonomous systems like self-driving cars. This model is used in automotive system functions and control.

2.4. Machine Learning Models

Machine learning models are computational algorithms and statistical techniques that enable computers to learn from the training data and make predictions or decisions based on learning and validation. These models form the foundation of machine learning and are used across various applications and industries. Below we will explore some common types of machine learning models:

2.4.1. Linear Regression

This is the simplest model which uses the mean squared error method for regression tasks. The model is trained on the available dataset to predict the outcome. This model establishes a linear relationship between input features and a continuous target variable.



The linear model can be represented as: $y=\beta0+\beta1x1+\beta2x2+\ldots+\beta nxn+\epsilon$

Here, y is the predicted outcome (dependent variable).

x1, x2,...,xn are the input features (independent variables).

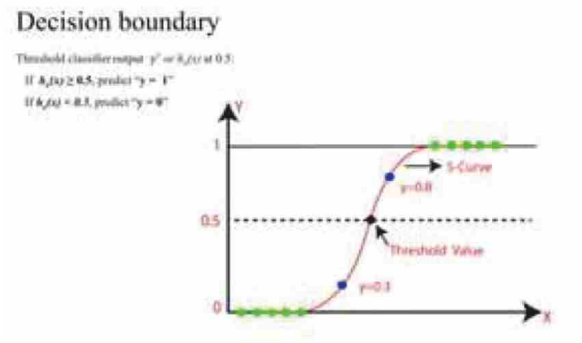
β0, β1,...,βn are the model parameters (coefficients or weights) that need to be learned.

ϵ represents the error term, which accounts for the variability in the data that the model cannot explain.

Example: Predicting house prices based on square footage etc.

2.4.2. Logistic Regression

Logistic Regression is a fundamental statistical and machine learning model used for binary classification tasks. It is named after the logistic function or Sigmoid function it employs to model the relationship between the input variables and the probability of a binary outcome (typically, 0 or 1). In other words, it estimates the probability that a given input belongs to one of the two possible classes using Sigmoid function. If the value of outcome >0.5 it is classified as 1, and when it is <0.5, it is classified as 0.



This is most widely used Machine learning model. The function and details of the Logistic Regression model are explained below:

(i) Binary Classification

Logistic Regression is primarily used for binary classification tasks, where you want to predict one of two possible outcomes, often denoted as 0 and 1 (or "negative" and "positive," "no" and "yes," etc.).

(ii) Sigmoid Function

Logistic Regression uses the logistic function (also known as the sigmoid function) to model the probability of the positive class (class 1) given the input features.

The sigmoid function is defined as: σ(z)=1/(1+e^−z)

Here, σ(z) is a linear combination of the input features and model parameters.

(iii) Linear Relationship

Logistic Regression assumes a linear relationship between the input features and the log-odds of the probability of the positive class.

Mathematically, this can be expressed as: ln(p/(1−p)=β0+β1x1+β2x2+…+βnxn

Here, p represents the probability of the positive class, x1,x2,…,xn are the input features, and β0,β1,…,βn are the model parameters to be learned from the training data.

(iv) Training the Model

The model parameters β0,β1,…,βn are learned from the training data using optimization techniques like gradient descent or maximum likelihood estimation.

During training, the model adjusts its parameters to minimize the difference between its predicted probabilities and the actual class labels in the training data.

(v) Making Predictions

Once trained, Logistic Regression can make predictions by calculating the probability that a new input belongs to the positive class.

If the estimated probability is greater than a specified threshold (typically 0.5), the model predicts class 1; otherwise, it predicts class 0.

(vi) Probability Interpretation

One of the advantages of Logistic Regression is that it provides not just a binary prediction but also the probability associated with that prediction.

This probability can be used to rank instances in terms of their likelihood of belonging to the positive class.

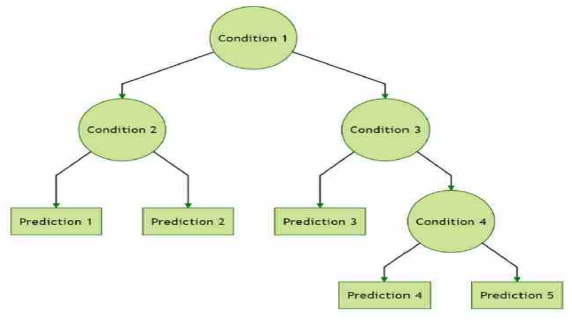
(vii) Regularization

Logistic Regression can be regularized to prevent overfitting by adding penalty terms to the cost function during training. This helps improve the model's generalization to unseen data.

Logistic Regression is widely used in various fields, including medicine (for disease diagnosis), finance (for credit scoring), marketing (for customer churn prediction), and more. It is a simple yet powerful tool for binary classification tasks when the relationship between input features and the probability of the positive class is assumed to be approximately linear.

2.4.3. Decision Trees

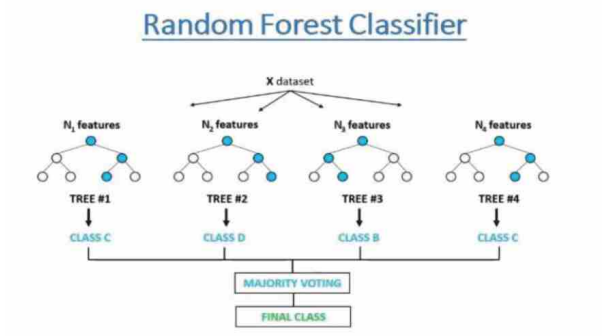
This is used for both classification and regression tasks. It is represented as tree-like structures where each node represents a feature, and each branch represents a decision rule.



Example: Predicting whether a loan applicant is likely to default.

2.4.4. Random Forests

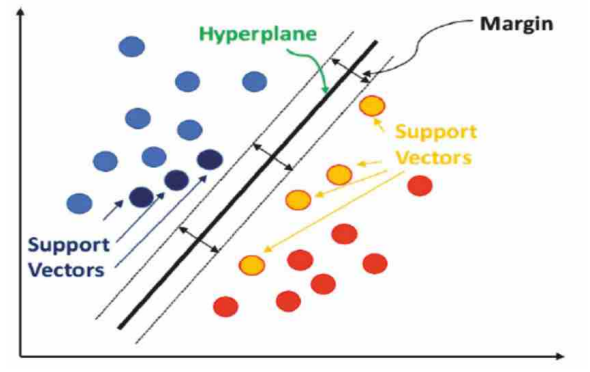
It is an ensemble model composed of multiple decision trees. It combines predictions from individual trees to improve accuracy and reduce overfitting.



Example: Predicting customer churn in a telecom company.

2.4.5. Support Vector Machines (SVM)

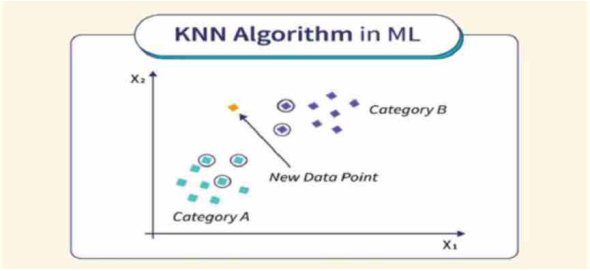
It is used for classification tasks. It finds the hyperplane that best separates data into different classes.



Example: Classifying images as {+,-} class or cats or dogs etc.

2.4.6. K-Nearest Neighbours (K-NN)

It is used for classification and regression tasks. It assigns a data point's class or value based on the majority class or average of its k-nearest neighbours.



Example: Recommending movies based on user preferences.

2.4.7. Neural Networks (Deep Learning)

It is used for a wide range of tasks, including image recognition, natural language processing, and more. It is composed of interconnected layers of artificial neurons that can learn complex patterns from data.

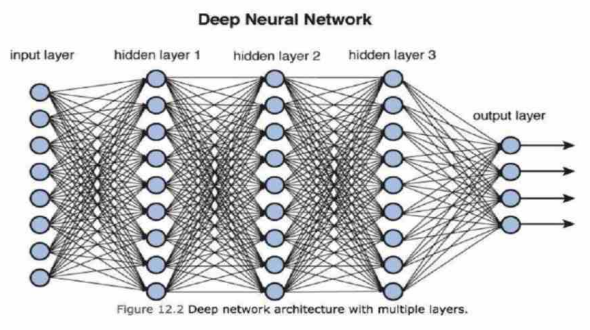
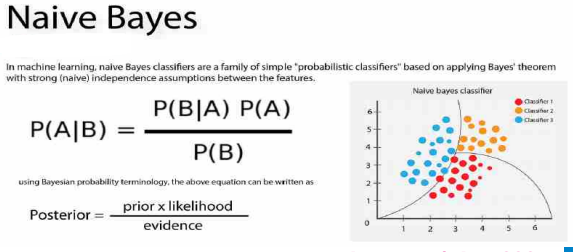


Figure 12.2 Deep network architecture with multiple layers.

Example: Training a deep neural network to recognize handwritten digits in images (MNIST dataset).

2.4.8. Naive Bayes

It is used for classification tasks, especially in text classification. This model assumes that

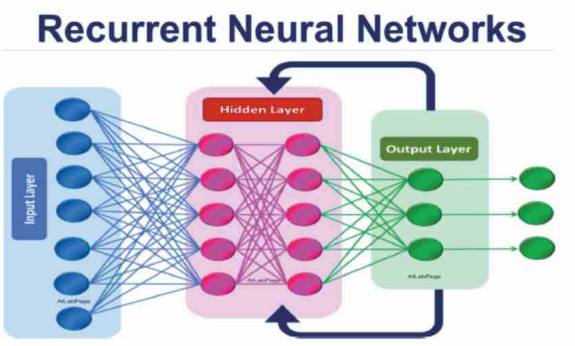


features are independent, making it particularly effective for text data.

Example: Spam email detection.

2.4.9. Recurrent Neural Networks (RNN)

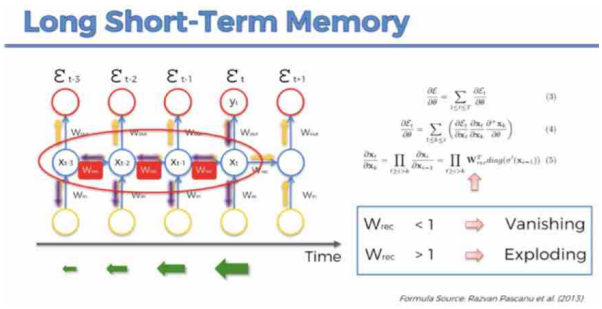
It is used for sequential data, such as time series or natural language. It has connections that allows information to flow in loops, making it suitable for tasks involving memory.



Example: Predicting stock prices or generating text.

2.4.10. Long Short-Term Memory (LSTM)

A type of RNN designed to address the vanishing gradient problem. It is effective for tasks that require learning long-term dependencies.



Example: Language translation with neural machine translation models.

These are just some of the many machine learning models available. The choice of model depends on the nature of the problem, the type of data, and the desired outcome. Additionally, model selection often involves experimenting with multiple models to determine which one performs best for a specific task.

3. ADVANCED TECHNIQUES

3.1. Deep Learning

Deep learning, facilitated by Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), has revolutionized computer vision and natural language processing. For instance, the use of CNNs in image recognition has achieved human-level accuracy, as seen in applications like self-driving cars.

3.2. Transfer Learning

Transfer learning techniques, such as Fine-Tuning Pre-trained Models, accelerate training for new tasks. An example is the use of OpenAI's GPT-3 in various natural language understanding applications.

3.3. Explainable AI (XAI)

Interpretable ML models like LIME (Local Interpretable Model-agnostic Explanations) enhance model transparency, ensuring trust in applications such as medical diagnosis.

4. REAL-WORLD APPLICATIONS

4.1. Healthcare

ML is transforming healthcare with applications like the Random Forest algorithm used in disease prediction. Predictive models help identify patients at risk and optimize treatment plans.

4.2. Finance

In finance, ML models like Long Short-Term Memory (LSTM) networks are employed for stock price prediction, portfolio optimization, and fraud detection.

4.3. Autonomous Systems

Reinforcement learning algorithms, such as

Proximal Policy Optimization (PPO), power autonomous systems by enabling agents to learn from interactions, a critical component in selfdriving cars.

4.4. Natural Language Processing (NLP)

Transformer models, like BERT, are at the forefront of NLP tasks, enabling sentiment analysis, language translation, and virtual assistants.

4.5 Telecommunications

Logistics regression and linear regression models help develop regression prediction in telecommunications in terms of customer acquisition, customer satisfaction, tariff plans and revenue prediction for any year.

5. CHALLENGES AND ETHICAL CONSIDERATIONS

Despite the many advancements in AI, there are still several challenges that need to be addressed. One of the biggest challenges is the development of AI systems that are safe and reliable. AI systems can be very powerful, but it is important to ensure that they are used in a responsible way.

Another challenge is the development of AI systems that are explainable. It is important to be able to understand how AI systems make decisions, so that we can trust them and use them responsibly. While ML promises tremendous benefits, ethical concerns arise. Algorithms like

FairML aim to mitigate bias in data and models, ensuring fairness and transparency. Privacy

preservation techniques, like Differential Privacy, safeguard sensitive information.

Finally, it is important to ensure that the benefits of AI are shared widely. AI has the potential to improve the lives of everyone, but it is important to ensure that it is not used to create or exacerbate inequalities.

6. Future Scope

The future of ML holds great promise. Quantum machine learning is on the horizon, offering exponential speedup.

Innovations in reinforcement learning promise applications in personalized education, robotics, and more. The field will continue to evolve, shaping industries and society.

7. CONCLUSION

Artificial Intelligence (AI) and Machine learning is a powerful and rapidly developing field with the potential to revolutionize many aspects of our lives. However, there are still many challenges that need to be addressed before AI can be widely and safely deployed. It is important to develop AI systems that are safe, reliable, explainable, and accessible to everyone. Machine Learning is a dynamic and transformative field, with its algorithms enveloping diverse domains. With responsible research and applications, ML has the potential to bring about profound positive changes in the world. Ethical considerations must guide its evolution to ensure a future where AI and humans collaborate for the greater good. This article provides a comprehensive review of Artificial Intelligence and Machine Learning as an important subset, supported by specific algorithms and case studies. It underpins the practical impact of ML in various domains while emphasizing ethical considerations and the potential for future advancements and deployment across industries.

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ARTIFICIAL INTELLIGENCE APPLICATION IN TELECOM BUSINESS

Santosh Kumar Kukkadapu

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Artificial Intelligence (AI) has vast potential in telecom business. Telecom business can now focus more on the customer and meet their needs in real time. AI tools can also be used to analyze the performance of competitors in telecom business and reveal customer's satisfactions. AI allows computer to analyze the vast telecom business data and assists human in solving problems effectively. Growth rate of AI enabled telecom business companies are higher than the average growth rate of telecom companies. The adoption of AI can help telecom companies to improve their efficiency in telecom operations, customer satisfaction and resolve the problems more quickly based on real time data. As a result, telecom business will achieve tremendous success in their business operations. This article attempts to scope of AI in telecom business. The applications of AI in various telecom segments are described.

The term Artificial Intelligence (AI) was first cited and introduced by McCarthy (1960). AI is a collection of new technologies capable of activities that need human intelligence, it is an engineering tool introduced to replace human in operations that require knowledge and able to give conclusion through learning. AI shows great success in different kinds of technological innovations, where the possibility of analyzing large amounts of data for decision-making process.

AI learning can be divided to machine learning, deep learning, neural networks and natural language processing. Learning is based on the normal functioning of AI and also represents an opportunity for business to create new knowledge and use it for managing business.

1.1 Machine Learning

Machine learning is the process of learning which is similar to human learning i.e collecting data through experience, is creating knowledge and storage it, solving the problem with every new cycle learning becoming more important. Machine learning is based on created algorithms which are enabling the system to recognize the situation and shape its behavior according to the identified state.

1.2 Deep Learning

Deep learning require the intervention of the human operator on how to solve the problem because human is an example of AI. This kind of learning is used in multi-layered learning and it is often used for the creation of complex programs that are designed for solving complex problems.

1.3 Neural Networks

Neural networks are similar to the human brain. Neural networks consist of several nodes and every node has activity task to ensure outcome for which network was created. Neural networks are used for solutions where problems are not linear.

1.4 Natural Language Processing

Natural language processing is subfield of AI, It understand the human languages by machine process algorithms so that they concerned with giving computers the ability to understand text

and spoken words in much same was human beings can and it perform repetitive tasks effectively.

1.5 Fuzzy Logic

Fuzzy logic attempts to solve problems with an open, imprecise data and gives accurate conclusions for decision making

Different application domains of AI are shown in Table1 and Fig 1.

Table 1: AI Application domains:

SNo	AI Application domain	Description
1	Data security	AI platforms are used to determine software bugs and prevent from cyber attacks
2	E-Commerce	AI is helping business partners to discover products with size, price, brand or color.
3	Education	AI chatbot can communicate as a teaching assistant, accessible at any time and any place
4	Social media	AI can organize massive amount of billions of user profiles data in efficient way and analyze latest trends and user requirements
5	Finance	AI helps drive insights for predictions, real time calculation, intelligent data retrieval and data analytics
6	Health care	AI make better and faster diagnosis and save the patient lives
7	Robotics	Intelligent humanoid robots have been developed which behave like a human
8	Telecom operations	AI enhances network optimization, predict and prevent outages, reducing downtime, improving telecom operations and thereby meet customer expectations.

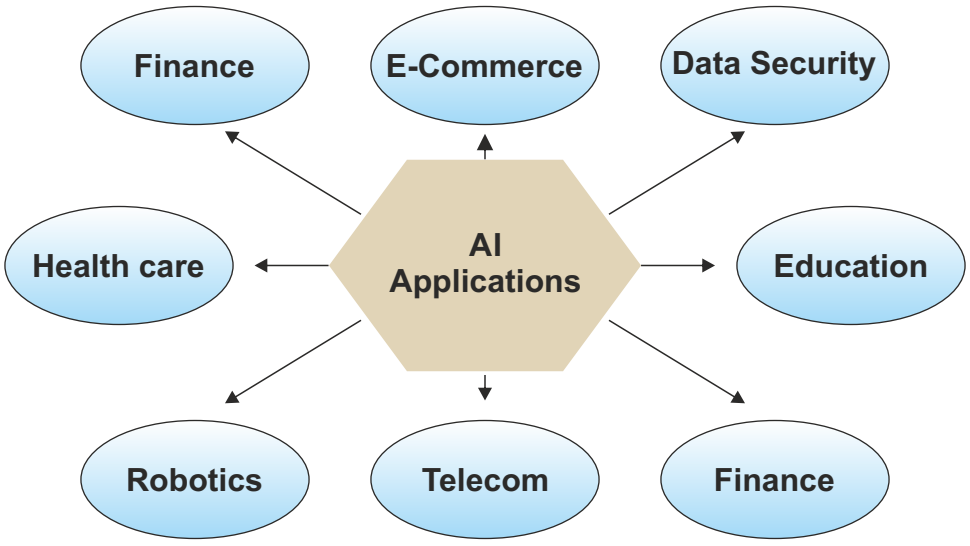

Fig. 1: AI Applications in different domains

2. Applications of AI in Telecom business

AI technology is being used in the telecom business are due to several benefits such as collecting and creating large amount of data, telecom business organizations can conduct different kinds of simulations which are used to analyze the future trends as well as the needs of stake holders in the telecom business environment. AI must conduct digital transformation of telecom business which is aimed to turning business into virtual sphere from tradition business ways. It should be determined that possibilities of adoption of AI technology in telecom business with competitors and business process significantly increase more effectiveness and efficiency. Applications of AI in different segments of telecom business are:

2.1 Customer relation management

Customer relation management is the prime important in telecom business. Possibility of identifying all requirements from the customer and to be focused on quality management parameters are described by regulatory authorities. AI finds application in customer questions which are send to the organization and those answers can be based on needs of the customer, AI can be used to answering to customer questions and requests. Through machine learning, the time taken to customer receives answer is decreasing, further more possibility of collecting different kinds data from customer which can be analyzed to improve the effectiveness. AI based chatbot can handle customer queries such as tariffs, billing, technical supports etc in their languages without need of human intervention.

2.2 Telecom Marketing

With the development of the AI, the business organizations can substitute marketing experts with one system which will do all functions such as collecting and analyze different kind of information in a much effective way. AI technology can be used to predictive analysis which is applicable to create marketing strategy and it is base for decision making in telecom business market. Table.2 shows that with the aid of AI tool, it is possible to create more accurate marketing strategy plans based on customer experience and their need.

Table.2. Marketing Strategy

Product	Price	Promotion	Position
Creating of new plan, Suggestions to the customers, Creating added value to customers	Creating processing based on kinds of customer and their need	Creating customer experience, benefits to the customer, decreasing disappointment effect	Distribution of channels, continuous customer support

2.1 Telecom Finance

AI in finance able to assist in enable transparency, eliminate risk, automatic operations, speed, accurate document processing, generate reports, analyze the financial data to simplify decision making and it further reduce costs. In addition to these, it also gives recommendations based on customer

data, peer interactions, and financial goal of business.

2.2 Network Optimization

Ai is being used to analyze the data received from network sensors to detect the problems in advance and there by proactive steps is taking to prevent outages.

2.3 Predictive Maintenance

Telecom operators can monitor the live status of equipment and anticipated network failures based on previous real time data to fix problems of hard ware such as cell towers, data services, optical equipments etc.

2.4 Fraud Prevention

AI algorithms able to detect real time fraudulent activities effectively from unauthorized network access, fake data and these are blocked easily.

2.5 Revenue Growth

AI driven data analysis, telecom business has tremendous increase in average revenue per user (ARPU) by anticipating customer requirements on real time basis.

Fig.3 shows application of AI in telecom business in different segments,

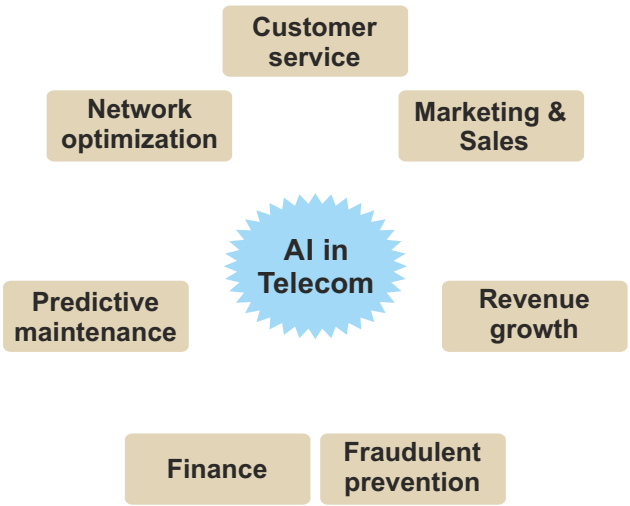

Fig.3 Application of AI in Telecom Business

3. Future of AI in telecom business

AI, 5G, cloud computing technologies are being used with customers have made it possible to answer all queries raised by customers in their languages. AI is also predicted to deal with customer behavior and impacting business decisions. There is no doubt that telecom market players will see with help of AI, systems are being operated day to day network operations and deliver more value to customers. The success of telecom business will depend on AI and no limit to AI can help us to achieve.

3.1 Challenges:

Development of AI technologies there is possibility to substitute humans and also for misuse of AI technology. With the help of AI technology organizations will be redesigned.

4. Conclusion

Artificial Intelligence (AI) has been applying in many fields and it has vast potential in telecom market. Telecom business can be focused more on the customer needs, network operations based on real time data. AI is able to solve majority of the problems in efficient and effective way and to achieve the tasks which human directly can't accomplish. No doubt that success of telecom business will depend on application of AI tools in day to day operations.

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6G USAGE SCENARIOS AND KEY CAPABILITIES

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Ashok Kumar is presently working as Dy Director General, Department of Telecommunications at Meerut. Before it, He was Dy Director General (Wireless Access), at the National Telecommunications Institute for Policy Research, Innovations and Training (NTIPRIT) . He is also Voice Chair of Study Group 16 of ITU-T. He is an ITS officer of the 1993 batch. He has done Bachelor of Engineering in Electronics and MBA (Marketing).

As part of his assignments at NTIPRIT, he had prepared inter-alia over 60 hours of technical sessions on 5G mobile communications for telecom professionals of the Government and delivered the course for officers of ITS and other services. He has also been delivering his sessions in a webinar series on "Emerging trends in 5G" being organized by NTIPRIT to create awareness and Education about 5G in the country. He has designed, developed, and conducted three batches of 12 weeks /36 hours certificate courses in 5G for officers of the Department of Telecommunication, other central and state Government officers, and PSUs. He has delivered 21 hours of Sessions for the online CEP 5G certificate program of IIT Delhi.

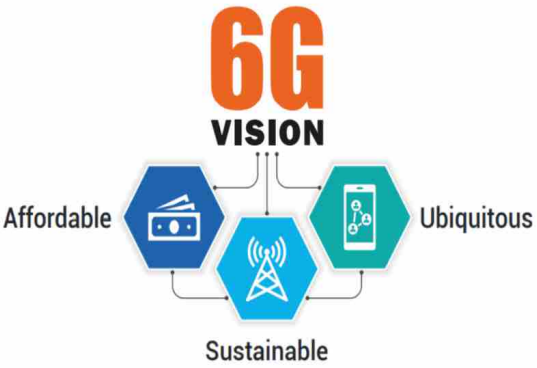
As a member of the Expert Group created by the Government of India to design and develop an Education and Awareness Training Program on 5G for Bureaucrats, Training Institutes Engineering collage etc, he has contributed significantly in fulfilling the mandate given to the Expert Group.

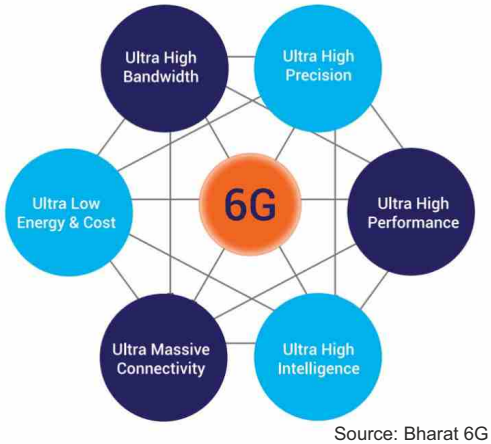
During his 7 years of deputation to UIDAI, he contributed to creating enabling policies, processes, and guidelines to expand the ecosystem and keep it viable and healthy resulting in achieving the mammoth task of enrolling over 90% of the population of India. He represented India (nominated by the Ministry of Communications, Government of India) as a speaker on "Plans and Lessons Learnt for National Digital ID" at the 19th APT Policy & Regulatory Forum (PRF-19) in Bhutan.

As part of India's contribution to the Commonwealth Telecommunications Organisation (CTO)), he delivered 5-day course on "WiMAX Planning and RF Engineering" in Johannesburg, South Africa to participants from 23 Commonwealth countries.

He has worked in DoT/BSNL in the field of planning, design, procurement, installation, commissioning, operation & maintenance of Mobile Telecommunications and other telecom technologies.

Bharat 6G Vision: Our Honorable Prime Minister Shri Narendra Modi unveiled the Bharat 6G vision document and launched the 6G research and development testbed on Wednesday, March 22, 2023. Bharat 6G vision is an ambitious initiative by India to Design, develop, and deploy 6G network technologies that provide ubiquitous intelligent, and secure connectivity for high-quality living experience for the world.





Source: Bharat 6G Vision

Figure 1: Bharat 6G vision

It is based on the principles of affordability, sustainability, and ubiquity. It aims to ensure that India takes its rightful place in the world as a leading supplier of advanced telecom technologies and solutions. Bharat's 6G vision envisages a 6G network that can support a wide range of applications and services, such as immersive media, holographic communications, smart cities, autonomous vehicles, industrial IoT, healthcare, education, agriculture, and more. It proposes to leverage the strengths of India's large and diverse talent pool, vibrant startup ecosystem, and strong R&D capabilities to create innovative and indigenous 6G solutions. It plans to establish a 6G research and development testbed, that will enable collaboration among academia, industry, and government to conduct 6G trials and experiments.

Evolution of Mobile Technologies

Mobile technologies have evolved from one generation to the next every ten years. The 1G technology was rolled out in the 1980s and 5G has been rolled from the year 2020. With every next generation of mobile technology, capabilities in terms of data speed, spectral efficiency, and other features increase multifold.

1G

The first generation of mobile networks was deployed during the 1980s. This system used analog signals. One of the 1G technology used was called AMPS (Advance Mobile Phone System) in the United States.

2G

The successful second-generation mobile communications was GSM and it was introduced in the 1990s. It used digital signals and provided better voice quality, higher capacity, and more security features than 1G.

Figure 2: Timelines of the evolution of mobile technologies

3G

The third-generation mobile communication system was launched commercially in the year 2000s. It provided broadband data services and higher data transfer rates than 2G.

4G

The fourth-generation mobile communication system was launched in the 2010s. . It provided native-IP networks and higher data transfer rates than 3G.

5G

Fifth-generation communication system began deployment in 2019. It provides enhanced mobile broadband, ultra-reliable low-latency communications, and massive machine-type communications

Role of ITU and SDOs in the Development of Mobile Technologies

International Telecommunication Union (ITU) develops the framework, vision, and performance requirements of upcoming mobile technology. It includes firming of usage

scenarios of the technology and required key capabilities to support the usage scenarios. ITU started doing it from 3G onwards. It is to be noted that ITU terms these technologies differently compared to its commercial naming.

Figure 3: Naming of mobile technologies by ITU

They call it International Mobile Telecommunications (IMT). 3G is termed as IMT 2000, 4G as IMT advanced, and 5G as IMT 2020.

Once the framework, vision, and requirement of upcoming mobile technology are approved by ITU, the Standard Developing Organisations (SDOs) such as 3GPP, IEEE, TSDSI, etc are free to develop candidate technology meeting the ITU requirements. After the development of technology, SDOs submit it to ITU, and ITU evaluates and declares it as one of the approved candidate technologies.

What is 6G

6G is the sixth-generation technology for wireless communications and is the successor to 5G. ITU has termed 6G as IMT 2030. With the evolution of information and communications technologies, IMT-2030 is expected to support enriched and immersive experiences, enhance ubiquitous coverage, and enable new forms of collaboration. Furthermore, IMT-2030 is envisaged to support expanded and new usage scenarios compared to those of IMT-2020 (5G), while providing enhanced and new capabilities.

The Framework, Vision, and Requirements for 6G / IMT 2030

ITU takes various steps to prepare and publish the framework, vision, and performance requirements of upcoming mobile technology over a period. ITU also decides the name of the upcoming technology. The timeline for various steps to develop 6G technology has been published by ITU recently as given in figure 4.

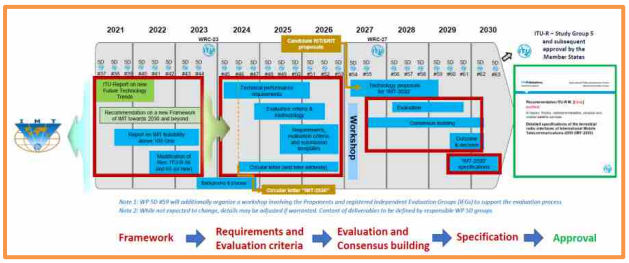


Figure 4: IMT 2030 (6G) timelines by ITU

As per the above time line 6G is expected to be rolled out by 2030. The Framework and Vision of 6G has already been approved by ITU recently and is under approval process from ITU state members. It is further expected that ITU will complete the work on the Technical Performance requirement of 6G radio in the year 2024 and thereafter SDOs will start working on it. Preparatory work has already been started by various SDOs.

6G Usage Scenarios

As you may know, 5G has three usage scenarios namely Enhanced Mobile broadband (eMBB), Ultra Reliable Low latency Communications (uRLLC), and Massive Machine Type Communications (mMTC). These usage scenarios have been Enhanced for 6G.

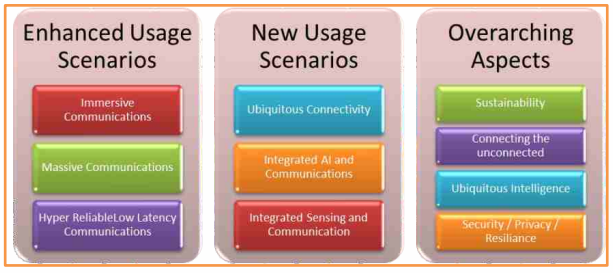


Figure 5: 6G Usage scenarios by ITU

In addition, 6G has three new usage scenarios and four overarching aspects. The overarching aspects are design principles and apply to all the six usage scenarios. The 6 usage scenarios and 4 overarching aspects of 6G are given in Figure 5

6G Key capabilities

To support 6 usage scenarios, ITU has defined a total of 15 key capabilities of 6G, nine of the capabilities are enhanced from 5G and six new capabilities are newly added.

Figure 6: 6G Key capabilities

Relation between Usage Scenarios and required key capabilities.

The different usage scenarios or use cases will require different capabilities of 6G for its implementation. Let us look at various usage scenarios and required key capabilities.

Immersive Communications

Immersive Communications help combine the physical world with a digital or simulated reality. Examples of Immersive communications are Augmented reality (AR) , Virtual reality (VR), and Mixed reality (XR). The key capabilities required will be peak data rate, spectral efficiency, use experience data rate, and area traffic capacity. This usage scenario extends the enhanced Mobile Broadband (eMBB) of IMT-2020 and covers use cases that provide a rich and interactive video (immersive) experience to users, including interactions with machine interfaces.

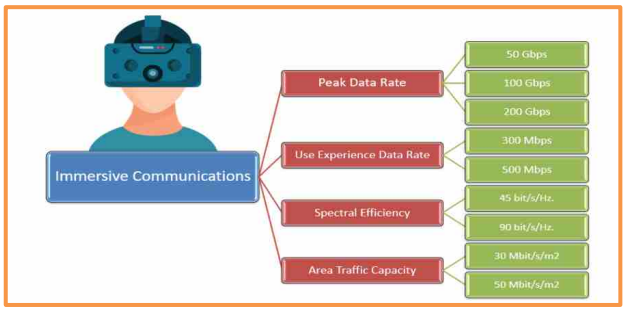


Figure 7: 6G capabilities targets to support Immersive Communications

The future of multimedia and human-centric communication enabled by 6G is expected to give an immersive experience through multi-sensory interactions and in-depth integration between physical and digital worlds. This is expected to provide a real-time interactive video experience. In addition, holographic telepresence might become common for work, social interactions, entertainment, tele-education, remote live performances, etc. It is expected that new human-machine interfaces would enable immersive and intelligent interactions, where control is maintained remotely, e.g., remote operations of machines, robots, and devices leveraging edge cloud computing resources and AI to deliver tactile internet and ambient awareness.

Peak Data Rate

As per ITU Peak data rate is the maximum achievable data rate under ideal conditions (in bit/s), which is the received data bits assuming error-free conditions assignable to a single mobile station, when all assignable radio resources for the corresponding link direction are utilized (i.e. excluding radio resources that are used for physical layer synchronization, reference signals or pilots, guard bands and guard times). The peak data rate target for 6G is envisioned to evolve from 50 Gbps to 100 Gbps to 200 Gbps.

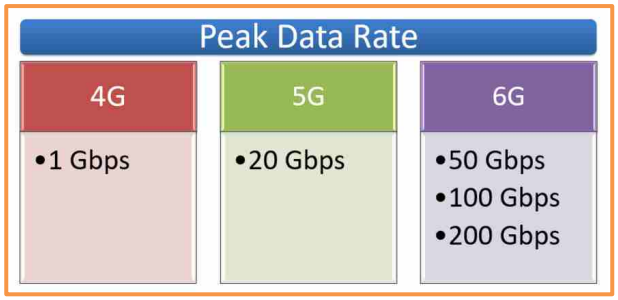


Figure 8: Evolution of peak data rate from 4G to 6G mobile technologies

These peak data rates are envisioned in the downlink direction. The peak data rate for the

uplink will be about half of the downlink peak data rate.

User Experienced Data Rate

The user experience data rate is the minimum data rate that one user can expect to get even at the edge of network coverage. ITU has defined it as the 5% point of the cumulative distribution function (CDF) of the user throughput. The use experience data for 6G is targeted to evolve to 300 Mbps to 500 Mbps with is 50 times faster than 4G and 5 times faster than 5G.

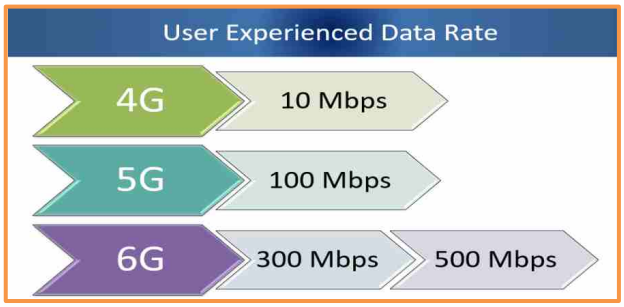


Figure 9: Evolution of User Experienced data rate from 4G to 6G mobile technologies

Peak Spectral Efficiency

Peak spectral efficiency is the maximum data rate under ideal conditions normalised by channel bandwidth (in bit/s/Hz), where the maximum data rate is the received data bits assuming error-free conditions assignable to a single mobile station when all assignable radio resources for the corresponding link direction are utilized (i.e. excluding radio resources that are used for physical layer synchronization, reference signals or pilots, guard bands and guard times)

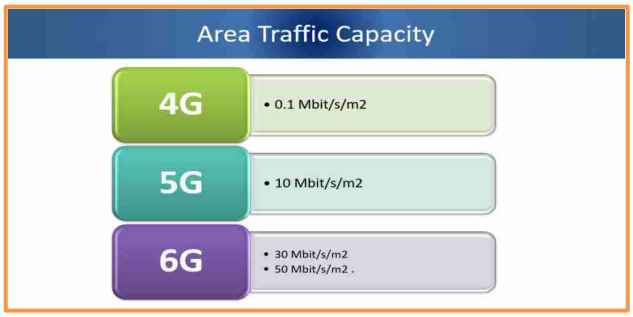


Figure 10: Evolution of Peak Spectral Efficiency from 4G to 6G mobile technologies

ITU has given the target of peak spectral efficiency for 6G to 45 bit/s/Hz and 90 bit/s/Hz. This is 9 times better than 4G and 3 times better than 5G

Area Traffic Capacity

Area traffic capacity is the total traffic throughput served per geographic area (in Mbit/s/m2. ITU has given a target of 30 to 50

Figure 11: Evolution of Area traffic Capacity from 4G to 6G mobile technologies

Massive Communications

A massive number of objects, machines, IoT sensors, wearable devices, etc will connect to mobile networks. Mobile networks will be required to support a very high density of connectivity in a geographical area. The other requirement for massive communications is deep coverage in remote areas, agricultural fields, offshore, and deep inside buildings. Typical use cases of Massive

Communications include applications in smart cities, transportation, logistics, health, energy, environmental monitoring, agriculture, and many other areas such as those requiring a variety of IoT devices without batteries or with long-life batteries. This usage scenario would require support of high connection density, and depending on use cases, different data rates, low power consumption, mobility, extended coverage, and high security and reliability.

Connection Density

The 6G is expected to support a connection

density up to ten crore devices per square kilometer of area which 100 times more compared to 5G.

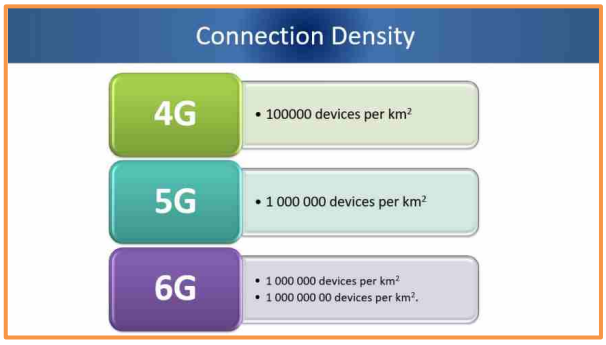


Figure 12: Evolution of Connection Density from 4G to 6G mobile technologies

Coverage

Coverage refers to the ability to provide access to communication services for users in a desired service area. In the context of this capability, coverage is defined as the cell edge distance of a single cell through link budget analysis.

Hyper Reliable Low Latency Communications (hRLLC)

This usage scenario is the enhancement of the Ultra-Reliable and Low-Latency Communication (URLLC) of 5G/ IMT 2020. Some of the use cases include communications in an industrial environment for full automation, control, and operation. These types of communications can help in realizing various applications such as robotic interactions, emergency services, telemedicine, and monitoring for electrical power transmission and distribution. This usage scenario would require the support of enhanced reliability and low latency, depending on the use case, precise positioning, and connection density.

Latency

Latency over the air interface refers to the contribution by the radio network to the time from when the source sends a packet of a certain size to when the destination receives it. The research target of latency (over the air interface) as given by ITU is 0.1 – 1 ms. 5G had latency up to 1 ms and 4G had it up to 10 ms.

Reliability Reliability over the air interface relates to the capability of transmitting successfully a predefined amount of data within a predetermined time duration with a given probability. The research target of reliability (over the air interface) for 6G could range from 1-10−5 to 1-10−7.

Positioning

Positioning is the ability to calculate the approximate position of connected devices. Positioning accuracy is defined as the difference between the calculated horizontal/vertical position and the actual horizontal/vertical position of a device. The research target of the positioning accuracy fpr 6G is to be 1 – 10 cm.

Ubiquitous Connectivity

This usage scenario aims to bridge the digital divide. This can be achieved by inter alia, interworking with other systems. One focus of this usage scenario is to address presently uncovered or scarcely covered areas, particularly rural, remote, and sparsely populated areas. This will also enhance coverage for IoT devices and mobile broadband communications.

Interoperability

Interoperability refers to the radio interface being based on member-inclusivity and transparency, so as to enable functionality(ies) between different entities of the system.

Integrated Sensing and Communication

There are services that require sensing capabilities. IMT-2030 /6G is expected to offer wide area multi-dimensional sensing that provides spatial information about unconnected objects as well as connected devices and their movements and surroundings.

The use case include assisted navigation, activity detection and movement tracking (e.g., posture/gesture recognition, fall detection, vehicle/pedestrian detection), environmental monitoring (e.g., rain/pollution detection), and provision of sensing data/information on surroundings for AI, XR, and digital twin applications.

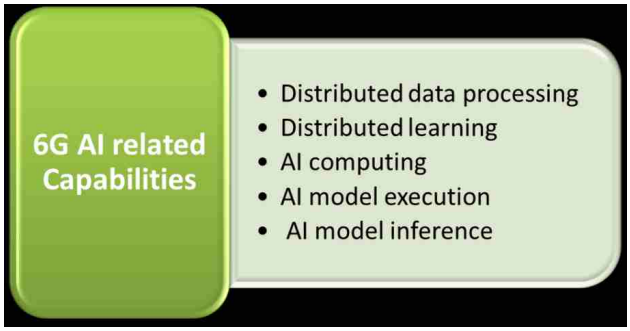


Figure 13: Sensing capabilities of 6G

Integrated Artificial Intelligence and Communications

This usage scenario would support distributed computing and AI-powered applications. This usage scenario will be enabled by leveraging data collection, local or distributed compute offload, and the distributed training and inference of AI models across various intelligent nodes, such as transmission reception points (TRxPs) and devices. The specific use case may include assisted automated driving, autonomous collaboration between devices for medical assistance applications, offloading of heavy computation operations across devices and networks, creation of and prediction with digital twins, and assisted collaborative robot (cobots).

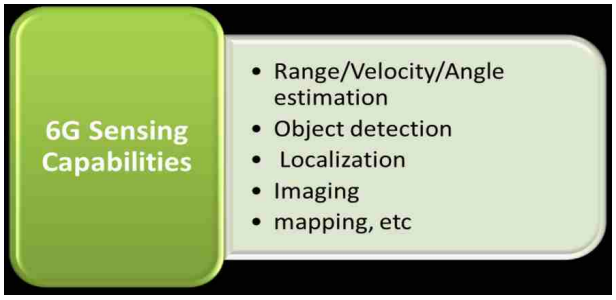


Figure 14: AI related capabilities of 6G

This usage scenario would require the support of high area traffic capacity and user-experienced data rates, as well as low latency and high reliability, depending on the specific use case. Besides communication aspects, this usage scenario is expected to include a set of new capabilities related to the integration of AI and compute functionalities into IMT-2030, including data acquisition, preparation, and processing from different sources, distributed AI model training, model sharing and distributed inference across IMT systems, and computing resource orchestration and chaining.

Overarching Aspects: Design Principals

ITU has also prescribed four overarching aspects/design principles that apply to all six usage scenarios of 6G. These are Security / Privacy /Resilience, Ubiquitous Intelligence, Sustainability, and Connecting the unconnected.

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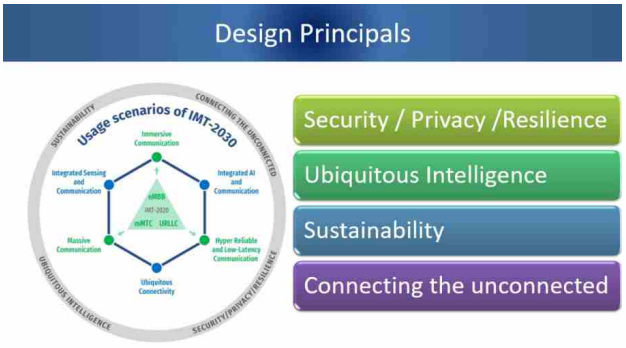

Figure 15: Overarching Aspects / Design Principals of 6G

Security, privacy, and resilience

The Security of the system includes Confidentiality, Integrity, and Availability. Privacy

includes the Protection of an individual's personal information, the Individual's ability to determine whether, when, how, and for what purpose such information is collected and processed by others, and for how long it is retained. The resilience includes capabilities of the networks and systems to continue operating correctly during and after a natural or man-made disturbance, such as the loss of a primary source of power, etc.

Ubiquitous intelligence

It is expected that intelligence will be present in every part of the communication system to support the building of smart cities and communities. Future connected devices may become fully context-aware for more intuitive and efficient interactions among humans, machines, and the environment. Possible autonomous management of networks by AI/ML could also be capable of performing self-monitoring, self-organization, self-optimization, and self-healing without human intervention. It is expected that the air interface will be enhanced by AI models. IMT-2030 is expected to serve as an AI-enabling infrastructure capable of providing services for intelligent applications. AI-enabled air interface along with distributed computing and intelligence could allow for end-to-end AI applications and the convergence of communication and computing. These systems would have functions of inferences, model training, model deployment, as well as computing distributed across networks and devices.

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BUILDING BRIDGES WITH AI:THE ChatGPT CONNECTION

Mrs. Shashi Banzal

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Artificial intelligence (AI) refers to the simulation or approximation of human intelligence in machines. The goals of artificial intelligence include computer-enhanced learning, reasoning, and perception.AI is being used today across different industries from finance to healthcare. Weak AI tends to be simple and single-task oriented, while strong AI carries on tasks that are more complex and human-like.ChatGPT is a powerful AI language model developed by OpenAI which is most popular application of it. It's designed to engage in natural language conversations with users, and provide information, generate text, answer questions, and assist with a wide range of tasks.The widespread fascination with ChatGPT made it synonymous with AI.

WHAT IS ARTIFICIAL INTELLIGENCE (AI)

Artificial intelligence (AI) is any system that uses a computer or software to replicate the idea of human intelligence. AI involves the development of computer programs and algorithm that can learn from and make decisions based on data, without the need for human intervention. Some of the tasks that AI performs include speech recognition, language translation, chatbots, text generation, and image and video analysis.

It the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings. The term is frequently applied to the project of developing systems endowed with the intellectual processes characteristic of humans, such as the ability to reason, discover meaning, generalize, or learn from past experience. Still, despite continuing advances in computer processing speed and memory capacity, there are as yet no programs that can match human flexibility over wider domains or in tasks requiring much everyday knowledge. On the other hand, some programs have attained the performance levels of human experts and professionals in performing certain specific tasks, so that artificial intelligence in this limited sense is found in applications as diverse as medical diagnosis, computer search engines, and voice or handwriting recognition.

The year 2022 brought AI into the mainstream through widespread familiarity with applications of Generative Pre-Training Transformer (ChatGPT) which is most popular application of OpenAI.

2. WHAT IS ChatGPT

ChatGPT, which stands for Chat Generative Pre-trained Transformer, is a large language model-based chatbot developed by OpenAI and launched on November 2022, which enables users to refine and steer a conversation towards a desired length, format, style, level of detail, and language.

ChatGPT is a powerful AI language model developed by OpenAI. It's designed to engage in natural language conversations with users, like you, and provide information, generate text, answer questions, and assist with a wide range of tasks. ChatGPT is based on the GPT-3.5 architecture and uses a deep neural network to understand and generate human-like text. This generative AI model has been designed to generate text with a more natural flow, giving us the feeling of conversing with a real person. When type in a query, we should receive a response that includes several sentences or paragraphs. This is a new advancement in the field of automatic text-generation AI.

3. KEY FEATURES OF ChatGPT

- **Conversational AI:** ChatGPT can maintain coherent and contextually relevant conversations, making it useful for a variety of applications, from answering queries to assisting with content generation.
- **Language Understanding:** It can comprehend and generate text in multiple languages and understand context, making it versatile.
- **Natural Language Processing:** ChatGPT can handle a broad spectrum of tasks, including summarizing text, translating languages, offering explanations, and more.
- **Text Generation:** It can generate text in a variety of styles, tones, and voices, depending on the user's needs.
- **Knowledge and Information:** ChatGPT's knowledge is based on a vast dataset, it can provide information up to that point.
- **Text Completion:** It can assist in writing, completing sentences, and generating creative content.

While ChatGPT is a powerful tool, it's important to remember that it's an AI model and not a human. Its responses are generated based on patterns in the text it has been trained on, and it may not always provide entirely accurate or up-to-date information.

4. ChatGPT'S USAGE

ChatGPT can be used for many different tasks, for example:

- speech and text analysis
- translations
- explanations of complex issues
- writing stories and essays
- learn coding
- debugging code

5. ARTIFICIAL NEURAL NETWORKS AND DEEP LEARNING

An artificial neural network is a mathematical system that is based on how we once thought the brain worked. Neural networks take in data, train themselves to recognise patterns within the data and then predict the outcome for similar data.

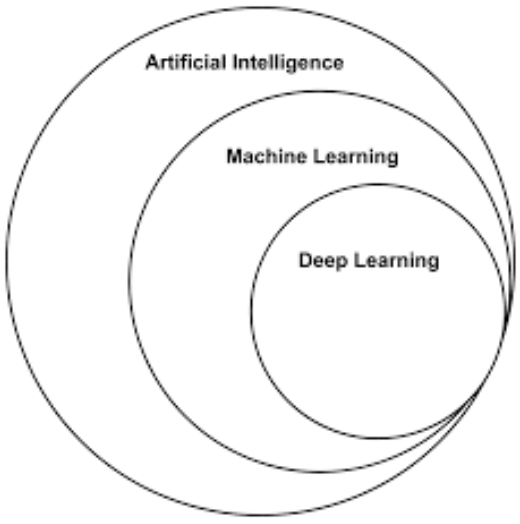

Figure 1. Basic AI Diagram

Deep learning involves the use of several neural networks. Deep learning algorithms

have many layers of neurons and nodes – dozens or even hundreds of them. The many layers are referred to as the depth, which is how deep learning gets its name. The image below is a simplified model of an artificial neural network. The yellow dots represent layers of nodes.

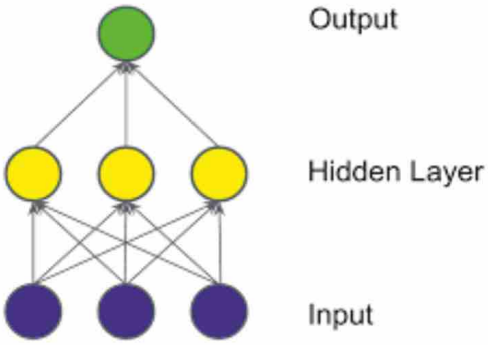

Figure 2.Neural Network Diagram

This image shows the parts and the connections between the parts of a neural network. This is a simple neural network. In real life, neural networks often have billions of nodes per layer and hundreds of layers.To put this all together in simple terms, deep learning, which uses neural networks, is a subset of machine learning, which is a subset of artificial intelligence.

6. CHARACTERISTIC OF ARTIFICIAL INTELLIGENCE

The ideal characteristic of artificial intelligence is its ability to rationalize and take actions that have the best chance of achieving a specific goal. A subset of artificial intelligence is machine learning (ML), which refers to the concept that computer programs can automatically learn from and adapt to new data without being assisted by humans. Deep learning techniques enable this automatic learning through the absorption of huge amounts of unstructured data such as text, images, or video.

7. TYPES OF ARTIFICIAL INTELLIGENCE)

Artificial intelligence can be divided into two different categories: weak and strong. Weak artificial intelligence embodies a system designed to carry out one particular job. Strong artificial intelligence systems are systems that carry on the tasks considered to be human-like. These tend to be more complex and complicated systems. These kinds of systems can be found in applications like self-driving cars or in hospital operating rooms.

Artificial intelligence can be categorized into one of four types.

- **Reactive AI** uses algorithms to optimize outputs based on a set of inputs. Chess-playing AIs, for example, are reactive systems that optimize the best strategy to win the game.
- **Limited Memory AI** can adapt to past experience or update itself based on new observations or data.
- **Theory-of-Mind AI** are fully-adaptive and have an extensive ability to learn and retain past experiences.
- **Self-Aware AI,** as the name suggests, become sentient and aware of their own existence.

8. ADVANTAGES OF AI

The following are some advantages of AI.

- **Good at Detail-Oriented Jobs.** AI has proven to be as good or better than doctors at diagnosing certain cancers.
- **Reduced Time for Data-Heavy Tasks.** AI is widely used in data-heavy industries, including banking and securities, pharma and insurance, to reduce the time it takes to analyse big data sets.
- **Saves labour and increases productivity.**

An example here is the use of warehouse automation.

- **Delivers Consistent Results.** The best AI translation tools deliver high levels of consistency, offering even small businesses.
- **Can Improve Customer Satisfaction through Personalization.** AI can personalize content, messaging, ads, recommendations and websites to individual customers.
- **AI-Powered Virtual Agents are Always Available.** AI programs do not need to sleep or take breaks, providing 24/7 service.

9. DISADVANTAGES OF AI

The following are some disadvantages of AI.

- Expensive.
- Requires deep technical expertise.
- Limited supply of qualified workers to build AI tools.
- Reflects the biases of its training data, at scale.
- Lack of ability to generalize from one task to another.
- Eliminates human jobs, increasing unemployment rates.

10. APPLICATIONS OF ARTIFICIAL INTELLIGENCE

The applications for artificial intelligence are endless. The technology can be applied to many different sectors and industries. AI is being tested and used in the healthcare industry for suggesting drug dosages, identifying treatments, and for aiding in surgical procedures.Other examples of machines with artificial intelligence include computers that play chess and self-driving cars.

- **AI in Healthcare**

Companies are applying machine learning to make better and faster medical diagnoses than humans. It understands natural language and can respond to questions asked of it. Other AI applications include using online virtual health assistants and chatbots to help patients and healthcare customers find medical information, schedule appointments, understand the billing process and complete other administrative processes.

- **AI in Business**

Machine learning algorithms are being integrated into analytics and customer relationship management (CRM) platforms to uncover information on how to better serve customers. Chatbots have been incorporated into websites to provide immediate service to customers. The rapid advancement of generative AI technology such as ChatGPT is expected to have far-reaching consequences: eliminating jobs, revolutionizing product design and disrupting business models.

- **AI in Education**

AI can automate grading, giving educators more time for other tasks. AI tutors can provide additional support to students, ensuring they stay on track. The technology could also change where and how students learn, perhaps even replacing some teachers. As demonstrated by ChatGPT, Bard and other large language models.

- **AI in Finance**

AI in personal finance applications, such as Intuit Mint or TurboTax, is disrupting financial institutions. Applications such as these collect personal data and provide financial advice.

- **AI in Law**

Using AI to help automate the legal industry's labour-intensive processes is saving time and improving client service. Law firms use machine learning to describe data and predict

outcomes, computer vision to classify and extract information from documents, and NLP to interpret requests for information.

- **AI in Entertainment and Media**

The entertainment business uses AI techniques for targeted advertising, recommending content, distribution, detecting fraud, creating scripts and making movies. Automated journalism helps newsrooms streamline media workflows reducing time, costs and complexity.

- **AI in Software Coding and IT Processes**

New generative AI tools can be used to produce application code based on natural language prompts, but it is early days for these tools and unlikely they will replace software engineers soon.

- **Security**

AI and machine learning are at the top of the buzzword list security vendors use to market their products. Organizations use machine learning in security information and event management software and related areas to detect anomalies and identify suspicious activities that indicate threats.

- **AI in Manufacturing**

Manufacturing has been at the forefront of incorporating robots into the workflow. For example, the industrial robots that were at one time programmed to perform single tasks and separated from human workers, increasingly function ascobots.

- **AI in Banking**

Banks are successfully employing chatbots to make their customers aware of services and offerings and to handle transactions that don't require human intervention. AI virtual assistants are used to improve and cut the costs of compliance with banking regulations.

- **AI in Transportation**

In addition to AI's fundamental role in operating autonomous vehicles, AI technologies are used in transportation to manage traffic, predict flight delays, and make ocean shipping safer and more efficient.

11. CONCLUSION

In conclusion, Artificial Intelligence (AI) and ChatGPT represent significant advancements in the field of technology and natural language processing. AI, as a broader concept, has the potential to transform various industries and aspects of daily life. It encompasses a wide range of technologies and applications, from machine learning and deep learning to robotics and autonomous systems.

ChatGPT, as a specific AI model developed by OpenAI, showcases the power of AI in natural language understanding and generation. It can engage in human-like conversations, answer questions, assist with tasks, and provide valuable information. ChatGPT's capabilities, combined with its knowledge base, make it a versatile tool for users in search of information, content generation, and more.

However, it's essential to remember that AI, including models like ChatGPT, has limitations. It relies on patterns in data and may not always provide completely accurate or up-to-date information. In the future, the continued development and responsible use of AI, including models like ChatGPT, will play a vital role in shaping how society interacts with and benefits from technology. Striking a balance between innovation and ethical considerations will be crucial to harness the full potential of AI for the betterment of humanity.

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USING ARTIFICIAL INTELLIGENCE IN 5G NETWORK

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Artificial intelligence (AI) is transforming industries across the globe, and telecom is no exception what benefits this technology offer for telecom networks? The telecom industry is rapidly pushing the wide adoption of cutting edge technologies like 5G broadband services, Internet of Things (IOT), ultra low latency communication . This growth is expected to continue due to the rapid adoption of AI in telecommunications to support networks operations and customers. This article will provide insights in what is driving the widespread adoption of AI by telecom industry AI has proven itself essential to the telecom's digital transformation strategy as it addresses the key challenges faced by telecom industry

Artificial Intelligence embedded technologies can be a useful tool in the telecommunications industry. Implementation of AI by Telco companies resulting in the development of highly personalized products, improved fulfilment processes and enhanced network management, allows telecommunications operators to provide their customers with more attractive services as well as enhance their customer retention.

The key driver for AI growth in the telecom industry is an increasing demand for autonomously driven network solutions. The networks of the telecommunications industry expand at a rapid pace, becoming more complex and difficult to manage. By using AI-powered network solutions, CSPs can reduce network congestion and improve network quality, therefore enhancing the customer experience.

1.1 The Challenges that AI in Telecommunications can Address

Poor Network Management

Global traffic and the need for more network equipment are growing dramatically, resulting in more complex and costly network management.

Lack of Data Analysis

Telecoms struggle to leverage the vast amounts of data collected from their massive

customer bases over the years. Data may be fragmented or stored across different systems, unstructured and uncategorized, or simply incomplete and not very useful.

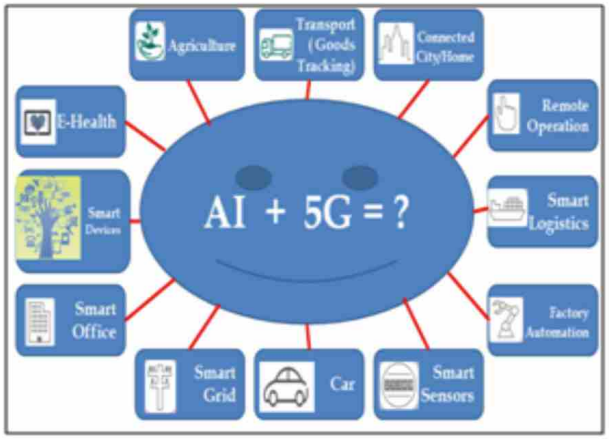
High Costs

Following massive investments in infrastructure and digitalization, industry analysts expect telecoms' global operating expenditures to increase by billions of dollars. Many telecoms face a financial crunch and must find ways to improve their bottom lines.

Customer Service

Telecom customers are demanding higher quality services and better customer experience (CX) and are known to be especially susceptible to churn when their needs are not met.

2.0 How is AI being used in 5G Networks?



As 5G matures, AI and ML (Machine Learning) are already being introduced for study by the 3rd Generation Partnership Project (3GPP), the standardization body that maintains cellular standards. Following are use cases of applying Artificial Intelligence to telecom network

AI in 5G for Dynamic Allocation

The data available within a 5G network provides insights on performance, user behavior and environmental factors. AI algorithms can use this information to suggest optimizing network resources. This includes dynamically allocating bandwidth and resolving bottlenecks. AI can help ensure better overall performance and improve the user experience.

AI for Predictive Maintenance

As in many other industry sectors, AI can be employed to predict and detect potential network faults and failures proactively. This enables network operators to take preventative actions and conduct maintenance before issues arise. Preventative maintenance is reducing downtime and enhancing network reliability.

Network Resource Management

5G networks require efficient management of various resources like spectrum, energy and computing power. AI can enable intelligent resource allocation and distribution based on real-time demand, traffic patterns, and usage trends. This is leading to more efficient use of network resources and improved energy efficiency.

AI for Improving 5G Network Security

AI can help detect and respond to security threats in real time. Using the vast amount of data generated by 5G networks, AI-powered security systems can identify anomalies and potential attacks quickly. These measures are protecting sensitive user information and network infrastructure.

AI for Intelligent RAN Automation

A series of technologies, solutions and services that use intelligent, machine learning to improve network performance, enhance customer experience and reduce operational costs and energy consumption.

AI for Augmented MIMO Antenna Sleep

In Ericsson Radio System, AI algorithms run on the baseband to predict traffic patterns and autonomously turn off antennas as required to reduce energy usage. It's also possible to combine with Cell sleep and the Low Energy Scheduler solutions for even better savings.

AI for Zero Touch Operations

Zero-touch makes network operations more data-driven, predictive and proactive. Technologies like artificial intelligence reduces the need for manual activities and enables greater business agility

AI for Fraud Detection

With the help of AI, it becomes easier to implement algorithms that can detect and respond to fraudulent activities on the network.

Machine learning algorithms are used to cut down the many fraudulent activities by prominent telecom companies such as fake profiling, illegal access to the network, and more. The algorithm learns the difference between faulty and normal trends and finds anomalies by analyzing the data.

With the aid of these advances, the system can detect anomalies occurring in real time. This is far more efficient than what human analysts can do.

AI in 5G Dynamic Network Slicing

5G can support network slicing. Slicing involves isolating portions of the network and customizing it for specific use cases. AI can play a role in dynamically managing and optimizing these network slices based on the applications and services they are running. Close and responsive management ensures each slice can access the performance and resources it needs. AI analysis of customer behavior can even enable intent-based optimization of network slices.

Wider Network Analysis and Planning

AI-driven analytics can help gain insights from massive data generated by an operator's entire 5G network. This data can be used to improve network planning, traffic management, and improve the business intelligence network operators rely on

Network Optimization

AI and ML algorithms can be used to optimize the 5G network, by predicting traffic patterns and adjusting the network accordingly. This can help to reduce network congestion and improve the overall user experience.

Network Analytics

AI and ML can be used to analyze large amounts of data in real time generating insights that can be used in network optimization, security analysis and personalization of services for end users.

Network security: AI and ML can be used to detect and prevent

Virtual Assistants and Chatbots

Conversational AI platforms are one of the biggest influencers on the growth of the AI in telecommunication market. These virtual assistants, or chatbots, as they are also known, can automate the handling of customer requests.

2.1 What Types of AI Will Help Telco?

Being an umbrella term, AI can be divided into different technology segments, such as machine learning, deep learning, natural language processing, image processing, and speech recognition. However, a central role in the telecommunications industry belongs to machine learning, deep learning, and natural

language processing

Machine Learning

Machine learning (ML) is a subset of AI, which focuses on a computer program that is able to parse data using specific algorithms. Such a program is able to modify itself without human intervention, producing the desired output based on analyzed data. In essence, using ML techniques, a machine is trained to analyze huge amounts of data and then learn to perform specific tasks.

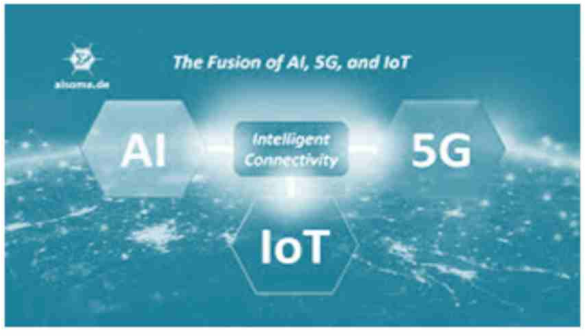
Deep Learning

Deep Learning (DL) is a subset of machine learning, whose algorithms and techniques are similar to machine learning, but capabilities are not analogous. The main difference between ML and DL lies in the interpretation of the data they feed on. In DL, a computer system is trained to perform classification tasks directly from sounds, texts, or images by using a large amount of labeled data, as well as neural network architectures.

Natural Language Processing

Natural Language Processing (NLP) is a sub-field of AI that is focused on enabling computers to understand, interpret, and manipulate human language. In essence, NLP allows machines to read texts, hear sounds, interpret them, and measure sentiments.

3. Future outlook of AI in Telecommunications



AI in the telecom market is increasingly helping operators manage, optimize and maintain infrastructure and customer support operations. Network optimization, predictive maintenance, Virtual Assistants, RPA, fraud prevention, and new revenue streams are all examples of telecom AI use cases where the technology has helped deliver added value for enterprises.

As big data tools and applications become more available and sophisticated, the future of AI in the telecom industry will continue to develop. Employing AI, telecoms can expect to continue accelerating growth in this highly competitive space.

The applications for AI across telecoms are endless. AI in mobile network infrastructure is expected to lower costs by automating functions that typically require human interaction and to speed new revenue-generating service offerings, which becomes increasingly important in the deployment of edge, open radio access networks (Open RAN), and cloud-native 5G cores. 5G is the latest generation of wireless technology providing faster speed, lower latency, and the ability to connect a very high density of sensors. AI brings a new computing paradigm in which algorithms learn from the data to efficiently handle the ever-growing amount of information that sensors generate, including being able to infer patterns and trends in near real-time.

4. Conclusion

Overall, the integration of AI with 5G networks has the potential to significantly improve network performance, efficiency, and security and user experience. The use of AI in the Telecom industry is booming. And it is still growing multiple telecom companies around the globe are experimenting with AI algorithms

and are harnessing capabilities

The telecommunication industry continues to be the epicenter of growth, new opportunities and innovation with the integration of Artificial Intelligence and cloud-based technologies to make it highly competitive for all. With 5G, the Internet of Things and cloud computing, artificial intelligence is radically reshaping the telecommunications landscape in an era of advanced digitization and high-speed technological development

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OPEN RADIO ACCESS NETWORK ARCHITECTURE & INTERFACES

R P Porwal

Open RAN" is the movement in wireless telecommunications to disaggregate hardware and software in radio access network and to create open interfaces between them Most of the CAPEX required to build a wireless network is related to the RAN segment, reaching as high as 80% of the total network cost. Any reduction in the RAN equipment cost will significantly help the bottom line of wireless operators as they struggle to cope with the challenges of ever-increasing mobile traffic and declining revenues

It is an effort to describe the RAN evolution towards open models and make an attempt to indicate potential open RAN benefits. Aim of this article is to simplify the world of Open RAN Explaining the different between C-RAN , V-RAN and O-RAN. and also give an insight on how Radio Access Networks have evolved over the time.

O RAN is a term used for industry-wide standards for RAN (Radio Access Network) interfaces that support interoperation between vendors' equipment and offer network flexibility at a lower cost. The main purpose of open RAN is to have an interoperability standard for RAN elements including non-proprietary white box hardware and software from different vendors. Network operators that opt for RAN elements with standard interfaces can avoid being stuck with one vendor's proprietary hardware and software.

Wireless cellular networks have traditionally operated on closed RAN structures, with network infrastructure equipment such as antennas and base stations built with proprietary equipment from a handful of select suppliers. In this model, the wireless network structure is tightly controlled and closed except to those suppliers. This structure ensures well-designed interoperability of the components and coordination of network functions by the software. Still, sources for backup or replacement parts are limited, and network performance evolution is in the hands of a few.

1.1 Evolution of RAN

The goal of RAN evolution is disaggregation of radio access network hardware and software, to help operators improve flexibility, reduce costs and meet growing demand

Fig.1shows evolution path from D-RAN to O-RAN

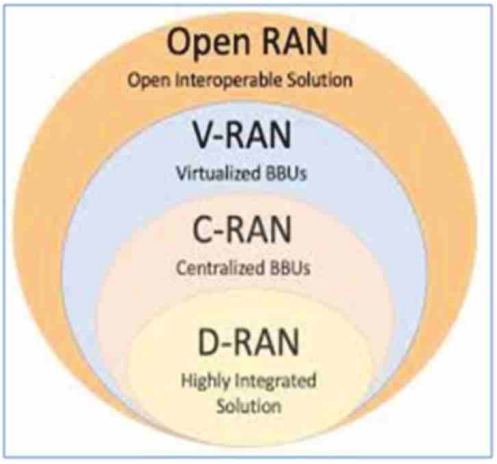


Fig.1-Evolution of Radio Access Network

1.2 Overview of RAN types

(A) D-RAN stands for Distributed RAN

D-RAN is a classical setup where RRU (Remote Radio Unit) and BBU (BaseBand Unit) are co-located at every cell site. They run proprietary applications on specialized hardware. Each radio site with all of its functions are in a single location and connected back to the core network through backhaul as shown in Fig 2

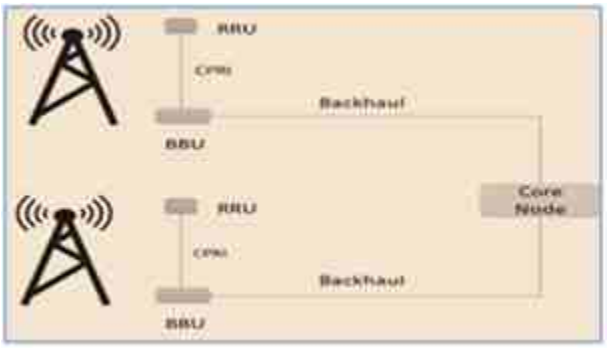
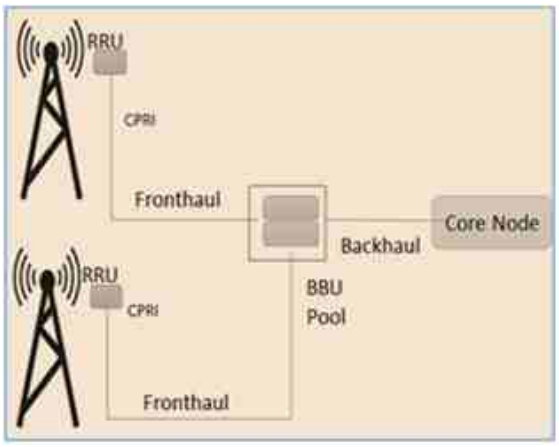


Fig.2 Distributed RAN

(B) C-RAN stands for Centralized RAN or Cloud RAN.

In C-RAN (Cloud RAN) the BBU moves to a centralized location and the cell site only has the antenna and the RRU. This centralization of BBU functionality (also called BBU pool) results in the name centralized RAN or C-RAN. BBUs from several sites are grouped into a pool and located in one location as shown in fig.3This leads to more efficient use of computing resources. but what is important to understand is that we still need software and hardware to be coming from a single vendor.RRU: Remote Radio unit interfaces with an antenna on one end and BBU on the other. It connects to BBU through CPRI interface as shown in fig.3& while fig.4 & 5 shows various options to form C-RAN i.e. without BBU split & with BBU split



`Fig. 3 C-RAN

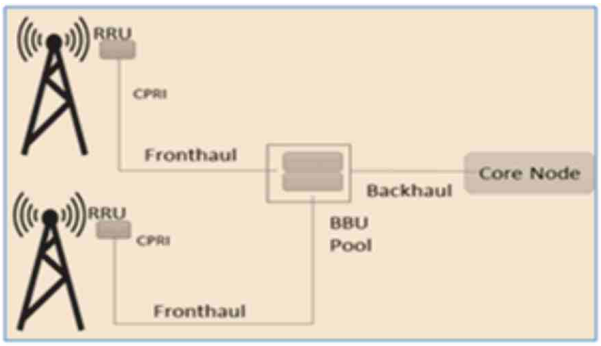


Fig-4CRAN without BBU split (Option 1)

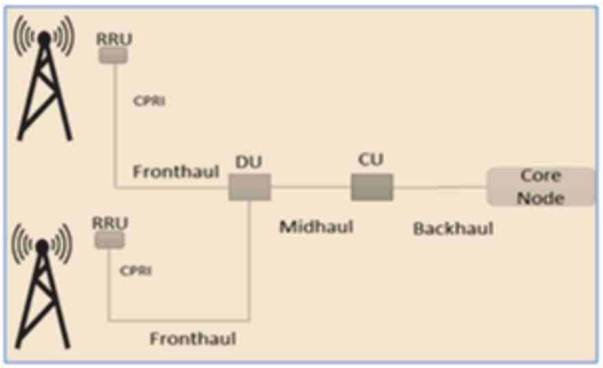


Fig.5 C-RAN with BBU Split (option 2)

(C) vRAN also called Virtualized RAN

vRAN decouples the software from hardware by virtualizing Network Functions. It uses virtual machines (VNF approach) or containers (CNF approach) to deploy CU and DU on top of COTS servers as shown in fig.5. vRAN decouples the software from Hardware by virtualizing Network Functions. It uses virtualization technologies such as NFV or containers to deploy CU and DU over x86 server. (or virtual BBU on a server).as shown in fig.6

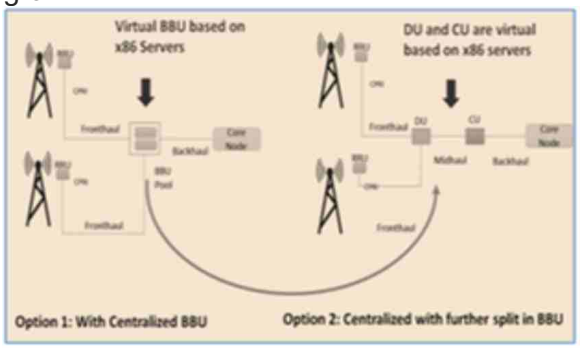


Fig.6 V-RAN

vRAN decouples the software from Hardware by virtualizing Network Functions. It uses virtualization technologies such as NFV or containers to deploy CU and DU over x86 server. (or virtual BBU on a server). So there is no difference between vRAN and C-RAN except that traditionally C-RAN uses proprietary hardware while vRAN uses Network Functions on the server platform. vRAN is infact a type of C-RAN

(D) Open RAN

Open RAN/O-RAN takes vRAN to the next level. While traditionally vRAN is a closed network, as RU, DU and CU, which are all part of the RAN must be bought from the same vendor The O-RAN alliance is working on specifications to open the interface between RRU and DU and further between DU and CU. This means that a customer can mix and match the components from different vendors without being locked to one vendor for all these three components, thus resulting in an open RAN network as shown in fig.7.

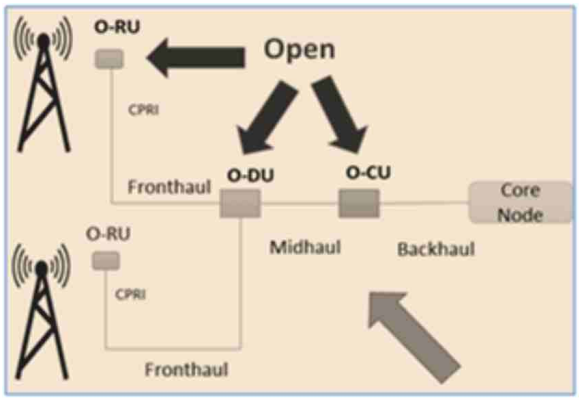


Fig.7 Open RAN

These new open components as per O-RAN alliance's specs are called O-RU, O-DU and O-CU (where O stands for Open) which is actually a modular base station software stack on off-the-shelf server hardware

1.1. Traditional RAN vs Open RAN

In traditional RAN deployments, the software and interfaces remain either proprietary or “closed” by the individual vendor and are often tied to the underlying hardware by the same vendor. Meaning operators cannot put vendor B's software on a BBU from vendor A or connect a radio from vendor A to a vBBU hardware and software from vendor B. Any software upgrades are tied into the installed base, and if an operator wants to do a vendor A swap, they need to rip out all of it: from the vendor A radio to the vendor A BBU hosting the vendor A software - they cannot replace just one component in the legacy RAN deployment. This creates a vendor lock-in

The key thing with Open RAN is that the interface between the BBU and RRU/RRH is an open interface, so, any vendor's software can work on any open RRU/RRH. More open interfaces enable them to use one supplier's radios with another's hardware - which is not possible with C-RAN or V-RAN

The Open RAN makes the RAN open within all aspects and components, with the interfaces and operating software separating the RAN control plane from the user plane, building a modular base station software stack that operates on commercial-off-the-shelf (COTS) hardware, with open north- and south-bound interfaces. This software enabled Open RAN network architecture enables a “white box” RAN hardware - meaning that baseband units, radio units and remote radio heads can be assembled from any vendor and managed by Open RAN software to form a truly interoperable and open “best of breed” RAN. So, a mobile operator can virtualize and disaggregate their RAN, but unless the interfaces between the components are open, the RAN is not truly open

2.0 The O-RAN SYSTEM MODEL

The open RAN standards are being developed using virtual RAN (vRAN) principles and technologies

An Open RAN is disaggregated into three main building blocks:

- Radio Unit (RU)
- Distributed Unit (DU)
- Centralized Unit (CU)

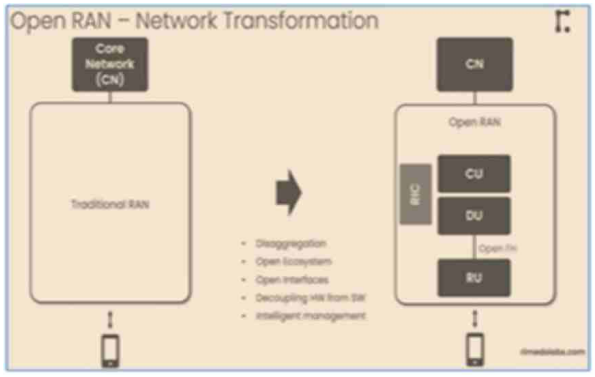


Fig.8 Transformation of RAN

Fig. 8, shows the transformation of the Radio Access Network (RAN) when moving from the traditional approach to the Open RAN. The legacy way of providing RAN is that there is a single black box and the internal interfaces within that box are closed and are in hands of one vendor. Moving towards Open RAN (O-RAN), we are splitting the different functions of the base station into the following entities with open interfaces between them: a centralized unit (CU), a distributed unit (DU), and a radio unit (RU). A similar architecture is defined within 3GPP, but with the O-RAN approach, those entities can be developed by different vendors due to the open interfaces between them (including Open Fronthaul, Open FH). In addition to that, the important part is that the orange box, i.e. RAN intelligent controller (RIC) is extracted from the processing units and allows to reach the management interfaces, like radio resource management (RRM) or self-organizing networks (SON) functions, which control the radio resources and network operation. In the O-RAN concept, this is where the intelligence sits, by the means of artificial intelligence (AI) models for radio network automation.

The O-RAN architecture is well documented in the O-RAN alliance. The key elements of O-RAN architecture are

Service Management and Orchestration Framework (SMO) – includes an integration fabric and data services for the functions it manages. It allows managed functions to interoperate and communicate within the O-RAN. The SMO connects to and manages the RICs, O-Cloud, the O-CU, and O-DU.

RAN Intelligent Controller (RIC) – There are two types of RICs – non-real-time and near-real-time. Both are logical functions for controlling and optimizing the elements and resources of an O-RAN. A near-real-time RIC controls and optimizes elements and resources with granular data collection and communication over the E2 interface. The E2 interface connects the near-real-time RIC with the O-CU and O-DU

- **O-Cloud** – a cloud computing platform made up of the physical infrastructure nodes using O-RAN architecture. It also creates and hosts the various virtual network functions (VNFs) used by the RICs and other infrastructure elements.
- **O-RAN** central unit (O-CU) – Logical node that hosts a handful of protocols, which are the radio resource control (RRC), service data adaptation protocol (SDAP), and packet data convergence protocol (PDCP).
- **O-RAN** distributed unit (O-DU) – Logical node that hosts another set of protocols, which are the radio link control (RLC)

protocol, medium access control (MAC) protocol, and the physical interface (PHY).

- **O-RAN** Radio unit (O-RU) – It processes radio frequencies received by the physical layer of the network. The processed radio frequencies are sent to the O-DU through a front haul interface.

High-level functional partitioning into the CU, DU and RU is shown in fig 9.

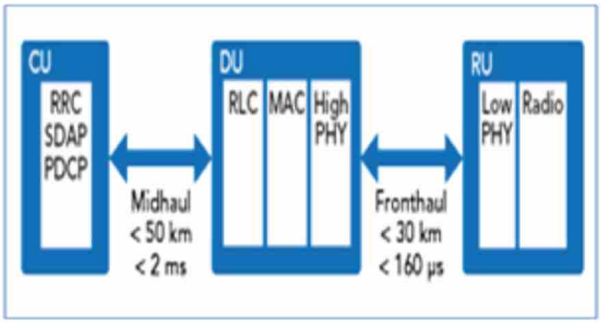


Fig.9 High level functional split in openRAN

3.0.Future outlook

With the move toward Open RANs, operators and integrators need to validate that the technology all works together before it goes into the live network. O-RAN will have many individual components, operators will have to benchmark and test each component independently. Integrating O-RAN components from different vendors and making sure they work properly together requires a little bit of time.

Creating seamless interoperability in a multi-vendor, open ecosystem introduces new test, management and integration challenges that require diligence and cooperation to overcome. In the single-vendor model, accountability is a foregone conclusion and problem isolation and troubleshooting are managed through an established command structure.

Dispersion of vendors could potentially lead to finger pointing when root cause identification is inconclusive. These same complications could plague on-time launch schedules and revenue growth by diluting management and orchestration responsibilities across an array of new O-RAN players.

4.0 Conclusion

The Radio Access Network (RAN) is the expensive, proprietary equipment that connects to cellular antennas, processes the access request and sends it to the core network. Communication Service Providers (CSPs) who need to stay agile to meet the growing demands of enterprise and customers find RANs to be a bottleneck and have turned to vRANs and Open RAN to help Open RAN is about horizontal openness - with open interfaces enabling functions of the RAN to connect with other functions, from a radio unit (RU) to a baseband (DU-CU), to the controller to the NMS/orchestrator.

When RAN is opened up horizontally, it could bring in a new range of low-cost radio players, and it gives mobile operators a choice to optimize deployment options for specific performance requirements at a much better cost.

Open radio access networks (O-RAN) are transforming mobile networks. O-RAN is about the disaggregation of the traditional RAN system into the radio unit (RU), distributed unit (DU) and centralized unit (CU) components and their hardware and software platforms.1 O-RAN fosters innovation by involving more manufacturers in the development of the RAN infrastructure, enabling new entrants to compete and disrupt the market if they can offer a competitive edge. Ideally, the O-RAN specifications will create a broad RAN supplier ecosystem, where operators can pick and choose components from different suppliers and not be bound to a single company. The disaggregation of hardware and software

enables virtualization, meaning large parts of the network functions become virtualized and can be run on commercial off-the-shelf hardware or general purpose processors. Virtualization also enables “cloudification,” where many functions are hosted by multiple servers, typically bundled in one or more data centers.

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APPLICATION OF AI TO DETECT FRAUDULENT SIMs

L. Anantram

The author belongs to ITS 1979 batch and retired as Advisor, MH LSA, DOT in March 2018. He has 37 years of experience in the various branches of telecom. He contributed lot of articles to Telecommunications Journal published by the erstwhile T&D Circle, Jabalpur. After retirement he is blogging articles on telecom and also contributing articles to Newspapers.

SIMs taken on forged documents and in third party's names are involved in the majority of the crimes, taking the advantage of anonymity and untraceability of these SIMs. The fraudsters are creating fake/forged documents with such advanced techniques that conventional text based analysis can never catch them.

Recently it came out in the newspapers that DOT, Maharashtra LSA (Licenced Service Area) has disconnected 21,031 SIMs which were taken using forged documents. Using ASTR (Artificial intelligence and facial recognition powered Solution for Telecom subscriber verification), they could detect such fraudulent connections. Similar disconnections were done by other LSAs also.

"The scenario before the SC verdict in 2018 on Aadhaar, mobile connection linkage"

Mobile operators were activating new connections through Aadhaar Based EKYC authentication. Aadhaar was used as Proof of Identity (POI)/Proof of Address (POA).

DoT was also insisting the operators to conduct Aadhaar based Re-verification (linking the mobile number with Aadhaar) of the already working prepaid connections and the deadline was also fixed for the same.

Aadhaar based EKYC authentication was an easy, cost effective and secure way for SIM activation for the telecom service providers. Prospective customers could just walk in to the POS (Point of Sale) and get a connection.

Filling up of Customer Acquisition Form (CAF)/submission of photographs by the prospective customer and scrutiny of POI/POA documents submitted by the prospective customer before activating the connection by the TSP were not required. CAF was generated by the system itself.

The menace of fake documents was not there. The boarding time of the subscriber was very less. Scanning of CAFs and maintenance of the warehouse for the storage/retrieval of documents was not needed. Aadhaar based EKYC authentication was also used in Port-in of the customer in MNP (Mobile Number Portability).

In the Aadhaar based Re-verification process, the actual mobile connection user was becoming the person on whose name connection was there on the records- a requirement in security angle.

After the starting of the Re-verification process, TSPs had stopped scanning CAFs and POI/POA documents and storing the scanned images.

In view of National Security considerations,

DOT had stipulated that an individual can't have more than nine mobile connections. With Aadhaar based EKYC activations/Aadhaar based Re-verification, it was easy for the TSPs to monitor the number of connections subscribed by an individual as the mobile numbers were linked to the individual's Aadhaar number.

The TSPs were monitoring the > 9 connection cases in the following scenarios:

- New SIM activation
- Port-in through MNP
- Aadhaar Based Re-verification.

If any individual has more than nine mobile connections, further connection (new or Port-in) was denied to him until he surrendered one of the existing ones. With Aadhaar based activation/re-verification of connections, it was easy for DOT to enforce this rule.

1. Situation after the SC verdict

As per the Supreme court Judgement dated 26.9.18, to give new SIM connection, Telecom Service Provider (TSP) can't seek Aadhaar details. Other KYC documents like voter ID card, driving License etc. can be taken as POI/POA document to give a new mobile connection.

The operators may accept a copy of physical Aadhaar or e-Aadhaar letter having masked or unmasked Aadhaar number as proof of identity "if offered voluntarily by the subscriber" for issuing the new mobile connection.

Since Aadhaar based Re-verification was stopped (because of SC verdict), the TSPs had to restart scanning CAFs and POI/POA documents and storing the scanned images.

After the Supreme Court judgement, DOT has brought out a digital process for KYC (D-KYC) of mobile subscribers which envisaged CAF to be embedded with live photograph of the subscriber and scanned images of POI/POA documents thereby digitising the end to end process for onboarding of new mobile subscribers. All the phone connections at present are issued through the D-KYC process.

UIDAI had announced that if any customer, whose SIM was activated through Aadhaar based EKYC, wishes to get her or his Aadhaar EKYC replaced by the fresh KYC, she or he may request the TSP for delinking of her/his Aadhaar by submitting the valid documents which will act as POI/POA.

2. TAFCOP Module

AP LSA , DOT has developed TAFCOP (Telecom Analytics for Fraud management & COnsumer Protection) module which is an AI algorithm that facilitates a mobile subscriber to check the number of mobile connections taken in his/her name. It also facilitates reporting the mobile connection(s) which are either not required or not taken by the subscriber.

This is part of Sanchar Sarathi portal which was launched by the Minister of Communications (MOC) on 17.05.23, World Telecom and Information Societies Day. Sanchar Sarathi portal is a citizen centric initiative of DOT to empower mobile subscribers, strengthen their security and increase their awareness about citizen centric initiatives of the Government.

3. ASTR

This is one of the consumer centric reforms (other two are CEIR (Central Equipment Identity Register) and TAFCOP which are available for the public) launched by MOC on 17.05.23. ASTR is an innovative and indigenous solution developed by Haryana LSA, DOT. This next gen platform can potentially bring down cyber frauds by

detecting and blocking possible fraudulent mobile connections. DOT had issued orders to all the TSPs to share the subscriber database including user's photos with the department. These images constitute the core database on which ASTR is run. Human faces in subscriber's images are encoded using Convolutional Neural Networks (CNN) in order to account for the tilt and angle of the face, opaqueness and dark colour of the images. After that, a face comparison is carried out for each face against all faces in the database and similar faces are grouped under one directory. Two faces are considered to be identical by ASTR if they match to the extent of at least 97.5%. ASTR is capable of detecting all SIMs issued against a suspected face in less than 10 seconds from a database of one crore images. Once the faces are matched, ASTR's algorithm uses Fuzzy logic (Fuzzy logic is a mathematical approach that deals with uncertainty and imprecise information. It allows for the representation of vagueness and partial truth, unlike traditional binary logic) to find similarity or approximate matches for the subscriber names. It also accounts for typographical errors while filling CAF.

This platform:

- Look up if there are more than nine connections against a single individual's photograph.
- It runs a search through the database to see if the same person has taken SIMs under different names.

4. Wayforward

While issuing a new SIM or while acquiring the customer through MNP, it should be ensured by the TSP that the prospective customer is not having nine or more than nine connections already. After this verification only, new SIM should be activated. This will avoid possible fraud by the customer before his SIM is disconnected after detecting that more than nine connections are working. But at the same time this should not delay the activation of SIM for a normal customer. ASTR runs on a CDAC supercomputer and such computing resources can't be established at many places. DOT should examine whether it is practically feasible to detect fraudulent customers before their SIMs are activated using ASTR/ TAFCOP and if there are difficulties in this implementation, it should appeal against SC verdict of 2018 (which says that for SIM activation TSP can't seek Aadhaar details), with convincing arguments.

As per recently enacted Telecommunications act 2023, SIMs will be issued only through verifiable biometric identification. Though in the act, specifically Aadhaar based verification is not mentioned for issuing SIMs, perhaps the rules that will be framed will bring clarity in this regard.

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PON TECHNOLOGY FOR 5G FRONTHAUL

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Mr Rajeev Kumar Gangwar is presently working as a Faculty Head (TX) at ALTTC, Ghaziabad. He has engaged from last 25 years in design, development and conduction of various opticalfibre technology courses (SDH, NGSDH, DWDM, FTTH, CPAN, OTN, RoF etc) for the officers of BSNL, Army, SSB, GAIL, APT (Asia Pacific Tele-community) participants, Commonwealth Telecommunication Organisation (CTO) participants and other organization.

Mr Rajeev Kumar Gangwar was also deputed to deliver presentation on various topics on optical technologies like Next Generation SDH, Passive Optical Network, and Fiber to the Home Technology (FTTH), Optical Wireless Connectivity-FSO etc. in Seminars/Conferences organized by BSNL and IETE. He has also developed and coordinated courses on “Digital Transmission System” and “Optical Fiber Technology” out of total 7 courses for EETP Program(A joint initiative of AICTE & BSNL) launched by BSNL on a countrywide basis.

He has attended training on 10G DWDM at Shenzhen, China and also delivered international training in Nigeria and Philippines under CTO and APT.

Mr Rajeev Kumar Gangwar has also received a prestigious award of BSNL (Vishista Snchar Seva Padak) for the year 2012-13.

5G Networks promise to deliver faster data speeds, ultra-low latency, ultra reliability, increased availability, massive network capacity and a better uniform user experience for various applications and services. Today, Mobile Operators are facing new challenges to keep up with these new demands. Cloud radio access network (CRAN) has emerged as a cost-effective architecture that improves 5G performance. The fronthaul segment of the CRAN requires a high-capacity and low-latency connection. Passive optical network (PON) technology offers a cost-efficient alternative to support 5G and beyond 5G Mobile Network Fronthaul (MFH).

The main purpose of the Fronthaul transport network is to multiplex the traffic of densely deployed radio sites on a common medium with high efficiency. An Optical fibre which provides huge bandwidth capacity with limited latency is considered the promising option to build a transport network.In many countries, passive optical network, or PON, is designed to allow a single fibre from a service provider to provide an efficient broadband connection for multiple end users.PON is flexible, reliable, and efficient enough to provide 5G fronthaul transport for both cellular and fixed broadband in a single network, which gives advantage over other distribution networks that require different types of distribution for different technologies. By using this architecture based on the point-to-multipoint tree topology of PON, operators can reduce the number of fibres that are used.

2.0 Transport Architecture from 4G to 5G

Cloud radio access network(C-RAN) technology is one of the key technologies to increase the efficiency and also bring down costs of 5G networks. In C-RAN, Baseband Unit (BBU) processing is offloaded from individual base stations, called remote units (RUs)to a distributed unit (DU) and central unit (CU), which gives many advantages such as simplified network maintenance, efficient use of processing resources through statistical multiplexing at the CU, reduced costs for

equipment rooms at base station sites etc.

The RAN architecture in 4G consists of evolved packet core (EPC), BBU (Broadband Unit) and remote radio head (RRH). When moving to 5G, the BBU functionality is split into two functional units: a distributed unit (DU), responsible for real time L1 and L2 scheduling functions, and a centralized unit (CU) responsible for non-real time, higher L2 and L3. When moving to 5G, the BBU is disaggregated by putting some of its functions to the RU (Low PHY), DU, and CU, Layer 2 (L2) non-real time and Layer 3 (L3) functions from BBU to CU, a distributed unit (DU) is responsible for Layer 1 (L1)/L2 real-time functions and the rest of L1 functions from BBU to RU. Part of the user plane (UP) functions are also moved from the evolved packet core (EPC) to the CU and DU. EPC functions are redistributed among the next generation core (NGC), CU and DU. The two new transport links between CU and DU and between DU and RU are frequently called fronthaul-II (or Midhaul) and fronthaul-I (or simply Fronthaul), respectively. The specific functions deployed in CU, DU, and RU are well defined.

The Fig. shows the architecture evolution from 4G to 5G.

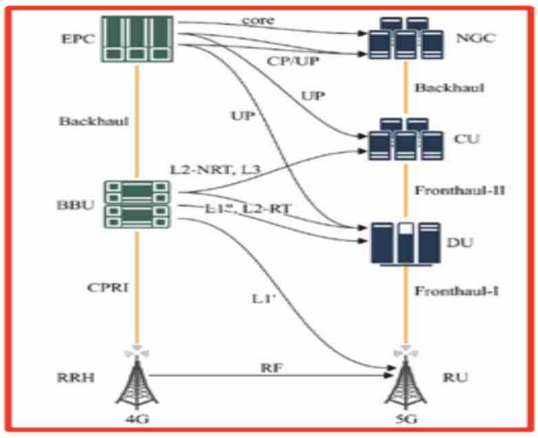

Fig. 1: Evolution from 4G architecture to split function architecture in 5G

The 5G RAN architecture allows for a range of deployment options, supporting a range of 5G services. There are multiple options on functional split (how the RAN can be disaggregated into distributed and centralised components), which offer different trade-offs. The 5G RAN has two main functional splits options: high layer split (HLS) and low layer split (LLS).

3.0 Function Split Options and Transport Bandwidth Requirement

The 5G RAN architecture allows for a range of deployment options, supporting a range of 5G services. There are multiple options on functional split (how the RAN can be disaggregated into distributed and centralised components), which offer different trade-offs. The industry has so far identified two split options i.e.,high layer split (HLS) option-2 and low layer split (LLS) option-7 to address operator requirements. The option 7 splithas been further diversified by several forums, both in view of different modes of cooperation between multiple radio sites and in view of fixed network transport requirements.For split option 7 (intra-PHY), multiple sub-options have been defined (7.1, 7.2, and 7.3).

The function split option reduces FH data rate by redefining the task distribution between BBU and RRH. Possible mappings of the functional split options F1 and Fx to the CU/DU/RU architecture are illustrated in Figure. Each of the three elements, CU, DU and RU can host any of the signal processing functions.

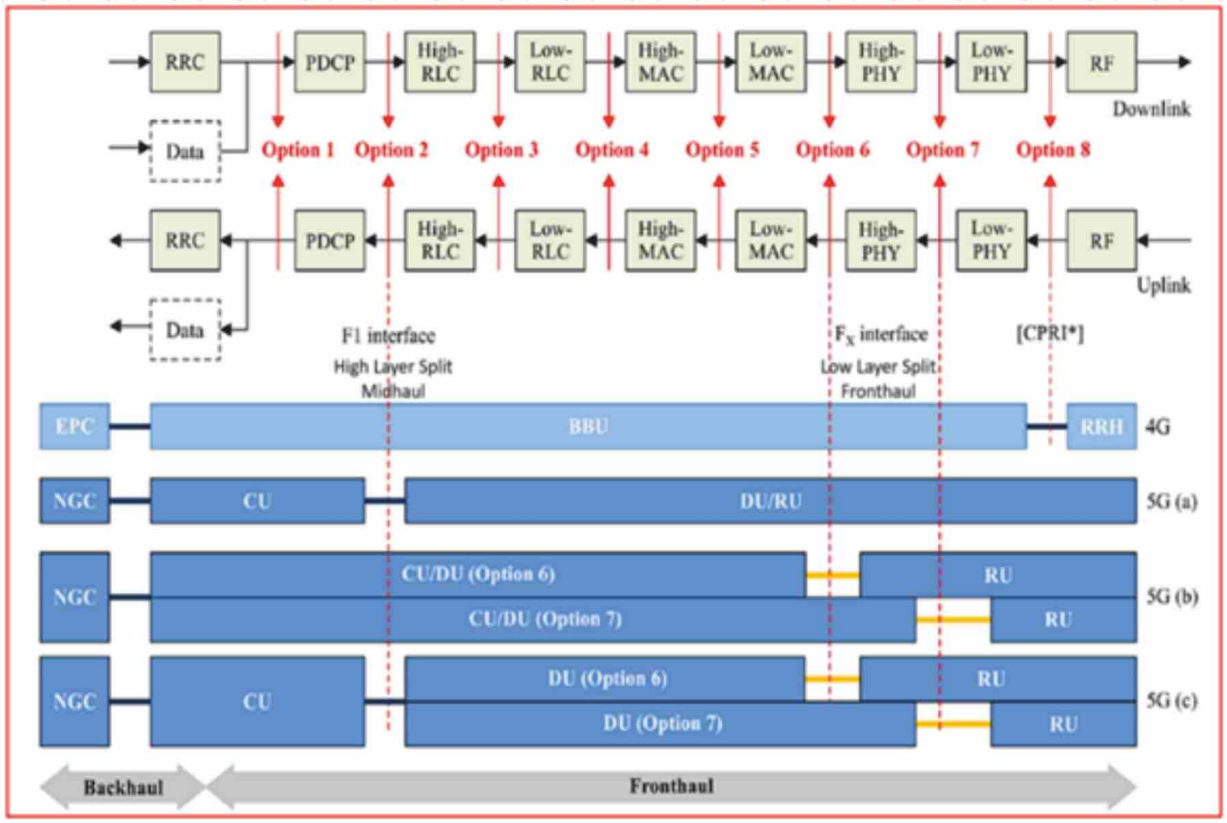

Fig 2: Functional split options and mapping of CU/DU/RU functions according to the split points. 5G(a) high layer split (F1); 5G(b) low layer split (Fx); 5G(c) cascaded split

* CPRI (Common Public Radio Interface) is one possible transport protocol for option 8.

To provide a rough insight into possible scaling of bit rates when going through the different split options, Table-1 shows the transport data rates calculated for a particular cell scenario [3GPP TR 38.801] having:

- 100 MHz radio bandwidth,
- 256-QAM modulation,
- 8 MIMO layers,
- 32 antenna ports (same for downlink and uplink), and
- radio frequency range of < 6GHz

It is observed that option 1 to 7 require a low amount of data and allows the network operators to statistically and efficiently aggregate traffic among multiple cells thus permitting the use of shared media in FH interface. However, each functional split option offers different trade-off between RRH complexity, system performance, and bandwidth requirements.

Table 1 – Transport bit rates and latency ranges at different functional split interfaces, adapted from Annex A in [3GPP TR 38.801]

Protocol split option	Required downlink bandwidth	Required uplink bandwidth	One way latency (order of magnitude)
Option 1	4 Gbit/s	3 Gbit/s	1-10 ms
Option 2	**4016 Mbit/s**	**3024 Mbit/s**	
Option 3	[lower than Option 2 for UL/DL]		
Option 4	4000 Mbit/s	3000 Mbit/s	100 to few 100 µsec
Option 5	4000 Mbit/s	3000 Mbit/s	
Option 6	**4133 Mbit/s**	**5640 Mbit/s**	
Option 7a	**10.1-22.2 Gbit/s**	**16.6-21.6 Gbit/s**	
Option 7b	**37.8-86.1 Gbit/s**	**53.8-86.1 Gbit/s**	
Option 7c	**10.1-22.2 Gbit/s**	**53.8-86.1 Gbit/s**	
Option 8	157.3 Gbit/s	157.3 Gbit/s	

Note: Bit rates shown in Table only apply for the very particular cell site configuration as described above. The bit rates at one or more split points sensitively change with any modification of the cell site configuration and shall hence not be taken literally for other cell sites.

4.0 PON Architecture for 5G Fronthaul Transport

Both 3GPP and IEEE describe the concept of layered network architecture in (3GPP TS 38.401& IEEE 1914.1). According to their definition, CU/DU/RU belong to the radio network layer (RNL), while OLT/ONU belong to the transport network layer (TNL) as illustrated in Figure.

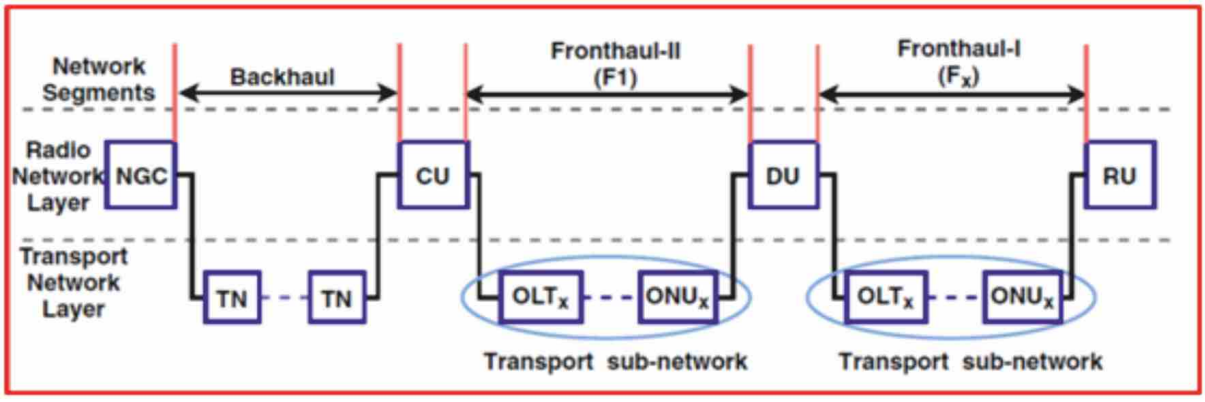

Fig 3: Concept of layered structure showing RNL (CU, DU, RU) and TNL (OLT, ONU)

The PON network that is deployed to enable fixed access/broadband services, which can alsobe used for 5G fronthaul by sharing the network. By using this architecture operators can save the number of fibres that are used but in order to avoid any degradation to fixed access/user services, a more practical scenario is to build dedicated PONs specifically for mobile fronthaul as given below:

4.1 Low Layer Split (LLS) Fronthaul

Figure shows a use case for dedicated PON to support low layer split. Since low layer split has strict latency requirement, WDM-PON (Wavelength Division Multiplexing-PON) can be used for this use case. A dedicated TWDM-PON (TDM Wavelength Division Multiplexing-PONwould be more resource efficient due to its ability of statistical multiplexing. It would however need improved bandwidth allocation and ranging schemes. It is to be noted that each OLT CT can support multiple ONUs.

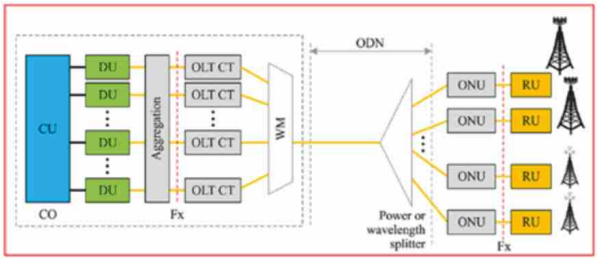

Figure 4: Low layer split fronthaul based on dedicated PON

4.2 High Layer Split (HLS)Fronthaul

High layer split can be supported by dedicated PON for wireless services as shown in Figure. Compared with low layer split, the requirement of both bandwidth and latency are much relaxed. Cascaded split can also be supported when a second ODN is appended as shown in the bottom part of the figure.

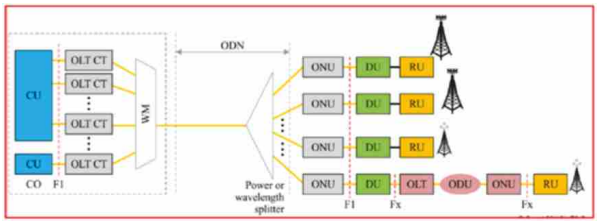

Figure 4: High layer split fronthaul based on dedicated PON

4.3 Mixed high layer and low layer split

A PON fronthaul with mixed low layer and high layer splits is possible when considering sub-tended RU from a central site as shown in Figure. It is to be noted that the CUs could be separate units as shown in Figure or share the same unit.

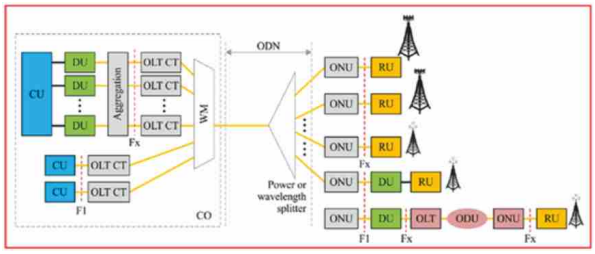

Figure 5: Mixed Low layer and high layer splits fronthaul based on dedicated PON

5.0 Latest PON standards:

The latest PON standards from ITU with their corresponding capacity are given below:

- **XG-PON (10G down / 2.5G up):** ITU G.987, 2009. XG-PON is essentially a higher bandwidth version of GPON. It has the same capabilities as GPON and can co-exist on the same fibre with GPON.
- **XGS-PON (10G down / 10G up):** ITU G.9807.1, 2016. XGS-PON is a higher bandwidth, symmetric version of GPON. Again, it features the same capabilities as GPON and can co-exist on the same fibre with GPON. XGS-PON deployments are just beginning.

- **NG-PON2 (10G down / 10G up, 10G down / 2.5G up):** ITU G.989, 2015. NG-PON2 systems have a baseline capacity of 40 Gbit/s using four wavelength channels with line rates of 10 Gbit/s downstream and 2.5 Gbit/s upstream. NG-PON2 co-exists well with GPON, XG-PON, and XGS-PON.
- **50G PON:** In September 2021, the first version of the 50G-PON standard was officially published in ITU-T, including technical specifications that support asymmetric rates (50G/12.5G, 50G/25G) and that support two generations of coexistence (coexistence with 10G PON or coexistence with GPON). In September 2022, ITU-T consented the first amendment of the 50G-PON standard (Amd1), which added the technical specifications of the symmetric 50G-PON (50Gb/s in downstream and 50Gb/s in upstream), and that supports the coexistence of three generations (50G-PON, 10G-PON and G-PON coexist at the same time).

6.0 Conclusion

PON is certainly the best solution for 5G fronthaul transport, because it is already available and provides single network that supports both broadband and 5G cellular. Moreover, PON optimises cost while enables flexible, reliable and efficient fronthaul transport solution and having excellent capability of sharing fibre resources and its wide deployment around the globe with its unique feature of providing low latency and higher data rate capabilityhave made it dominant technology for 5G Fronthaul transmissions.In September 2022, recommendations hasalready been published in the ITU-T for a 50 Gb/s line rate passive optical network (PON) system which will take a significant leap in line rate from the 10 Gb/s systems being deployed today in fibre access applications.

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