Saudi Arabia
Centre for the
Fourth Industrial
Revolution

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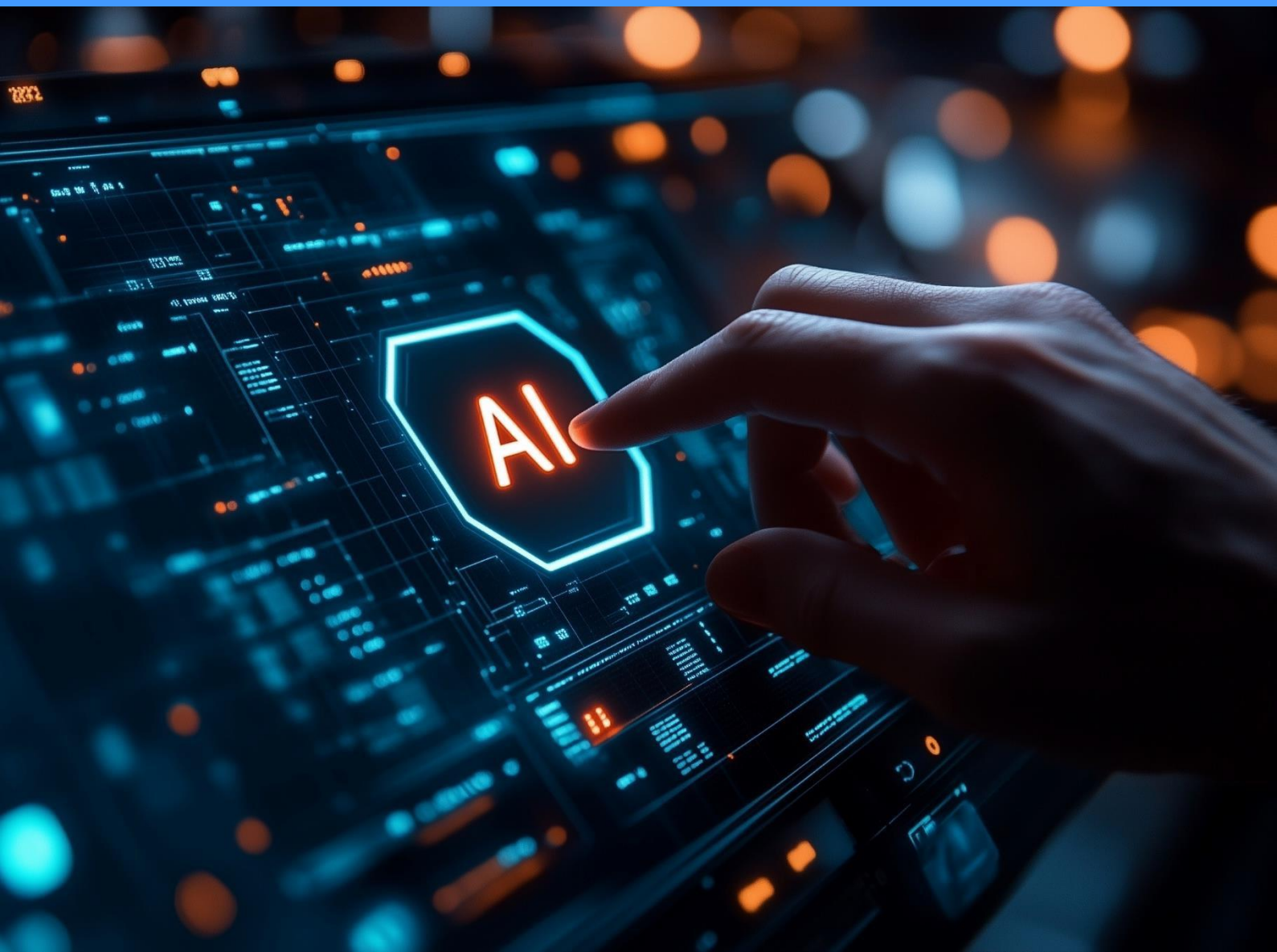
AI's Role in Mobile Networks

Community Paper

March 2025



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Acronyms

3GPP	3rd Generation Partnership Project
5G	5th Generation of Cellular Network Technology
AI	Artificial Intelligence
AIOps	Artificial Intelligence for IT Operations
AIaaS	Artificial intelligence as a service
AR	Augmented Reality
CAPEX	Capital Expenditure
CSP	Communications Service Providers
GPRS	General Packet Radio Service
IA	Information Architecture
IMT	International Mobile Telecommunications
ITU	International Telecommunications Union
ML	Machine Learning
MLOps	Machine Learning Operations
MR	Mixed Reality
RAN	Radio Access Network
SDN	Software Defined Network
SGSN-MM	Serving GPRS Support Node-Mobility Management Entity
TCO	Total Cost of Ownership
VCN	Virtualized Central Unit
VDN	Virtualized Distributed Unit
VNFS	Virtualized Network Functions
VR	Virtual Reality
XR	Extended Reality

Abstract

The landscape of mobile networks is experiencing a fundamental transformation with the rise of Artificial Intelligence (AI) as a game-changing force. This community paper highlights the important aspects of mobile networks on which AI can have a profound impact

This paper will discuss the mobile network vision for 2030, highlighting key stages and the mandate of each stage. In addition, it will provide an analysis on the impact of AI in relation to various network aspects, identifying dimensions that impact how mobile networks should develop, be developed, managed, and operated. It will further explore the ethical considerations and challenges associated with deploying AI. The paper offers a roadmap for organizations leveraging AI to transform their mobile network operations.

Executive Summary

Mobile networks and AI are converging to transform fields that were previously thought to be the exclusive preserve of human expertise. AI is transforming diagnostics, providing rapid analysis, and offering predictive insights to support the decision-making process.

AI has been observed in several use cases in the telecom domain for years and is increasingly being used to improve network performance and enable intelligent network automation.
Amidst the AI boom, machine learning has emerged as a transformative force, empowering organizations to automatically extract patterns from vast amounts of data.

AI-powered dynamic expansion utilizes historical pattern recognition and real-time trend analysis to ensure optimal resource utilization and minimize overprovisioning. This results in a decreased total cost of ownership.

The emergence of AI is poised to transform the telecommunications industry by enhancing operational efficiency, optimizing network performance, and elevating overall business processes. AI can also orchestrate and manage virtualized network functions (VNFs), enabling dynamic and flexible network configurations.

The native AI network will excel in situations with inherent randomness, non-determinism, and unstructured data. It can be used to uncover hidden patterns, predict potential issues, and even automate complex tasks.

AI-native network architecture provides a unified platform to manage the entire lifecycle of AI artefacts, including Models, Pipelines, Features, Datasets, etc. AIOps or MLOps capabilities are essential for organizations that want to effectively manage and deploy AI applications.

To define the AI native journey in the telecom industry, the guiding principle is to increase the span and autonomy of AI native implementation, while decreasing the level of human intervention and control. While ethical considerations, safety, and trustworthiness are crucial across all AI implementations, they vary significantly across different regions. The maturity model emphasizes flexibility and adaptability.

Significant research is underway to enhance the fairness and transparency of AI algorithms, but there are still risks. It's crucial to incorporate ethical considerations, rigorous testing, and robust oversight measures in AI development and deployment.

Introduction

In the hyper-interconnected world, two technological forces, -mobile networks and AI, have emerged as transformative pillars, reshaping the way we communicate, work, and navigate our daily lives.

Mobile networks have become the backbone of our modern world, and their importance cannot be overstated. On the other hand, mobile phones (customer devices), in just a few decades, have evolved from clunky, dull, and expensive devices to sleek smartphones, which we cannot imagine life without.

Mobile networks, the lifeblood of our digital age, have evolved from limited availability to being omnipresent in almost no time. In today's world of connectivity, we are experiencing the evolution of hardware and a paradigm shift from mobile networks to AI-enabled networks.

Global Mobile Connections[1]

5.5B

Mobile Internet connections[6]

4.4B

* End of 2022

In **2022**, mobile technologies and services generated **5%** of global GDP, a contribution that amounted to **$5.2** trillion of economic value -value, supporting **28** million jobs across the wider mobile ecosystem[1].

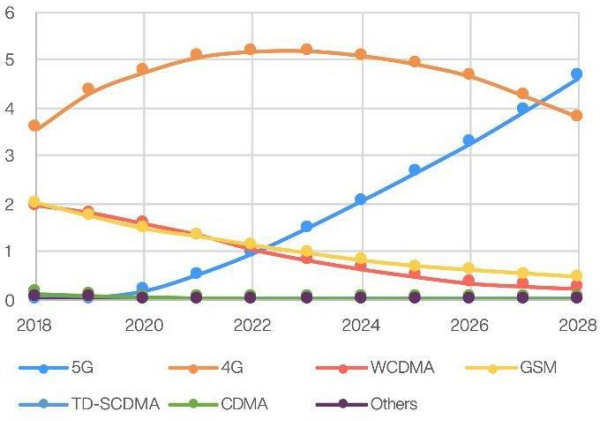

Figure (1) Mobile Subscription (billions)[2]

Introduction (AI)

-Mobile technology has been progressing steadily with an uninterrupted development of successive generations of mobile networks and technologies. In parallel, AI, with its ability to simulate human intelligence, is birthing a new era of possibilities. AI is being used in almost every field, transcending automation and augmenting our capabilities. Imagine the convergence of these two forces: Mobile networks and AI, where the agility of connectivity and high performance meets the prowess of intelligence.

AI is making inroads in areas once considered the exclusive preserve of human expertise, such as Healthcare, Finance, Investment decision-making, Crisis Response, Emergency Management, and beyond. In healthcare, AI is revolutionizing diagnostics, providing rapid analysis of medical images, and offering predictive insights for personalized treatment.

As AI continues to evolve, its influence extends beyond these realms into other industries, demonstrating potential to enhance human capabilities, ushering in a new era of innovation and collaboration between artificial intelligence and humans.

In the telecom domain, the increasing value of AI in use cases has been observed for several years. Along with AI's adoption in key areas, the value of AI is prominent in mobile standardization, i.e., 3GPP specifications of 5G and 5G Advanced, where AI-based solutions are increasingly being used to improve network performance and enable intelligent network automation.

The nuanced implications of AI native's multifaceted aspects for Communications Service Providers (CSPs) are gradually becoming clearer, offering a more distinct understanding of how they should strategically plan the evolution of their networks.

The term "AI native" may encompass systems, technologies, or individuals inherently possessing knowledge, skills and capabilities to integrate with other AIs and its applications[10].

Future Terrestrial network

IMT-Advanced, also known as IMT-2020, strategically implemented a suite of advantages such as higher spectrum efficiency, reduced latency, enhanced reliability, increased connection density and improved energy efficiency. These progressive enhancements aimed to adeptly accommodate the evolving use cases and applications expected to characterize the network landscape by the year 2020.

The foundational principles within ITU's vision for IMT networks, extending towards 2030 and beyond, encompass the following dimensions:

Figure (2) IMT 2030 Driving Axis

ITU's IMT 2030 vision aims to develop communication systems that enable widespread connectivity through innovative applications across industries that promote sustainable, resilient, and inclusive digital ecosystems. The pivotal driving factors shaping future technological trends beyond 2030 include:

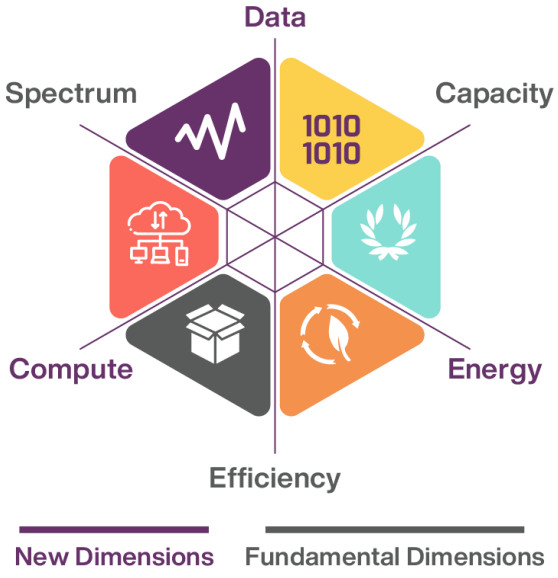

Figure (3) Driving factors shaping future technology

The verticals within the ITU's vision for IMT networks toward 2030 and beyond highlights:

01	Customization of user experience
02	Privacy due to increased data economy
03	Intelligent assistants
04	Transhumanism and digital twins
05	Customization of user experience
06	Immersive digital realities AR/VR/MR/XR

The next-generation networks, enablers for Industry 4.0 require higher reliability and QoS for both consumers and industrial applications. Industrial devices for automated tasks and haptic applications, notably multi-stream holographic applications, require precise timing synchronization and stringent jitter requirements[12].

Remote machine operations require the use of virtual reality (VR), and holographic communications aided by tactile sensors for the actuation and control via kinaesthetic feedback[3].

Kinaesthetic feedback is sensory input related to the awareness of the position, movement, and tension of one's muscles and joints[13].

Remote and robotic surgery is an application of tactile and haptic internet applications.

Current systems cannot fully provide the technical requirements for haptic internet capability.

AI serves as the blueprint for the future communication systems, acting as the cornerstone for a pervasive intelligence. A distinctive feature of upcoming communication systems, in contrast to IMT-2020, lies in their utilization of mobile technologies to facilitate the widespread integration of AI. Furthermore, these systems leverage radio networks to enhance the pervasiveness of distributed Machine Learning (ML)[3].

AI & Mobile Networks

The expanding domain of Cognitive Computing, and the practical application of Artificial intelligence (AI) has introduced a transformative era of value creation. By emulating the cognitive characteristics of human expertise, these systems exhibit an extraordinary capability to tackle problems with a human-like reasoning process. To achieve robust and synergetic decision-making, cognitive systems embark on a four-step journey[11]:

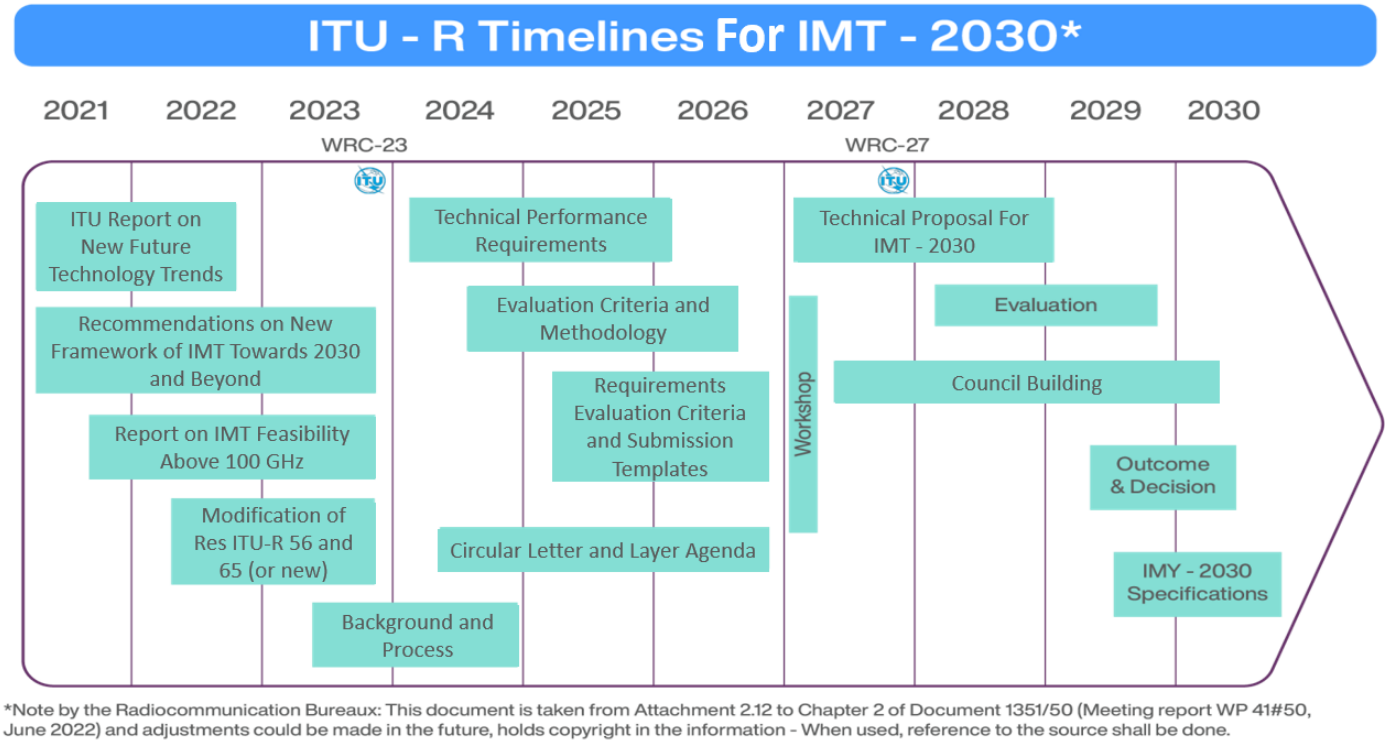

Figure (4): ITU – R IMT 2030 Timelines

Four-Step Journey[11]:

(1) Observation: Observe the visible phenomena.
(2) Interpret: Draw on what we know to generate hypotheses.
(3) Evaluate: Analyze the hypotheses (which is right or wrong)
(4) Decide: Make informed decisions.

By seamlessly integrating these four steps, cognitive systems harness the power of AI to revolutionize decision-making processes, unlocking a new frontier of efficiency and value creation.

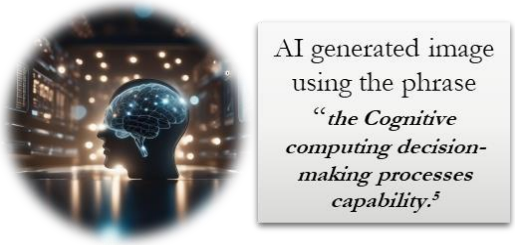

Figure (5): Text Base AI generated Image

Amidst the AI boom, the practical application of machine learning has emerged as a transformative force, empowering organizations to automatically extract patterns and rules from vast amounts of data, often referred to as "big data." This process, driven by specific criteria, enables machine learning and deep learning algorithms to learn and accumulate knowledge autonomously,
expanding their understanding of the underlying patterns and rules.

AI's fundamental role in real-world applications manifests in three distinct functions[4]:

(1) Identification: AI formulates and executes plans efficiently based on the insights from identification and prediction.
(2) Prediction: Through an in-depth analysis of temporal patterns, AI forecasts future trends with a higher degree of accuracy.
(3) Execution: AI formulates and executes plans efficiently based on the insights from identification and prediction.

AI's ability to seamlessly integrate these three functions has revolutionized the way we interact with technology, unlocking a new era of intelligent decision-making and enhanced productivity. Traditional network architecture relies heavily on demand forecasting, which is based on the need to account for peak demand periods that may be infrequent and short-lived. This process often leads to overprovisioning and increased CAPEX. Therefore, network resources remain underutilized for a significant portion of the time, squeezing the total cost of ownership (TCO).

In contrast, AI-powered dynamic expansion utilizes historical pattern recognition and real-time trend analysis to optimize resource allocation. AI-powered networks can intelligently adapt to fluctuating demand, ensuring optimal resource utilization and minimizing overprovisioning.

The telecommunications industry is poised for a transformative era as Artificial Intelligence (AI) emerges as a driving force in mobile network evolution. AI's ability to harness and analyze vast amounts of data, coupled with its potential for real-time processing, holds immense promise for enhancing operational efficiency, optimizing network performance, and elevating overall business processes.

AI-driven expansions align seamlessly with operational excellence by providing data-driven decision-making.

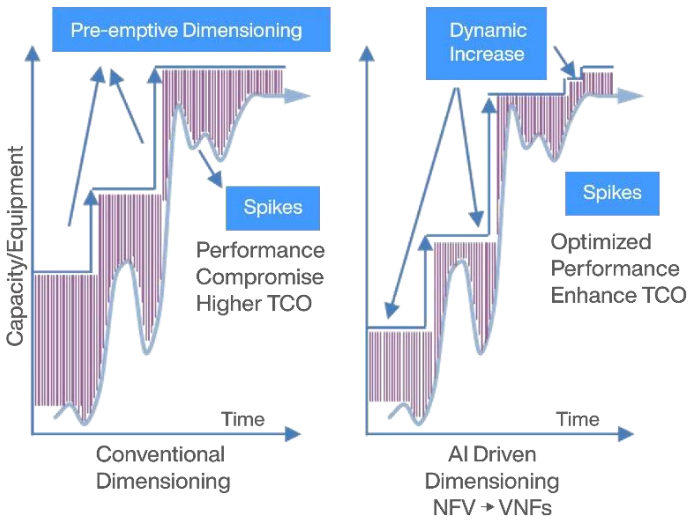

Figure (6): Dimensioning Comparisons

The transformative impact of AI extends beyond operational efficiency, augmenting and enhancing prevailing trends in mobile network architecture and technology such as:

Network Virtualization Function:
AI can orchestrate and manage virtualized network functions (VNFs), enabling dynamic and flexible network configurations for faster service provision, network expansion, and resource optimization.

Software Defined Network:
AI complements SDN by providing real-time insights into network behavior, enabling intelligent traffic routing and congestion management.

Open RAN:
AI can facilitate the integration of Open RAN architectures, enabling a more open and interoperable network ecosystem providing optimized vCU and vDU configurations.

AI Framework

The emergence of AI-native environments represents a transformative shift in telecom network management, characterized by the deep integration of AI capabilities throughout the network lifecycle. From planning and design to deployment, AI is no longer an afterthought but an integral component of network operations and management.

These benefits extend far beyond operational efficiency. By leveraging AI's ability to analyze vast amounts of data, it can uncover hidden patterns, predict potential issues, and even automate complex tasks. This novel approach enhances network reliability and security and frees human experts to focus on higher-value strategic initiatives.

AI-native environments are data-driven knowledge-based ecosystems, in this dynamic interplay of continuously consuming and generating data, AI adapts and learns, augmenting existing rule-based mechanisms to respond proactively to changing demands, optimize resource utilization, and deliver exceptional performance.

The transition towards AI-native environments is not merely a technological advancement but a paradigm shift in network management. By embracing AI as a fundamental component of the network lifecycle, network providers can unlock unprecedented efficiency, adaptability, and innovation levels.

The journey, to develop AI native architecture, starts with developing Information Architecture (IA).

The reality is there is no artificial intelligence (AI) without Information Architecture (IA).

Many organizations can't embark on this journey because 80% of their data is locked in silos and it is not business ready. So, how do you turn your aspirations into outcomes?

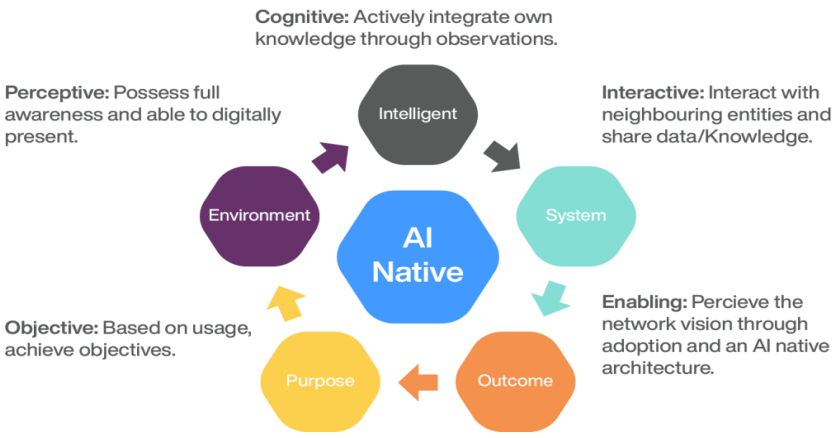

Figure (7): AI native in telecom context

The AI ladder has four steps:

1- Data Collection: Make it simple and accessible "Information Architecture".
2- Data Organization: Create a business-ready analytics foundation.
3- Data Analysis: Analyze both for trust and transparency.
4- Infuse the data.

In other words, AI is used for the operations of the entire business.

The AI ladder starts with modernizing all the data on a single platform that runs on a cloud for maximum utilization. The first step in this ladder is called Information Architecture.

- To develop AI native architecture, any architecture should be equipped with the following: Intelligence everywhere; Distributed data infrastructure; Zerotouch;
- AIaaS

There are three approaches to implementing or augmenting AI in the existing systems as follows[6]:

(1) Replacing an existing functionality using AI techniques.

Telecom vendors are placing AI functionality in their products in the mobility management entity (SGSN-MME). Other examples are Automated Data Entry, Predictive Maintenance, Fraud Detection, etc.

(2) Adding a completely new AI-based component:
Some existing examples include AI-powered energy optimizers and 5G-aware traffic management.

(3) Adding an AI-based component that acts as a control for legacy component(s).

AI-based control provides automation, optimization, and/or extra features on top of the legacy functionalities, as in AI-powered advanced cell supervision.

Both the first and second approach require backward compatibility with the existing system implementation.

Native AI Mobile Networks

In the telecommunications sector, the convergence of AI and network architecture marks a pivotal moment. AI's ability to analyze big data, make real-time decisions, and optimize resource allocation holds immense promise for enhancing operational efficiency, optimizing network performance, and reducing TCO.

AI techniques excel in situations where there is inherent randomness, non-determinism and unstructured data. Where the complexity of capturing patterns and correlations in available data is based on complex inputs. It takes an inordinate amount of effort by humans to train machines to make use of the available data to extract the pattern and assist humans in decision-making.

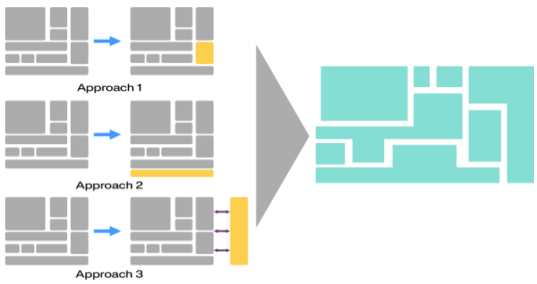

Figure (8): Native AI System[7]

The guiding principle is to increase the span and the autonomy of the AI implementation progressively, while at the same time, decreasing human intervention and control, allowing personnel to focus on specific goals and monitoring outputs.

AI's benefits extend far beyond operational efficiency. By leveraging AI's ability to analyze vast amounts of data, it can uncover hidden patterns, predict potential issues, and even automate complex tasks. This novel approach enhances network reliability and security and frees experts to focus on higher-value strategic initiatives.

Maturity Model – Native AI

Well-structured and robust data availability is key in the native AI architecture. Various data streams with different purposes are required to integrate seamlessly. This implies that data infrastructure and model orchestrators need to interact with each other. Sometimes, data may be transported to AI, and other times, it may be more efficient to bring AI closer to the data. The Data Ingestion Architecture is expected to evolve continuously as AI technology advances.

To achieve this maturity, several functions need to be in place, such as data observability and pre-processing, feature engineering, model training and model drift detection, and execution monitoring.

AI-native network architecture will provide a unified platform to manage the entire lifecycle of AI artifacts, including Models, Pipelines, Features, Datasets, etc. This capability is referred to as AIOps or MLOps which aims to streamline the development, deployment, and maintenance of AI applications.

The integration of AIOps or MLOps capabilities into the AI-native network architecture is essential for organizations that want to effectively manage and deploy AI applications.

-The adoption of AIOps/MLOps and intelligence everywhere implies that AI techniques can be used in a cross-cutting fashion across the whole architecture, and it is not limited to one layer of the architecture. The same goes for the data infrastructure. Data and knowledge need to be shared across layers and AI techniques can be applied in each layer and even across layers.

Automation of AI and data management should be fully autonomous. Personnel would still be in control of requirements by expressing these to the system and ensuring that they are completed without manual intervention. This aspect is called zero-touch. Introducing zero-touch for managing AI and data may be an enabler for a fully autonomous network, which is a network with self-configuration, self-healing, self-optimization, and self-protection capabilities.
In the context of AI native and its implications for architecture, the pertinent question is “How can a reference framework be defined for the AI native journey in the telecom industry?”

To devise the maturity model, the guiding principle is “Increase the span and the autonomy of the AI native implementation, while decreasing the level of human intervention and control.”

In this respect, AI becomes increasingly the heart of implementation, with humans focusing only on specifying goals and monitoring outputs.

Ericsson has proposed a maturity model, which consists of a matrix of five levels, with an additional level of zero. The dimensions, such as architecture, collaboration, data ingestion, and so on, can be analyzed in relation to their level of AI nativeness as shown below.

The columns are to be seen as a measurement tool rather than an absolute standard or fixed benchmark.

	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5
AI Architecture	No architecture defined	Basic reference architecture	AI aware O&M and AI support services	Distributed computing	Mature AI architecture	AI managed AI architecture
Collaboration	AI functions that do not collaborate	AI functions that collaborate by sharing data	AI-driven features integrated into a central AI platform	Seamlessly integrated AI functions	Level 3 AI systems that collaborate	Collaborative knowledge sharing among distributed AI functions
Data ingestion Storage and Processing	Manual and offline	Automatic data collection and online analysis	Partially adapted to data ingestion architecture	Fully adapted to data ingestion architecture	Seamless integration with data pipelines and data mesh	AI-driven universal data mesh
Model LCM and security	No Dedicated model LCM	Manual model deployment	Automated model deployment	Dynamic model Basic security	Automated Model Advanced security	Complete automated model (LCM* and security)
Self-	Proprietary, non-standardized logging, FM, PM, CM	Self-aware, self-configuring, monitoring	Self-diagnosis, self-optimization and prediction	Self-healing remedies and preemptive behaviour	Self-augmenting business management	Self-designing, AI-driven AI

Figure (9): Ericsson AI Maturity Model

The evaluation criteria in each column provide independent measures of an organization's AI-native readiness. Achieving the highest level of maturity across all criteria may not be universally applicable or necessary. Organizational structures and contexts vary greatly, and each organization possesses a unique "DNA" that shapes its approach to implementing AI-native architectures.

The maturity model emphasizes the following points:
Evaluation criteria at each stage are independent, meaning success in one area does not necessarily imply success in another.

There is no "one size fits all" approach to AI-native implementation.

Each organization's unique characteristics and context should be considered when evaluating its AI readiness.
The choice is left to each application to, for example, mandate level 3 on data management but settle for level 1 on the self-dimension.

While ethical considerations, safety and trustworthiness are crucial across all AI implementations, their specific interpretations and regulations vary significantly across regions.

Due to this inherent complexity and dynamism, the maturity model does not address these aspects directly. Instead, the model prioritizes flexibility and adaptability to comply with evolving regional requirements, allowing organizations to build an AI-native architecture tailored to their specific contexts and regulatory landscape.

An AI-native approach should involve AI being implemented as the system's first thought and not as an afterthought. In other words, the system is designed to leverage AI to achieve zero-touch networks that deliver different needs. In other words, the system is designed to leverage AI to achieve zero-touch networks.

The Telecom industry is on the cusp of delivering a transformative portfolio using the latest cutting-edge technologies and evolving toward an AI-native architecture in a stepwise approach.

It is of paramount importance for the industry to come together and leverage AI native technologies as needed for scaled adoption.

Risks and Challenges[7]

As AI grows more sophisticated and widespread, the voices warning against the potential dangers of artificial intelligence grow louder.

The risks associated with AI can be broadly categorized into three main areas, which capture the diverse range of concerns surrounding AI technology and its potential for malicious use:

1. Emerging AI race
2. Organizational risks
3. The rise of rogue AIs.

Mobile networks, the primary form of connectivity, have encompassed concerns regarding AI's widespread use, such as algorithmic bias, loss of human connection, privacy breaches, and lack of transparency.

AI systems often require enormous amounts of data to function optimally. The algorithm is only as good as the data it’s trained on.

As AI becomes more integrated into our daily lives, the risk of misusing or mishandling personal data increases, underscoring the need for robust data protection measures and regulations.

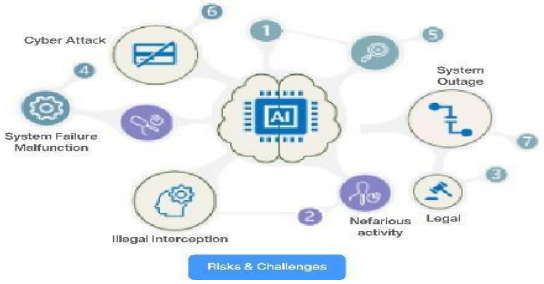

Figure (10): Ericsson AI Maturity Model

Algorithmic bias caused by bad or intangible data could result in a biased outcome, which could negatively impact the decision-making process. Significant research efforts are underway to enhance the fairness and transparency of AI algorithms.

These initiatives range from algorithmic auditing techniques to fostering data diversity and developing self-aware algorithms capable of mitigating biases. Risks may include privacy violations, algorithmic bias, job displacement, and security vulnerabilities, which could impact the creation of AI that surpasses human intelligence and becomes uncontrollable.

The inherent complexity and unpredictability of AI systems can exacerbate these risks. Therefore, it's crucial to incorporate ethical considerations, rigorous testing, and robust oversight measures in AI development and deployment to mitigate these risks.

The question is, can we fix the challenges of AI?

Strutt Russel highlights this challenge in his book "Human Compatible: AI and the Problem,"[8] where he states, "The problem is right there in the definition of AI. We say that machines are intelligent to the extent that their actions can be expected to achieve their objectives, but we have no reliable way to make sure that their objectives are the same as our objectives."

Mustafa Suleyman simplifies the challenges ahead of the AI era in his latest book, "The Coming Wave: Technology, Power, and the 21st Century's Greatest Dilemma." It explains four features of the coming wave9:

1. Huge asymmetric impact;
2. Fast development; Ominous nature;
3. Autonomy beyond previous technology.

Understanding these features is key to unlocking the benefits of AI and guarding against its risks.

The view of Strutt Russel Machine having Artificial General Intelligence (AGI): "Success would be the biggest event in human history and perhaps the last event in human history" - Strut Russel[8]

Case Study

Analyzing the network using real-time data and recommending change requests to meet the business needs and user demands.

Carrying out comprehensive network analysis and performance monitoring predating future trends using ML learning models which are trained and monitored incorporating market dynamics and business objectives.

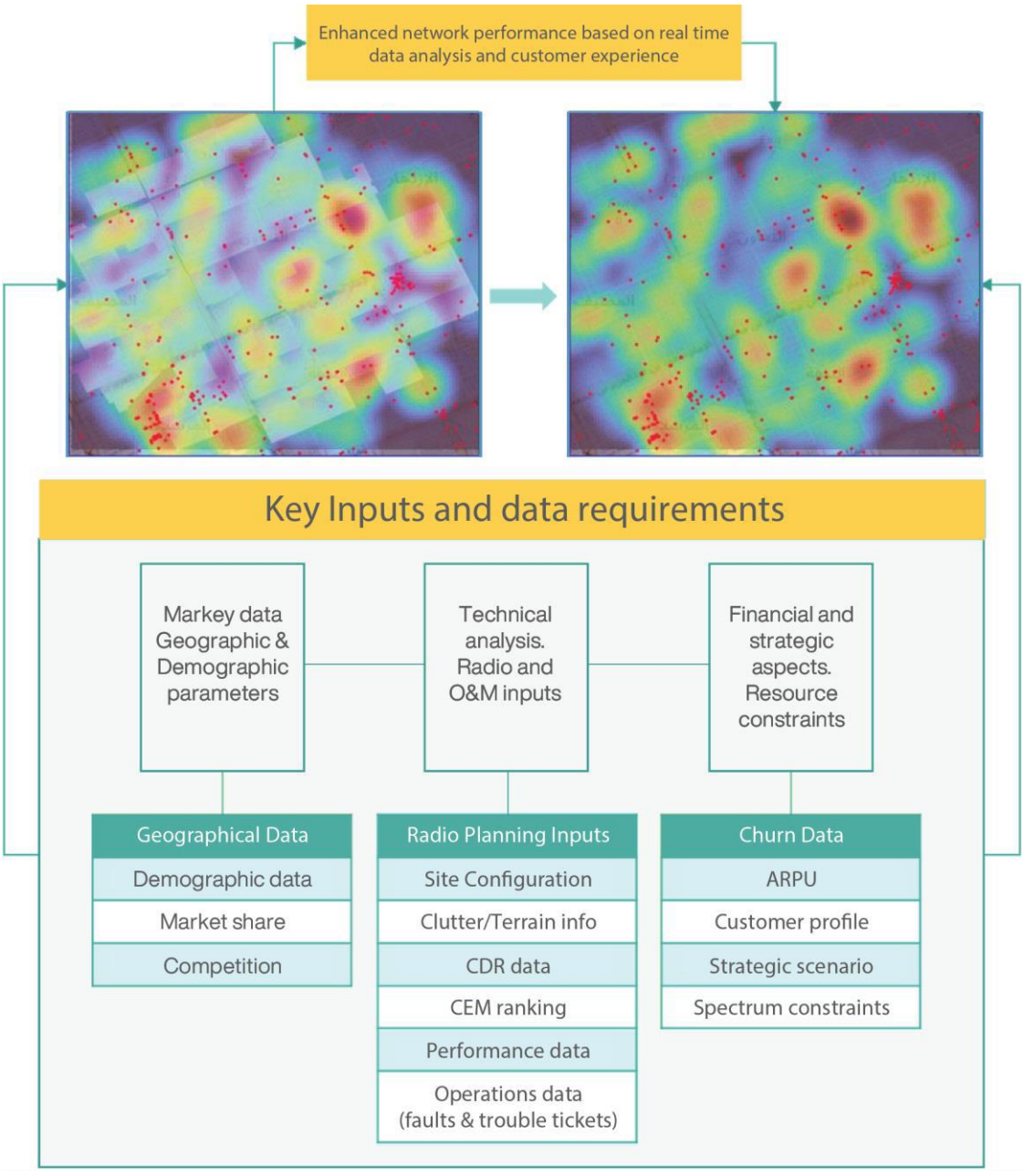

Figure (11): Data Analysis - Key Inputs and Data Requirements

Future Trends

01 Generative AI

Massive investments will propel generative AI's growth, paving the way for groundbreaking tools in text, video, image, and audio generation.

02 Singular to Multimodal

AI, capable of integrating diverse data streams like text, images, and video, are creating a paradigm. This fusion of modalities unlocks more accurate and enriched outcomes.

05 Industrial Use Cases

AI will introduce new capabilities that will spur the emergence of novel use cases in education, healthcare, manufacturing, and agriculture, etc.

06 AI Personalization

AI algorithms will transform communication for one-on-one interactions. It will make it scalable, enabling widespread implementation in daily life.

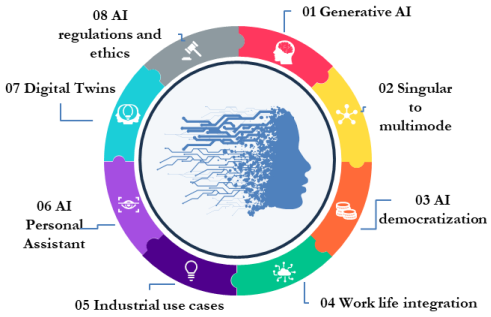

Figure (12): FutureTrends

03 AI Democratization

AI is breaking down barriers and reaching the masses. User-friendly apps and tools are transforming everyday life, allowing individuals of all backgrounds to unleash the power of the future seamlessly.

04 Work Integration

On the one hand, AI empowers with increased efficiency and productivity, and on the other, it reshuffles the job market, displacing some roles while creating new ones.

07 Digital Twins

Digital twins are gaining importance in various domains such as industrial simulations, online meetings, shopping experiences, highly skilled training, and critical services in healthcare.

08 AI Regulation and Ethics

AI regulation ensures responsible development by addressing bias, transparency, and privacy. Ethical frameworks promote fairness and accountability, balancing innovation with oversight. Governments and organizations aim to align AI with societal values while preventing harm.

Conclusion

The process of harnessing AI for organizational success is a journey rather than a sprint. The potential advantages are extensive, encompassing heightened efficiency and productivity, as well as refined decision-making and innovation. However, unlocking these benefits requires a strategic and responsible approach.

Moving forward, the following are considerations to harness the benefits of AI.

1. Begin with a clear vision and goals:
    a. Define overall business objectives
    b. Identify specific areas where AI can have the most significant impact
    c. Prioritize use cases that address critical challenges
    d. Create an execution plan using a modular approach

2. Build a strong foundation:
    a. Invest in data infrastructure, talent acquisition, and ethical considerations
    b. Cultivate a culture of AI literacy
    c. Prioritize responsible AI practices to mitigate potential risks
    d. Build trust with stakeholders

3. Embrace experimentation and iteration
    a. Don't expect overnight success
    b. Treat AI initiatives as experiments
    c. Learn from successes and failures and adapt your approach accordingly
    d. Encourage collaboration among different teams to foster innovation

4. Measure and track progress:
    a. Establish clear metrics to assess the progress
    b. Track key performance indicators (KPIs)
    c. Regularly evaluate the return on investment (ROI)[14]

By following these guiding principles, the organization can embark on a journey of AI-powered transformation paving the way to unlock new levels of efficiency, innovation, and success.

AI should be approached with a clear vision, a commitment to responsible practices, and a continuous learning mindset. The future is full of possibilities, and AI is a powerful tool to help navigate it.

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Endnotes

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