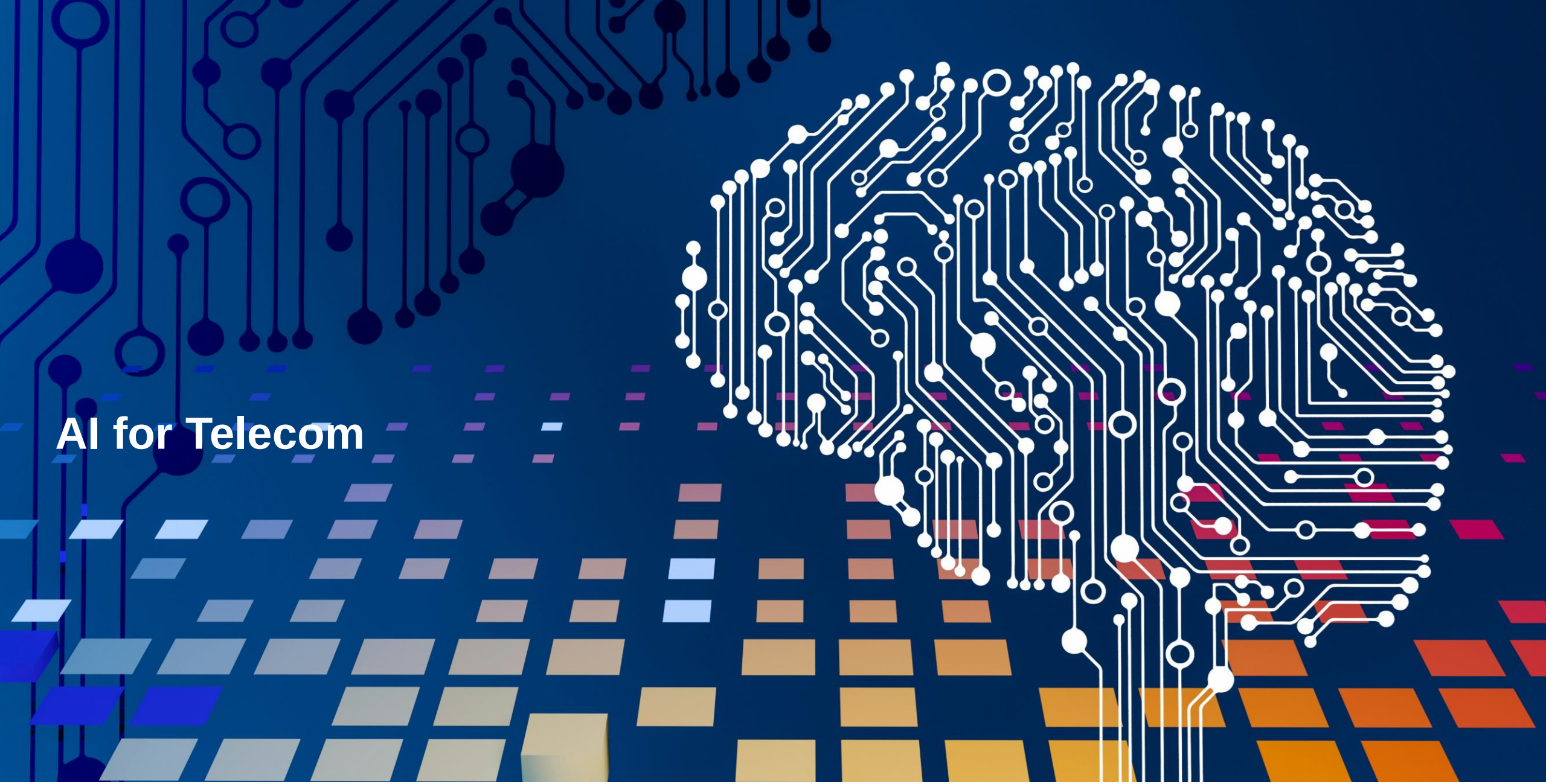
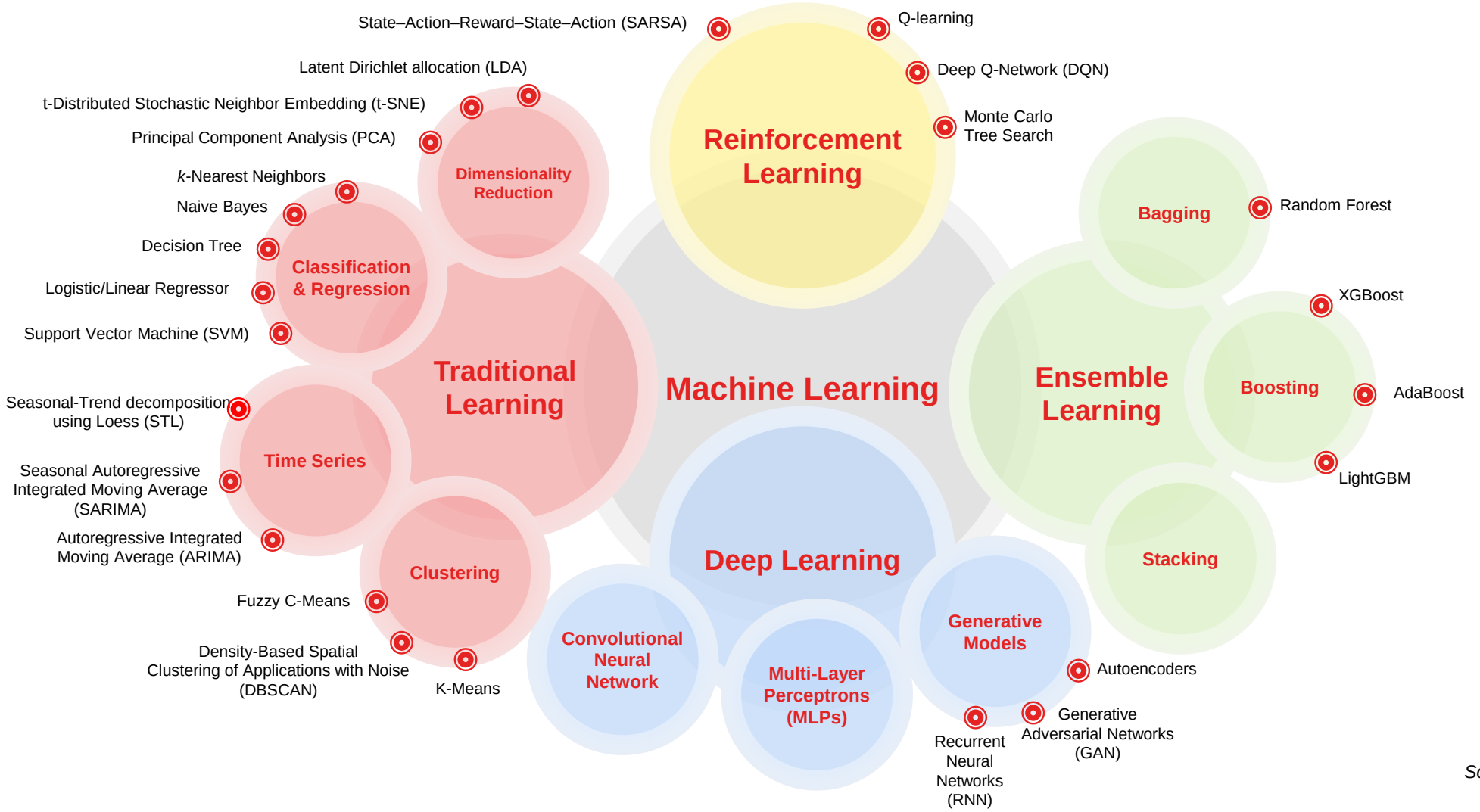

AI for Telecom

Machine Learning Algorithms

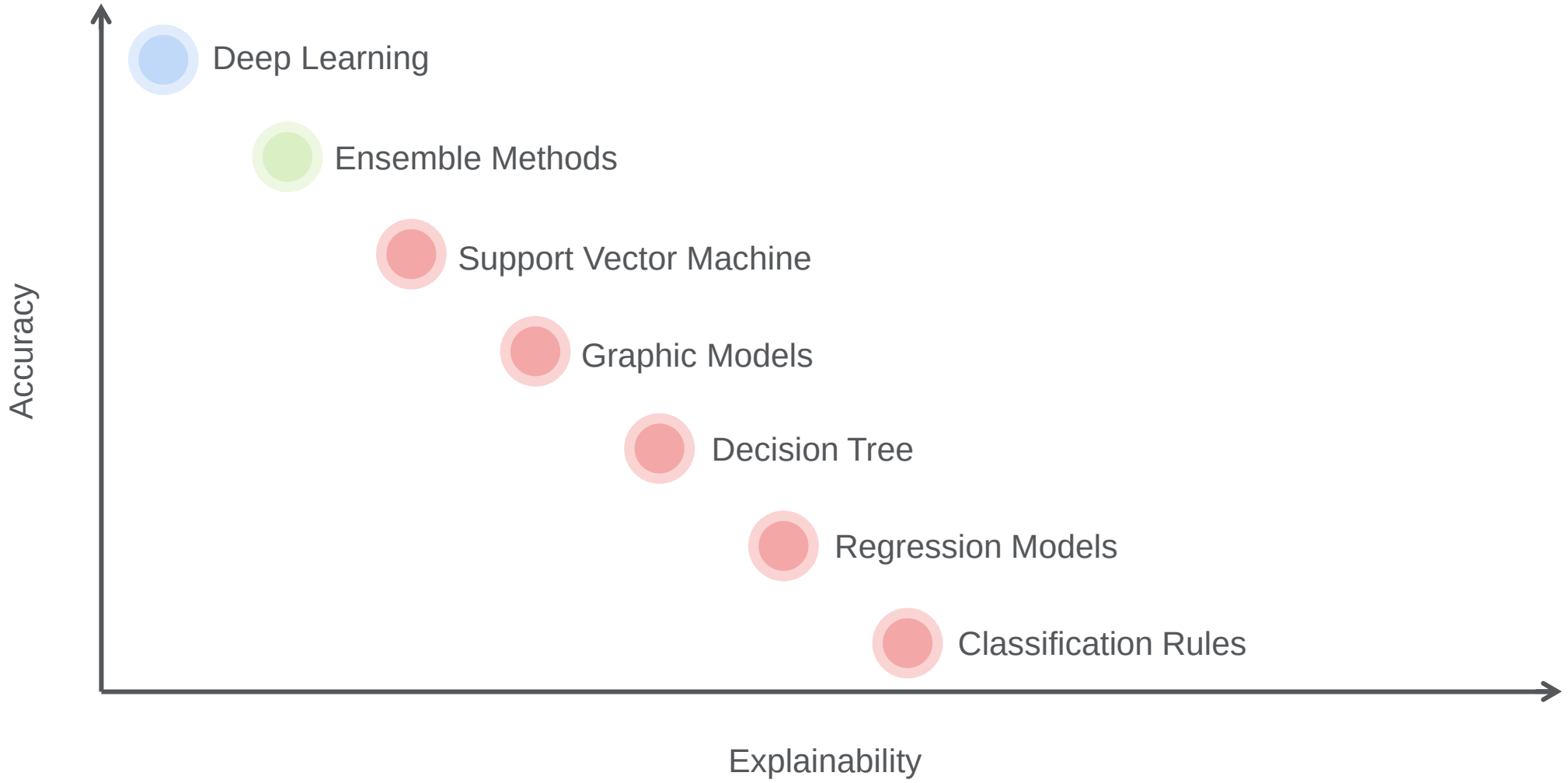
Taxonomy



Source: ICT Consulting, 2024

ML Algorithms Accuracy & Explainability

Trade-off: accuracy vs. explainability

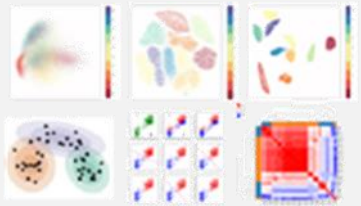


Source: Quantum.com, 2022

AI/ML Learning Strategies and Key Challenges

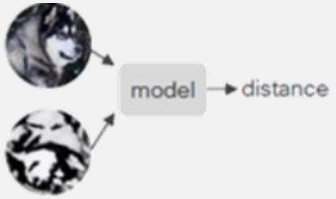
From Unsupervised Learning – discovering patterns in unlabeled data – to Reinforcement Learning and Large Language Modes: AI learns through trial and error, optimizing for rewards

Unsupervised Learning



Learn from ***patterns***

Self-Supervised Learning



Learn from ***structure***

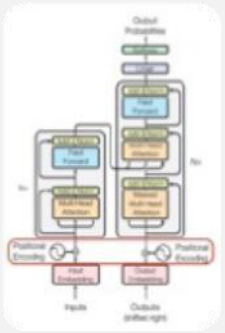
Supervised Learning

Learn from ***experts***

Reinforcement Learning

Learn from ***experience***

Large Language Model



The Dark Matter of AI Yann LeCun

Bits of information per sample

10^8 10^7 10^6 10^5 10^4 10^3 10^2 10^1 1

# of related topics and approaches

Explainable AI
How to make the model explain its predictions to a user?

Adversarial AI
How to trick or exploit models for malicious purposes?

Active Learning
How to collect training samples optimally?

Ethical AI
How to design algorithms that recognize societal biases in their training data?

Transfer Learning
How to re-use a model trained on a task X or another task Y?

Private AI
How to create models that never disclose private information from their training data?

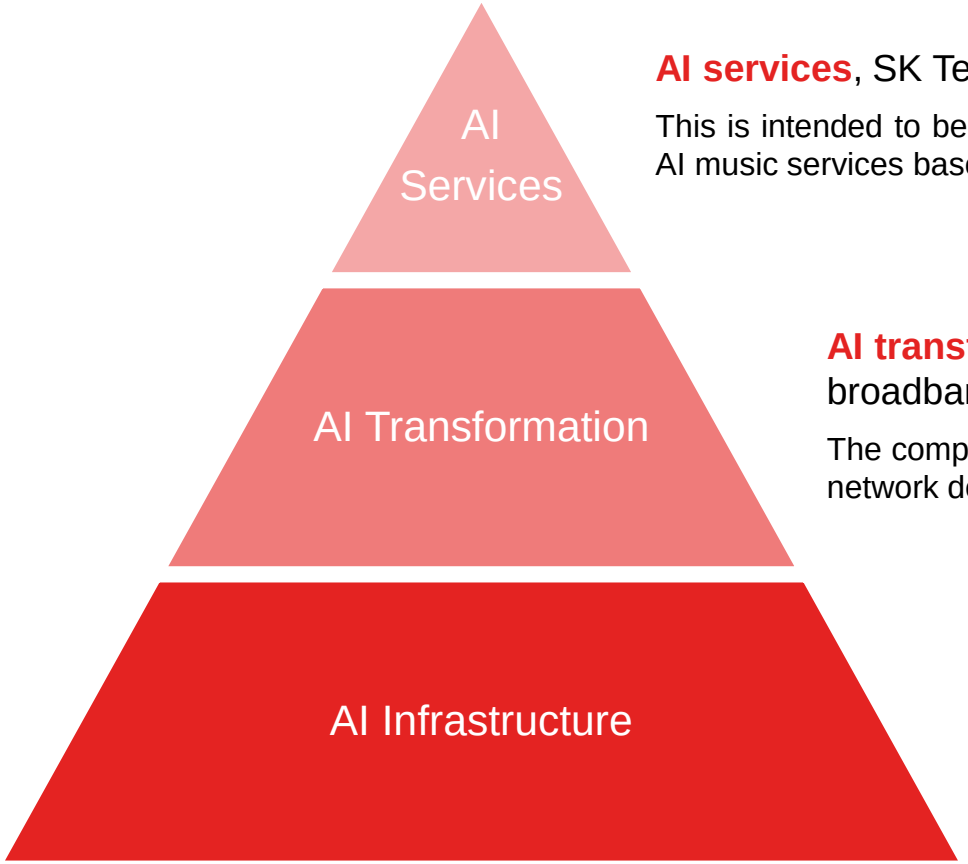
Multi-task Learning
How to train a single model that accomplishes several tasks?

Federated Learning
Use of decentralized device to collaboratively learn a shared model without sharing local data

Source: https://storage.googleapis.com/site-media-prod/meetings/NANOG90/4973/20240213_Vasseur_Is_There_A_v1.pdf (Cisco)

SK Telecom’s AI Pyramid Components

A holistic approach embraced by a pioneer telco



AI services, SK Telecom has officially launched **"A.", a personal AI assistant service**

This is intended to be a global offering, providing everything from AI sleep management solutions to AI music services based on generative customer prediction models

AI transformation (AIX) will improve existing core businesses, such as mobile and broadband services, while expanding into new areas, such as healthcare

The company expects to **reduce costs by 20-30% in the medium to long term** through AI-driven network deployment and operations efficiencies

AI infrastructure will include the construction of **AI data centers**, development of **AI semiconductors**, and a focus on Multi **Large Language Models (LLM)**

In response to the data center shortage and environmental concerns, the company plans to introduce energy-saving solutions such as **immersion cooling** systems and **hydrogen fuel cells**. It also aims to **double its data center capacity by 2030**

Source: SK Telecom, 2023

AI & Cloud Based, Autonomic Telecom Network

Reference architecture

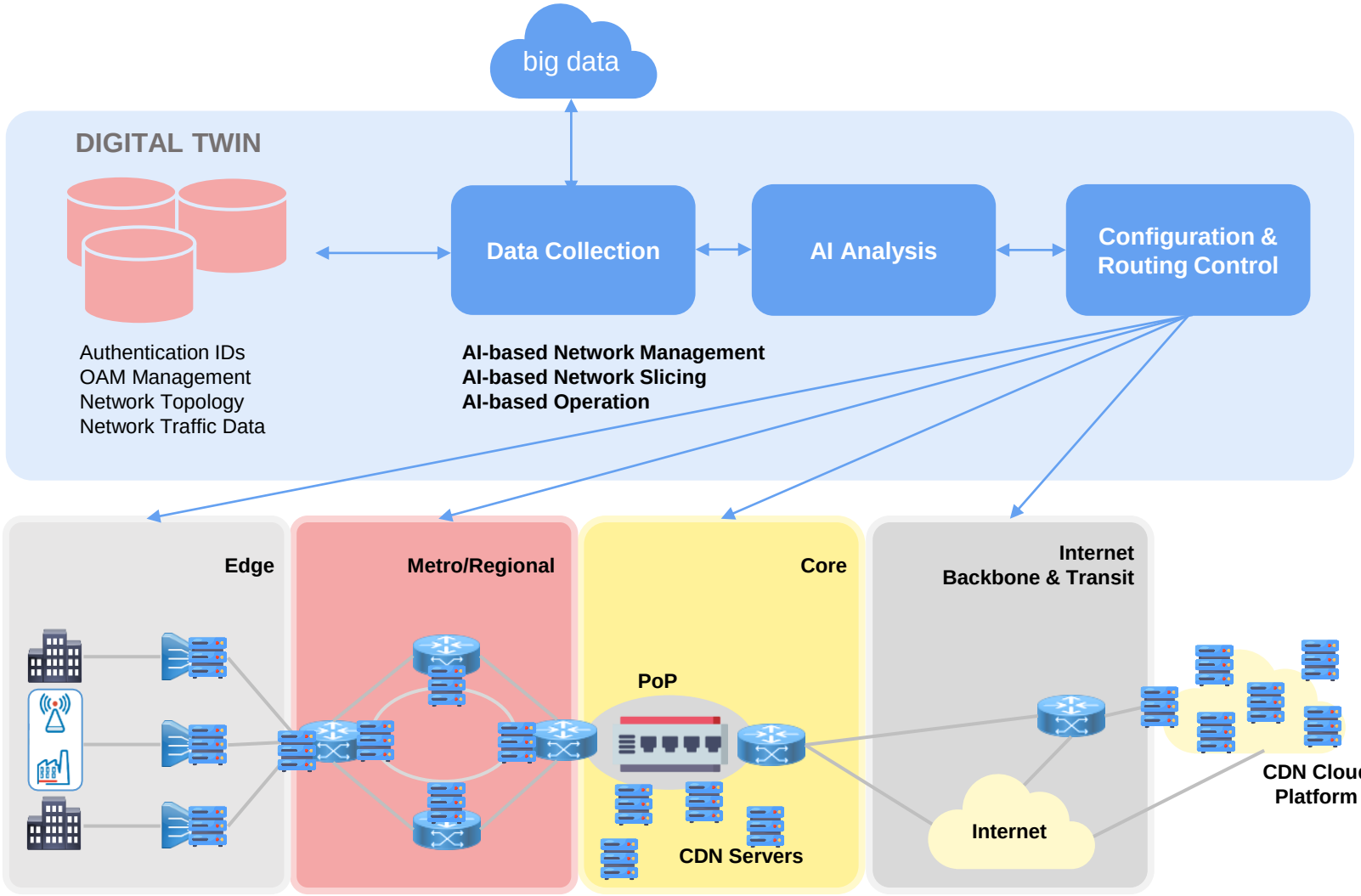
Self-aware
Self-configuring
Self-optimizing
Self-healing
Self-protecting

+ **Machine Learning**

Autonomic Cognitive Operation

Cloud Continuum
Core – Metro - Edge

Telco Network



Source: ICT Consulting, 2022

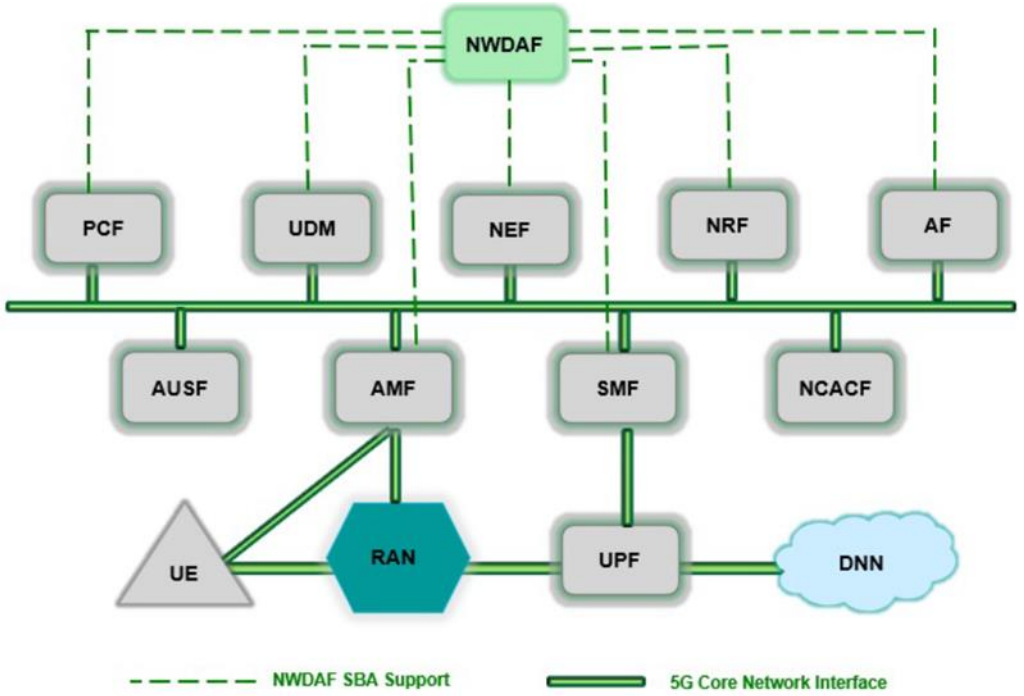
5G Advanced, Architecture for AI/ML Operation (eNA)

3GPP 5G Advanced Core: enhanced Service Based Architecture

3GPP 5G Core SBA Architecture w.r.t **Network Data Analytics Function**

What are the key functionalities of NWDAF?

- Support data collection from Network Functions (NFs) and Application Functions (AFs).
- Support data collection from OAM.
- NWDAF service registration and metadata exposure to NFs and AFs.
- Support analytics information provision to NFs and AFs.
- Support Machine Learning (ML) model training and service provisioning to NWDAF-MTLF (MTLF - Model Training Logical Function) & NWDAF-AnLF (AnLF - Analytics Logical Function).



AF	Application Function	(R)AN	(Radio) Access Network
AMF	Access and Mobility management Function	SEPP	Security Edge Protection Proxy
AUSF	Authentication Server Function	SMF	Session Management Function
DN	Data Network	UDM	Unified Data Management
FE	Front End	UDR	Unified Data Repository
NEF	Network Exposure Function	UDSF	Unstructured Data Storage Function
NRF	NF Repository Function	UE	User Equipment
NSSF	Network Slice Selection Function	UPF	User Plane Function
PCF	Policy Control Function		

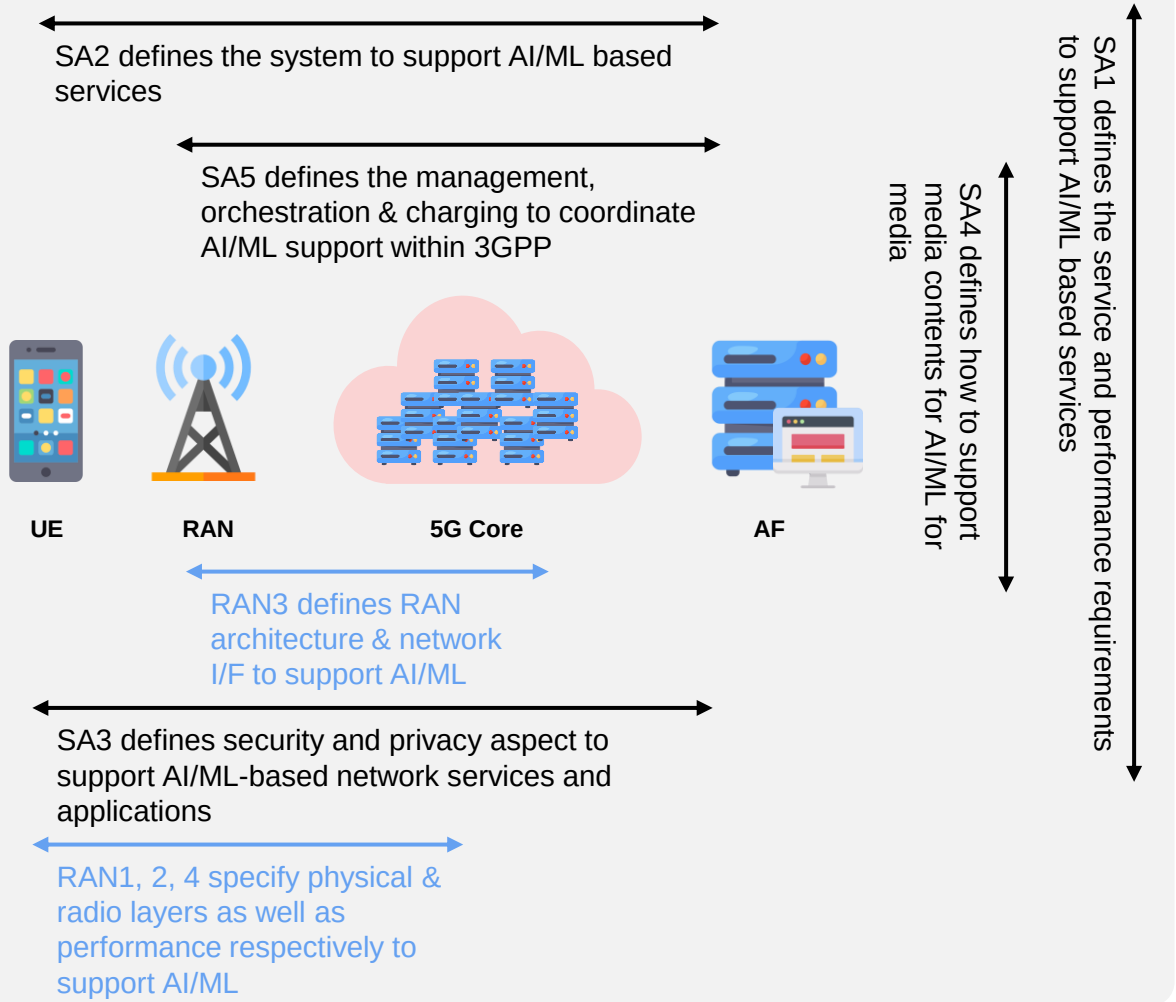
Source 3GPP for 5G, November 2023

3GPP Working Groups on ML/AI for 5G Advanced

Services, architecture, security, media & management plus RAN & radio layers (Cognitive Radio)

- SA WG-1 (**SA1**): Responsible for identifying service and performance requirements for 3GPP systems, in Rel-18, SA 1 focused on defining the AI/ML model transfer in 5G.
- SA WG-2 (**SA2**): Responsible for developing system architecture, in Rel-18, SA2 worked on 5G system support for intelligent transport for the AI/ML-based services.
- SA WG-3 (**SA3**): Responsible for security and privacy aspects. For AI/ML, SA3 examined and determined the system security and privacy impacts towards 5G Core when supporting AI/ML-based network services and applications.
- SA WG-4 (**SA4**): Responsible for defining media codec for the system and delivery aspects of the media contents, in Rel-18, SA4 defined the AI/ML for media.
- SA WG-5 (**SA5**): Responsible for management, orchestration, and charging for 3GPP systems, in Rel-18, SA5 defined AI/ML management to coordinate AI/ML functions across 5G system.

- RAN WG-3 (**RAN3**): Responsible for the overall RAN architecture and the specification of protocols for the related network interfaces, in Rel-17 and 18, RAN3 defined the initial support for AI/ML for next-generation RAN (NG-RAN).
- RAN WG-1,2, and 4 (**RAN1, RAN2, and RAN4**): Responsible for physical layer, radio layer and performance of the radio interfaces for EU, Evolved UTRAN, NG-RAN, and beyond, respectively, in Rel-18, these WGs define AI/ML for new radio (NR) air interface which is led by RAN1.



Source 3GPP for 5G, November 2023

AI/ML in Networking

The implementation of Artificial Intelligence and Machine Learning in networking has become increasingly crucial due to the growing complexity and distribution of networks

Troubleshooting and Issue Resolution

- AI/ML technology enhances troubleshooting by **quickly identifying and diagnosing network issues**. It **provides insights into root causes**, allowing network engineers to address problems more efficiently
- Instead of relying on reactive troubleshooting (where customers/ systems report issues), **AI can proactively predict and prevent problems before they occur**

User and Application Experience

- AI/ML improves user experience by optimizing network performance. It ensures that applications run smoothly and respond promptly
- Critical insights gained from AI/ML **help enhance overall user satisfaction and productivity**

Security Insights and Threat Response

- AI augments security by improving threat detection and response. It **analyzes network behavior patterns to identify anomalies or potential security breaches**
- With ML, networks can **learn from historical data and adapt security measures to evolving threats**

Network Automation

- AI/ML enables **automation of network management tasks**, such as deploying and managing network policies
- It integrates zero-trust security solutions, ensuring consistent network security across devices and locations

Continuous Learning and Optimization

- **AI will enable networks to continually learn, self-optimize, and even predict and rectify service degradations before they impact users**

Source: ICTC elaboration based on https://www.cisco.com/c/en/us/solutions/artificial-intelligence/artificial-intelligence-machine-learning-in-networking.html

GenAI Applications to Telecom Networks

Tentative list

1. **Generative AI**: AI can transform the deployment, management, operation, and improvement of Telecom networks
2. **Optimizing Radio Signals**: AI can be applied to optimize data flow to and from BTSs in mobile networks
3. **Power Management**: AI can be used to achieve power savings in mobile networks. Antennas can adjust their radiation pattern, direction and strength based on meteorology, number of users, and their positions
4. **Predictive Maintenance**: AI can predict equipment failures and schedule maintenance, thus reducing downtime and improving network availability
5. **Network optimization**: AI can analyze network traffic and performance to optimize resources allocation
6. **Demand Forecasting**: AI can predict network demand to allow optimal network planning and resource allocation
7. **Fraud Detection**: AI can analyze patterns and anomalies to detect fraudulent activities in real-time, protecting both service providers and customers
8. **Cyber-Security**: AI can detect and respond to security threats in real-time, protecting the network and customer data from cyber-attacks
9. **Customer Experience Management**: AI can analyze customer behavior to provide personalized services
10. **Virtual Assistants**: AI-powered chatbots and virtual assistants provide 24/7 customer service freeing up human resources

Source: ICT Consulting, 2024