BIF RESPONSE TO TRAI CP ON LEVERAGING ARTIFICIAL INTELLIGENCE AND BIG DATA IN TELECOMMUNICATION SECTOR

Q.1. What may be the most appropriate definition of Artificial Intelligence (AI)? What are the broad requirements to develop and deploy AI models in a telecom sector? Whether any major challenges are faced by the telecom service providers in adopting AI? Please justify your response with rationale and global practices, if any.

BIF RESPONSE

Over the years, there have been numerous attempts to define AI precisely. However, till date, there is no globally accepted definition of AI. Governments, regulatory agencies, international agencies, and other forums have adopted varying definitions depending on the context before them. According to John McCarthy, the father of AI, who coined the term in 1956, defines it as "the science and engineering of making intelligent machines."

Following are some of the definitions of AI that have been adopted in different contexts.

i. ETSI20 defines AI as “a computerised system that uses cognition to understand information and solve problems”.
ii. ISO/IEC 2382-28 [i.7]21 defines AI as "an interdisciplinary field, usually regarded as a branch of computer science, dealing with models and systems for the performance of functions generally associated with human intelligence, such as reasoning and learning".
iii. NITI Aayog in its report on the National AI Strategy defines AI as a constellation of technologies that enables machines to act with higher levels of intelligence and emulate the human capabilities of sense, comprehend and act while acknowledging the largely accepted definition of AI outlined by scientists such as John McCarthy, Alan Turing, and Marvin Minsky.

Opportunities for Telecom Sector The evolution of AI is creating new opportunities in new market sectors and developments are continuing to drive both service demand and development of new telecom applications. Some of the use cases of AI in telecom sector are:

- AI Ops for network optimization and operation
- Intelligent NFV operation and maintenance platform
- Intelligent data center
- Intelligent Quality Inspection System
- Disaggregated Network Operating System (dNOS)
- AI platform for network faults automatic prediction, selfhealing and illegal access prevention
- UAV for cell tower inspections
- Centralized-SON
- Self-driving network with self-configuration, self-monitoring and self-diagnosis function

- Application to find the best available Internet connection
- Expansion of the fiber optic network using AI Service
- Smart home platform •
- Intelligent online customer service bot •
- Smart home automation system •
- End-to-end service Digital Customer Experience (CX)
- Smart home service
- Intelligent assistant
- Smart notification platform Industries
- Smart government platform
- Smart police product
- Smart vehicle terminal •
- Medical image cloud
- "Super-brain" plan for smart city
- Smart city •
- Smart glasses and medical platform for people with poor vision •
- Smart retail, energy and city business •
- Smart transportation service and virtual tour service •
- Radio Positioning System (RPS) for UAVs •
- Smart agriculture solutions •
- AR/VR products Platform •
- Intelligent network platform •
- Smart customers service cloud platform •
- Open-source AI platform "Acumos" •
- Edge computing platform "Akraino Edge Stack" • AI platform

Use cases of AI in telecom:

a) **Enhancing Overall Quality of Service (QoS)**

b) **Adoption of AI and BD in telecom network** may play a key role in meeting these demands of users. Leveraging these technologies would enable telecom operators to

- optimise network quality with smarter detection and anomaly prediction, assisted capacity planning, and self-optimization to respond to changing conditions.
- Adoption of AI will ensure more reliable services by using historical data and sophisticated algorithms for predictive maintenance. For example, AI may be used in network to manage real time traffic. At initial stage, AI may predominately focus on training and serving the predictions based on static model. This initial training of model will be done on offline data using supervised learning. At later stage, the reinforcement learning paradigm may be used in real time environment where model will interact with real-time data, perform continuous simulations and take necessary actions that impact the real

time provisioning of the service. With the passage of time, the AI model based on historical data, can choose any action as a function of the history, and finally optimise the system parameters with the most recent real-time network changes.

- **Network Design**: The adoption of AI in network design provides opportunities for TSPs to predetermine cell parameters for a new site and its neighbours. The AI in the network design learns from historical radio network data and based on the learnings AI forms basis to predict network parameters and required design specifications. In the network design the AI can analyse and mine historical data to discover the reasons behind the past successes and failures and then exploit the extracted knowledge and experiences to properly allocate resources, guaranteeing end users with a high quality of experience, self-adaption to system renovation and dynamics. The AI can also help the network designers by providing 3D modelling of the network environment and its radio performance prior to the actual deployment. These AI models can also take into consideration small objects such as trees and building materials that traditional planning tools may omit. This level of granularity is particularly critical to the millimetre wave and even higher spectrum because the propagation of signals is affected by these objects. The AI not only helps in designing the network but it also optimises the design after deployment. It can also be updated regularly to ensure an accurate view and allocation of radio resources in line with customer expectations. AI supports network design process which result into better predictions in prioritising sites for network upgrades. It also gives scalability and flexibility in resource allocation that is not provided by the static propagation models used in most networks today.
- **Improving digital connectivity inside buildings**: A good digital connectivity would require coherence in planning of networks inside buildings and backhaul from which the building network can be easily hooked on. The alignment required is not only in terms of technical match of the components but also in terms of time when services should be available. The AI may be used in developing a model of the building from connectivity perspective, that may analyse the QoS at each corner of a building. In this case, the AI may learn the behaviour of the network for that building based on the parameters of the mobile device for each and every location. Based on the learnings, the AI may predict the best suitable network devices to be installed at a defined location to enhance the connectivity of the building. Further, after installing the proposed devices, the AI can continuously monitor the performance of devices to predict the factors that may degrade the network performance prior to any failure in the network devices. To give a better picture of the building in terms of digital connectivity, users may use their mobile device to run such AI models using techniques like federated learning which help in rating of buildings from

digital connectivity point of views at the same time without compromising the information of data.

- **Traffic Management using AI/ML:** In 2021, ITU launched Graph Neural Networking (GNN) Challenge 2021 "Creating a Scalable Network Digital Twin". The goal of this challenge was to create a Network Digital Twin solution based on neural networks, which can accurately estimate QoS performance metrics given a network state snapshot. Particularly, the objective of this challenge was to achieve a Network Digital twin that can effectively scale to considerably larger networks than those seen during the training phase. The challenge's problem statement brings a fundamental limitation of existing GNNs i.e. their lack of generalization capability to larger graphs. In order to achieve production-ready GNN-based solutions, there may be need of models that can be trained in network testbeds of limited size, and then be able to operate with guarantees in real customer networks which are often much larger in number of nodes. In this challenge, participants are asked to design GNN-based models that can be trained in networks of limited size (up to 50 nodes), and then generalize successfully to larger networks not seen before, up to 300 nodes. Solutions with better scalability properties will be the winners.
- **To solve routing complexity in Multipath TCP**: To fully utilize the network resources, multipath TCP is considered for 5G networks, which transfer packets over multiple paths concurrently. However, network heterogeneity in 5G networks makes the multipath routing problem become more complex for the existing routing algorithms to handle. A GNN-based multipath routing model51 is proposed by many to handle complex routing issues. The experiments under the SDN framework demonstrate that the GNN-based model can achieve a significant throughput improvement.
- **To solve complexity in network slicing**: As a software-based application concept, network slicing has been proposed and also recommended by TRAI for 5G network using network Graph-based Deep Learning for Communication Networks: Recommendations on Auction of Spectrum in frequency bands identified for IMT/5G virtualization to divide single network connection into multiple distinct virtual connections that provide services with different Quality-of-Service (QoS) requirements. However, the increasing network complexity is becoming a huge challenge for deploying network slicing. A scalable Digital Twin (DT) technology with GNN is developed for mirroring the network behavior and predicting the end-to-end latency, which can also be applied in unseen network situations. •
- **Traffic prediction** is also considered in cellular networks, with GNN-based solutions being proposed in recent years. As a prediction problem, the temporal dependencies may be modelled by a recurrent neural network, e.g. Long Short Term Memory (LSTM) or GRU. Different attention mechanisms

may also be incorporated. As an improvement over baselines, GNN is capable of modelling the spatial correlation between different nodes, e.g. a cell tower or an access point. •

- **Energy consumption** is another concern for the 5G network, which is designed to enable a denser network with microcells, femtocells and picocells. GNN-based power control solutions are proposed by many researchers for better control over the transmission power. Heterogeneous GNNs (HetGNNs) with a novel parameter sharing scheme are proposed for power control in multi-user multi-cell networks.
- A list of various applications of AI to improve quality of services Operators in India deployed AI in areas which include Network Planning (ML assisted smart radio planning, Rural network planning), Network Optimisation & Configuration (Resource Scheduling (BW/Power/Load balancing), Energy saving and efficiency improvement, (Vision based telecom network optimisation), Network Maintenance & Monitoring (Predicting Sleeping cell, Predicting Potential network faults and down time) etc.
- **Spectrum management**

(i) Wireless spectrum has been managed and utilised over many decades through a complex regulatory framework and policies. These policies are mostly suitable for allocation of fixed frequency bands for a particular type of services and they are often suboptimal and rigid, preventing efficient use of wireless spectrum. The manual process of assessing spectrum needs may be problematic due to the growing level of interdependencies in the spectrum domain. Manual allocation of spectrum so far has yielded satisfactory results but as the number of services using spectrum as resources are increasing exponentially, the demand for spectrum is also increasing exponentially. Further, technology advancements in radio systems, be it back haul and/or access has made spectrum usage more efficient across various bands through software-controlled Radio Frequency (RF) devices.

(ii) 5G Services which has varied applications in various frequency bands will be highly reliant on intelligent spectrum management techniques, and therefore will require a dynamic network environment for a high reliability and high quality-of-experience. In this context, use of AI and ML is expected to play a very important role in paving the way towards truly AI-driven spectrum management. Therefore, it has become imperative to adopt AI techniques for an effective and efficient spectrum management in various wireless networks.

(iii) **AI can improve performance of the spectrum through proper management.** One of the applications of AI is discussed in the

following paras. Spectrum sensing is an important task to realise Dynamic Spectrum Management (DSM) in wireless communication systems and is normally used to assist users to find out channel occupancy status. In order to increase the accuracy of spectrum sensing, many spectrum sensing algorithms have been developed in recent past. It is noticed that most of the existing algorithms are model-driven and need prior knowledge of noise or Primary User (PU) signals to achieve good performance. However, this feature makes them unsuitable for a practical environment especially due to lack of prior knowledge, resulting into performance degradation. To solve above concerns, machine learning techniques have been adopted to develop Cooperative Spectrum Sensing (CSS) framework. CSS framework considers a Cognitive Radio network, in which multiple Secondary Users (SUs) share a frequency channel with multiple Primary Users (PUs). The channel is considered to be unavailable for SUs to access, if at least one PU is active and it is available if there is no active PU. For cooperative sensing, each SU estimates energy level of the received signals and reports it to another SU which acts as a fusion centre. After reports of energy level from all SUs are collected, fusion centre makes final classification of the channel availability. Using machine learning techniques, fusion centre can construct a classifier to detect channel availability. With unsupervised machine learning, detection of the channel availability relies on the cluster in which sensing reports from all the SUs are mapped to. On the other hand, with supervised machine learning, classifier is first trained using the labelled sensing reports from all SUs. After classifier is trained, it can be directly used to derive the channel availability.

(iv) **Adaptive Modulation and Coding In the 5G mobile communication systems** and in Non-Orthogonal Multiple Access scheme, Adaptive Modulation and Coding (AMC) is going to be used heavily. AMC is highly effective in a high-mobility environment. By dynamically allocating resources depending on channel state information and signal-to-noise ratio (SNR) it improves spectrum efficiency and the received signal quality. Complex signal processing techniques for estimating SNR with high accuracy can cause feedback delay and degrade the throughput performance. Using an Artificial Neural Network (ANN) for estimating the SNR values drastically improves the latency and processing speed at the base station. The power spectral density values can be trained for SNR classification and mapped to the respective modulation and coding scheme using supervised learning.

Once the neural network (NN) is trained, the Modulation and Coding Scheme (MCS) can be computed with low complexity in latter cases.

(v) **Adaptive Beamforming:** For a MIMO transceiver system, adaptive beamforming can significantly improve the coverage and throughput. New beamforming algorithms can be created along with improvement of existing algorithms by using computer vision and adaptive machine learning based algorithms. Generative adversarial networks (GAN) can help by predicting the next beamforming directions based on the inputs from the previous directions by analyzing the locations of the mobile devices. Rotating the antennae or using previously placed ones, based on the estimated new location of the targeted device, signals can be transmitted and received in a directed way.

(vi) **AI in spectrum management which include Spectrum monitoring, Spectrum diagnosis, Mitigation of interference, Network integration and Spectrum sensing**, with automated, adaptive systems that handle parts of spectrum allocation management, including planning, sharing, authorization, monitoring, and pricing.

(vii) **Anomaly detection in the network**: Anomaly detection is a task of identifying instances whose behaviour differ significantly from normal and/or expected behaviour in the data. The importance of anomaly detection can be seen in identification of faults or failures in the systems. Anomaly detection has been applied in a variety of ways in the field of telecommunications. The analysis of KPIs based on network nodes performance data requires analysis of voluminous data which is practically not feasible through manual processes and therefore experts resolve problems through simulation and predictive data analysis. AI facilitates automatic analysis of thousands of network elements with hundreds of their behavioural and contextual features reflected in KPIs, which helps in identifying network nodes with deviant behaviour in quick time frame. AI based anomaly detection helps experts to become proactive in their ability to identify service degradations and outages by providing dynamic monitoring, real-time analysis, and by correlating between metrics across network layers, applications, databases, storage, CRMs etc

(viii) **Adaptive security**: Adaptive security studies patterns and behaviours rather than just examining log files, monitoring checkpoints and responding to alerts. It provides real-time network security monitoring that analyses the network for anomalies, malicious traffic, and vulnerabilities. If any threat is detected, the platform automatically implements security measures that counter the threat in a number of

ways. Gartner lists the four stages of an adaptive security as: predict, prevent, respond and defect. These can be briefly defined as: ●

(a) Predict – assess risk, anticipate attacks and malware, implement baseline systems and posture.

(b) Prevent – harden and isolate systems to prevent security breaches. ●

(c) Respond – investigate incidents, design policy changes, conduct retrospective analysis. ●

(d) Defect – prioritise risks, defects and contain incidents. These four stages, combined with policy and compliance measures, are used to create a system with an ability to quickly trace and respond to suspect behaviour at the source. This happens with situations such as malware connecting at an endpoint, or a user acting suspiciously.

(e) **AI to improve the customer experience** by employing chatbots, which enables virtual assistance for selecting voice or data packs, troubleshooting, answering FAQs, and personalised interaction etc. Airtel's "Callup"66 AI is a chat and voice assistant that uses the power of AI to quickly and effectively resolve customer queries over email, chat and phone calls in vernacular languages.

(f) **AI to assist customers in choosing tariff plan**: Currently, telcos offer variety of tariff plans and vouchers. Customers sometimes find it very difficult to choose best plan for them. AI may help customers to compare different plans in a more relevant way by considering customer specific consumption patterns. Such AI based applications might be offered by third parties as tariff plans are available in public domain and consumption pattern can be made available by the app installed on the device for this specific purpose. AI may also help telecom service providers to design new tariff plans considering the requirements of customers.

(g) Customer segmentation, Customer sentiment analysis and Price optimization are a few more applications of AI for improving customer experience and services in the telecom sector.

<u>Challenges being faced in implementing AI:</u>

Some of the common challenges that most companies face when trying to implement Artificial Intelligence, include

(a) limited AI expertise and knowledge, access to quality data, and AI specific infrastructure.

(b) Considering the inherent advantages associated with AI, in order to address the challenges related to trust, new terminologies such as Trustworthy AI, Responsible AI, Explainable AI are being coined by various organisations and nations. Some use these terms to build AI systems following defined principles.

(c) AI for Good (ITU), which aims to bring forward Artificial Intelligence research that contributes towards more global problems through the Sustainable Development Goals. AI, which may be responsible for the fourth industrial revolution, should be used responsibly dealing with the larger problems of humanity as a whole.

(d) Responsible AI (RAI): The impetus behind responsible AI is to design, develop and deploy AI with good intentions and to have a positive impact on society. This term "Responsible" has been used by many, for example, Google defined principles such as fairness, interoperability, security, and privacy. Microsoft put responsible AI principles into practice through the Office of Responsible AI. The notions of ethical and accountable artificial intelligence (AI) also referred to as "Responsible AI" have been adopted by many stakeholders from government, industry, civil society, and academic institutions. Making AI systems transparent, fair, secure, and inclusive should be the core elements of a responsible AI framework.

(e) **Explainable AI (XAI):** The magic with which AI can find hidden correlations in ostensibly uncorrelated data sets, is captivating. Unlike traditional paradigms of programming, the AI model requires a rich dataset to learn and create its own logic/ rationale to produce desirable output. However, the concern of people would be understanding how the AI/ML model arrived at a particular decision/prediction/output. Explainable AI is a set of tools and framework to help understand and interpret the model's behaviour. To increase confidence in model and end-user's trust, such initiatives are being taken by companies like google43, IBM44, and others. Some of the government initiatives are also active like DARPA's XAI initiatives by USA, among others.

(f) **Trustworthy AI:** In 2019, the EU presented Ethics Guidelines for Trustworthy Artificial Intelligence45. According to the Guidelines, trustworthy AI should respect all laws and regulations, respect ethical principles and values, and be robust from a technical perspective while taking into account its social environment. iv. Generative AI: AI is shifting from interpreting existing data to generating novel content at a scale. Generative AI emphasises on the capabilities of AI where it can generate or create something new for example, a new symphony, an artwork, etc, which is based on past learning experiences, Emulating the creative aspect of human beings. v. Augmented AI: Presently, research is focused on improving the capabilities of AI technology. However, augmented AI talks about leveraging AI for enhancing/augmenting human capabilities to process/analyse huge amounts of data. This is crucial because AI is good at identifying underlying patterns in huge data, which can augment human's

capabilities. It is similar to the use of exoskeleton technology which increases the strength and agility of humans to perform superhuman feats.

(g) Embedded AI: Devices such as smartphones, laptops, and other smart devices are being equipped with AI-enabled dedicated chips. For instance, A12 Bionic by Apple features a graphics processing unit and a Neural Engine which powers an artificial intelligence accelerator. With embedded AI, devices have the ability to run AI models at the device level and then directly use the results to perform an appropriate task or action

Q.2. Whether the big data in the telecom sector may be utilised for developing AI models? For efficient and effective handling of big data, whether there is a need for adoption of special programming models or software frameworks? Please justify your response with suitable examples and global practices, if any.

BIF RESPONSE

Yes-Big data should be utilised for developing AI Models. Augmented AI is about leveraging AI for enhancing /augmenting human capabilities to process and analyse huge amounts of data, underlying patterns in Big Data. Big Data plays a key role in supporting decision making which further contributes to AI.

With the increased availability and use of data, decisions are increasingly being facilitated or sometimes even completely taken over by using predictive modelling methods, often referred to as the use of algorithms. Using data to predict incidents or behaviour is a major part of developments related to AI. Using AI for BD is a logical step for companies looking to maximise the potential of big data. AI systems use data-driven algorithms and statistical models to analyse and find patterns in data. This is different from traditional rules-based approaches that follow explicit instructions. Big data provides raw material by which AI systems can derive insights. Many organisations are now realising the benefit of combining Big Data and AI.

Following are the examples of how adoption of AI for BD benefits the organisations. i. Netflix uses ML algorithms for better understanding the users, and providing more personalised recommendations. This keeps the user on their platform for longer period and creates an overall positive customer experience. ii. Google uses ML to provide users with a highly valuable and personalised experience. They are using ML in a variety of products including providing predictive text in emails and optimised directions for users looking to get to a designated location. iii. Starbucks is using big data, AI to provide personalised emails using data from customers' past purchases. Rather than crafting only a few dozen emails on a monthly basis with offers for the broad Starbucks audience, Starbucks is using its "digital flywheel" with AI-enabled capabilities to generate over 400,000 personalised weekly emails featuring different promotions and offers. iv. Topic Data is a Facebook technology that displays to marketers the responses of the audience about brands, events, activities, and subjects in a way that keeps their personal information private. Marketers use the information

from topic data to selectively change the way they market on the platform as well as other channels. With Topic Data, Facebook has grouped the data and stripped personal information for user activity to help marketers by offering insights on all the possible activities related to a specific topic. This gives marketers an actionable and comprehensive view of their audience, which can be further improved by adoption of AI. The discussion so far emphasises on how BD plays a key role in decision making for AI models. Big data contributes in analysing and visualisation of extensive datasets with heterogeneous characteristics. It also helps AI in predictions from the available datasets and utilising those predictions for improving the services. With the support of BD analytics, AI systems can learn, think and perform tasks by using past knowledge and learnings acquired through various scenarios. For example, the predictions from the information of traffic flow for an area help in providing customised services or personalised services to the customers of that area. The telecom sector also generates vast amount of such data at each and every node which is discussed below. This data along with AI may open up play new opportunities for telecom sector.

Q.3. Whether deployment of 5G and beyond technologies will help to accelerate adoption of AI in all the sectors and vice versa? Please justify your response with suitable illustrations including global practices, if any.

BIF RESPONSE

AI and 5G will be the key components that fuel future innovations. These technologies when combined together will work synergistically. This means AI advancement will work towards improving 5G systems performance and efficiency while expansion of 5G will drive distributed intelligence through connected devices. Further 5G will generate massive amounts of data from multitude of new services, and billions of IoT devices, which will enhance AI learning and model training.

AI for 5G : With the increase in interconnected devices, the traffic and demands of the network will increase constantly. Heterogeneity is expected to characterize the increase in connected wireless devices and mixed usage of cells of diverse sizes and access points with different multi-radio technologies. The industry and academia are embracing 5G as the future network capable of supporting next generation vertical applications with different service requirements. To realise this vision in 5G network, physical network has to be sliced into multiple isolated logical networks of varying sizes and structures, dedicated to different types of services based on their requirements and characteristics. With all these, the network would be characterised by increased traffic, various mobility levels and interference. In addition to this, multiple requirements such as Quality of Experience (QoE), resource efficiency, energy-efficient operation and cost efficiency need to be taken into account. To manage all these requirements in real time, there is a need for enhanced intelligent systems with programmable capabilities. The softwarization of network using Software-Defined Networking (SDN) and Network Function Virtualization (NFV) in 5G networks is expected to fill the void of programmable control and management of network resources.

Further, as some studies show, Telemetry data analytics based statistics from Network Data Analytics Function (NWDAF) and RAN Data Analytics Function (RAN-DAF), combined with AI/ML, will allow operators to dynamically optimize their networks and automate 5G network slicing management. The integration of AI with softwarization of network will make the network more flexible and agile by programming the network intelligently. AI enables faster decision making by gathering and processing network data in real time and automating network functions, so service providers can switch from reactive to proactive mode. In self-healing networks, AI systems are trained to look for patterns, detect, predict and localize network issues, and take proactive steps to fix the service before customers are impacted. This also has the benefit of freeing up IT professionals' time that would otherwise be spent on troubleshooting and repetitive tasks, letting them focus instead on strategic initiatives. As a result, AI will be able to support truly dynamic networks and services, accurately reflecting the prevailing state of the network with an up-to-date view of physical and virtual resources, while at the same time providing a complete historical record of the network to support cross-domain hybrid service orchestration and assurance.

While AI is supporting the effective management of 5G network and its services, there is a complementary role of 5G to drive rapid developments in AI. The high bandwidth, massive connectivity, and low latency capabilities of 5G will drive the development of IoT services by connecting massive devices. These interconnected devices will generate large amount of data to be used for training and modelling AI. Further, the low latency and high capacity of 5G will also allow AI processing to be distributed among the device, edge cloud, and central cloud, enabling flexible system solutions for a variety of new and enhanced experiences.

The on-device (networked devices) training has following important benefits that will lead to mass adoption of AI: a. Scale: Connecting massive devices can harness a significant amount of computational power by distributing processing over many devices, such as millions of smartphones. b. Personalization: The AI model learning is inherently customised with data used for on-device training. c. Privacy: Extracting the value of the data and preserving privacy is possible by training on devices. d. Speed: On device training would overcome the potential issue of transfer of data such as data transmission delay or loss, which would result in inconsistent service performance, thus on device training improves speed and precision. e. Real Time: Real-time processing is a fundamental advantage of on-device training. It supports delay-sensitive applications and services such as remote surgery, tactile internet, unmanned vehicles, and vehicle accident prevention. The AI-powered 5G networks will accelerate the fourth industrial revolution and create unprecedented opportunities in business and society.

AI/ML for 6G: The 6G is expected to blur the boundaries between digital and physical realities by infusing immersive experience of augmented and virtual realities in every vertical. Intelligent knowledge systems combined with ubiquitous computation will make humans more efficient and redefine their lifestyle, conduct and work environment. i. 6G is empowered by emerging technologies like AI/ML and digital twin models. The intelligence to learn from data and apply it in the real world is achieved through AI/ML whereas digital twin models

are simulations which allow us to analyze what's happening in the physical world, simulate possible outcomes, anticipate needs and then take productive actions. According to a version of 6G Vision, it highlights that evolution of telecom infrastructures toward 6G will consider highly distributed AI, moving the intelligence from the central cloud to edge computing resources. It also highlights that ML algorithms should be deployed and trained at different levels of the network: management layer, core, radio base stations, and in mobile devices, possibly with the assistance of the network itself (e.g. via configuration and/or device programmability). These new paradigms may drive the need for a ML-native and data-driven network architecture implemented as network functions within the network and management domains, possibly requiring data from different sources. Meanwhile, physical-layer algorithms (e.g. link adaptation), as well as higher layer algorithms (e.g. mobility), can be optimized with the controlled and predictable deployment of ML agents.

The era of 6G will bring following changes - a. Emergence of man-machine interfaces to control and consume information. b. Typing on touchscreen will gradually get replaced by gesture and voice control. c. Devices will come embedded into clothing and even transform into skin patches. d. Healthcare will be an important benefactor as wearables facilitate 24/7 monitoring of vital parameters and warning us of the potential health problems.

Digital cash and keys may become the norm. iv. The advanced multi-sensory telepresence that is created with very high data rates will reduce the need for travel through the introduction of multi-modal mixed reality telepresence and remote collaboration

Q.4. Do you think that a number of terminologies such as Trustworthy AI, Responsible AI, Explainable AI etc. have evolved to describe various aspects of AI but they overlap and do not have any standardised meanings? If yes, whether there is a need to define or harmonise these terms? Please justify your response with rationale and global practices, if any.

BIF RESPONSE

Yes. As explained in Response to Q1 above, these terminologies describe different features and aspects of AI. However, they do overlap in some manner and use Big Data and ML for developing algorithms. Globally also, there is no standardised definition of AI and it would be useful to have one which is harmonised between these different terms and interpretations.

Q.5. Which are the applications of AI and BD already being used by the TSPs in their networks to improve Quality of Service, Traffic Management, Spectrum Management and for Security purposes? Please list out all such applications along with the level of maturity of such applications. Please specify whether they are at trial stage or pilot stage or have reached the deployment stage? Details should include type of AI models, methods to access data, and procedures to ensure quality of data.

BIF RESPONSE

Details of this are already given in our detailed Response to Q1 above.

Q.6. What are the major challenges faced by the telecom industry, including policy and regulatory, in developing, deploying, and scaling applications of AI listed in the response to Q.5? How can such challenges be overcome? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Detailed Response is provided in our response to Q1 above

Q.7. In which areas of other sectors including broadcasting, existing and future capabilities of the telecom networks can be used to leverage AI and BD? Please justify your response with rationale and suitable examples if any.

BIF RESPONSE

AI can be used for selection of variety of options in other sectors including broadcasting also. The use of AI in the media and entertainment industry is helping them to improve their services and enhance the customer experience. Here are a few use cases of AI in media and entertainment industry: i. **Metadata tagging**: With countless pieces of content being created every minute, classifying these items and making them easy to search for viewers becomes a herculean task for media companies. That is because this process requires watching videos, identifying objects, scenes, or locations in the video classifying them appropriately and add tags. To perform this task on a large scale, AI may be used to analyze the contents of videos frame by frame and identify objects to add appropriate tags. AI tools identify the objects and scenes in images that are specific to the business needs. This mechanism is termed as metadata tagging. This technology is being used by content creators or media publishing, hosting, and broadcasting platforms to organize their media assets in a highly structured and precise manner. As a result, regardless of its volume, all the content owned by media companies becomes easily discoverable. ii. **Content personalization**: Leading music and video streaming platforms like Spotify and Netflix are successful because they offer content to people belonging to all demographies, having different tastes and preferences. These companies use AI and ML to share personalized recommendations. Such companies are using AI and ML algorithms to study individual user behaviour and demographics to recommend what they may be most interested in watching or listening, and suggesting next content and thereby keep them constantly engaged. As a result, these AI-based platforms are providing customers with content that caters to their specific interests, thus offering them a highly personalized experience. iii. Reporting automation: In addition to automating day-to-day or minute-by-minute operations, AI is also helping media companies to make strategic decisions. For instance, leading media and broadcasting companies are using AI to create channel performance reports from raw analytics data shared by Broadcast Audience Research Council of India (BARC). The weekly data usually received from the BARC is generally in the form of voluminous Excel sheets. Analysing these sheets on a weekly basis to derive and implement meaningful learnings proves to be quite daunting for the analytics team. By using AI-enabled data analysis and natural language generation-based reporting automation tools, business

leaders can create performance reports with easy-to-understand analysis, providing them accurate insights to make informed data-driven decisions. iv. Subtitle generation: International media publishing companies need to make their content fit for consumption by audiences belonging to multiple regions. To do so, they need to provide accurate multilingual subtitles for their video content. Manually writing subtitles for multiple shows and movies in dozens of languages may take hundreds or even thousands of hours for human translators. Today, most of the content platforms such as YouTube, Spotify, and Instagram and others allow publishers to add automatic transcription to their videos. Without AI algorithms, it may be difficult to find the right human resources to translate content for certain languages. Additionally, human translation can also be prone to errors. To overcome these challenges, media companies are leveraging AI techniques such as natural language processing and natural language generation for subtitle generation. For example, YouTube's AI allows its publishers to automatically generate closed captions for videos uploaded on the platform, making their content easily accessible.

Other areas in telecom where AI could be used are

i. Churn prediction: In the Telecommunication Industry, customer churn detection is one of the most important research topics that the company has to deal with for retaining on-hand customers. Churn means loss of customers due to exciting offers of the competitors or maybe due to network issues. In these situations, customers may tend to cancel the subscription to a service. Churn rate has a substantial impact on the lifetime value of the customer because it affects future revenue of the company and also length of service. Due to a direct impact on income of the industry, the companies are looking for a model that can predict customer churn. So, one way to reduce churn is to understand exactly what kinds of events cause customers to be unhappy enough to leave: a. Is dropped call a primary issue? If so, then how frequently does it occur and within what time-period? b. Do slow video visualisations cause by traffic overload trigger churn? c. What about SMS delivery issues? Leveraging ML in more advanced churn prediction68 reveals not only about the most likely churners, but taking it one step further, to activate marketing teams to respond positively through marketing methodologies (known as uplift modelling).

ii. Spam: As mentioned in Telecom Commercial Communications Customers' Preference Regulations 2018 (TCCCPR 2018) 69, AI/ML may be used in the Unsolicited Commercial Communication (UCC) Detect System. The TCCCPR 2018 highlighted that to deal with UCC from Unregistered Tele-Marketers (UTM), signature solutions need to be enhanced which shall be referred to as the UCC Detect System. While determining whether a person or entity is suspected sender of UCC, this system may include additional sources of inputs such as sending information (SI) from reports, inputs collected from Honeypots, information shared by Signature Solutions of other access

providers and information available from network elements (examples of which are HLR, and Missed Call Alerts). Such a system would be able to identify suspected UTMs with greater accuracy when it is equipped with more information about suspected UCC senders. Technology based solutions can be designed to carry out all these checks and retrieve desired information in a short time. This system may also use Artificial Intelligence (AI) and Machine Learning (ML) techniques to constantly evolve to deal with new signatures, patterns and techniques used by UTM for sending UCC and while remaining undetected. Further, AI may also be implemented to curb UCC by adopting AI in UCC detect system, smart preference management, smart complaint handling, smart consent acquisition and revocation, smart content template verification and management, and header allocation process.

iii. Telcos will also have more advanced tools at their disposal to reduce frauds by applying AI to usage/location analysis of devices and services. In particular, operators will be able to uncover and halt roaming and SIM-based frauds for subscription services. In the prepaid domain, AI will help detect abnormal accumulation of credit, top-ups based on stolen codes, and more.

The above sections emphasis that there are vast opportunities of AI in improving QoS, spectrum management, security, customer services, broadcasting and much more in the telecom sector. In future, AI may open up new opportunities in the telecom sector. Also, with AI, and other technologies such as SDN, NFV, cloud and edge computing, the telecom network has already transformed into an intelligent network and will further improve in future. These transformations in telecom network may further support adoption of AI and also open up new services or opportunities for other sectors.

Q.8. Whether risks and concerns such as privacy, security, bias, unethical use of AI etc. are restricting or likely to restrict the adoption of AI? List out all such risks and concerns associated with the adoption of AI. Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Detailed Response in this regard is included in our response to Q1 above including what measures are required to be taken to mitigate such risks and concerns.

Q.9. What measures are suggested to be taken to address the risks and concerns listed in response to Q.8? Which are the areas where regulatory interventions may help to address these risks and concerns? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Detailed Response is contained in our response to Q1 above.

Q.10. What measures do you suggest to instil trust and confidence regarding a robust and safe AI system among customers, TSPs and other related entities/stakeholders? Whether adopting general principles such as Responsible AI and ethical principles at the time of designing and operationalising the AI models will help in developing ethical solutions and instilling trust and confidence in the users? What may be such principles and who should formulate these and how compliance can be ensured? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Data is important for AI applications, and the variety of enriched data will aid applications of AI. However, privacy is one of the concerns. To make data more secure, various encryption and anonymisation techniques may be adopted by the experts. However, this may limit the data usage for the AI modelling. Therefore, it is a difficult task to ensure efficient utilisation of data in AI modelling and ensure security of the data at the same time. Thus, further research may be required to address such concerns. c. To build trust and confidence in AI based applications, there is a need to address concerns like biasedness, lack of explainability, risk of noncompliance of regulatory requirements and loss of direct control

Data is the basic requirement for an AI system. However, practically data accessibility is one of the major constraints. The effectiveness and efficiency of AI model depends on data provided for its training and testing. Thus, to improve overall services of the telecom sector, the telcos, solution providers and other key players might need data or insights of the entire telecom network. However, in all these scenarios, data accessibility is a critical constraint.

Currently, most of the data may be either available with a few big organisations or with the Government agencies. The organisations holding major portion of data may not be interested in sharing the same due to privacy, security concerns of their customers/organisations and also due to strategic business decisions. The customers may be reluctant to share their data due to the concern of privacy. Further, data available in public may have inherent biases, incomplete or in improper format.

Thus, to gear up adoption of AI, data may need to be made accessible with necessary insights to the concerned agencies. For instance, in Graph Neural Networking Challenge 2021, launched by ITU, participants were required to use the GNN approach where the dataset was provided by the ITU. This data was generated with a simulated network and was not obtained from a real network. If real network data is made readily available to the AI solution developers, efficient solutions could be formed. Thus, initiatives are required to be taken to make the data accessible. Once data is made available, its handling include activities such as storage, pre-processing, integration, protection, provenance among others. As per ITU Recommendations on Big data, each activity in data handling has certain requirements which need to be fulfilled for providing cloud services efficiently. These requirements include data collection process which requires collection of data from multiple sources in parallel. Similarly, data storage processes require support for different data types with sufficient

storage space, elastic storage capacity and efficient control methods to support storage for different data formats. Data formats include text, spreadsheet, video, audio, image, and map. Here, each activity in data handling has different requirements and fulfilling these requirements is a challenging task, especially, in case of telecom data, where data is generated in large quantum. Thus, a framework to handle the data for AI modelling may be required to address these issues.

Accessibility to user data may improve the overall performance of AI systems. However, users are concerned about their privacy which may be compromised while sharing data or insights for AI operations. These concerns may include identification, tracking and profiling of the individuals. Therefore, risks of privacy may become a constraint while using the data for AI applications. Encryption offers one of the ways to protect data from adversaries. Since data can exist in three different states: at rest, in transit, and in use, the standard encryption is used for the data in rest and transit only whereas the data in use is the most vulnerable form. It is also a fact that as the strength of encryption is increased, the data becomes seemingly The information on website of Statistics Canada also shows the trade-off between privacy and utility of data. However, to work with data i.e., to perform analysis, computation and mathematical operations, one requires the fundamental relationship and correlations which was removed by encrypting the data. Current solutions almost universally decrypt the data to use it, but this exposes unencrypted and sometimes private data, leading to legal and ethical challenges as well as increasing vulnerability to bad actors. The current endeavour is to find a solution to this tussle between data protection and loss of data utility.

Q.11. Whether there is a need of telecom/ICT sector specific or a common authority or a body or an institution to check and ensure compliance of national level and sector specific requirements for AI? If yes, what should be the composition, roles and responsibilities of such authority or body or institution? Please justify your response with rationale and suitable examples or best practices, if any.

BIF RESPONSE

It is also worth noting that the responsibility to oversee AI development has either been given to existing ministries like education, health, communication, etc, or a new entity has been created particularly for this purpose. In countries like Canada, France, Germany, and others, existing ministries are part of strategic planning for AI initiatives. Whereas, in countries like the United Kingdom, Japan, Singapore, and Saudi Arabia, a separate entity such as an office/council/ department/authority, has been established for AI development.

Government of India already proposes to have a Data Protection Authority under the aegis of the Personal Data Protection Bill (PDP Bill) which shall oversee the ethical use of consumer data while ensuring data privacy. All data fiduciaries shall be responsible to the DPA for compliance requirements. No other sector specific or any other independent authority is required. The composition, roles and responsibilities of the proposed DPA are included in the scope of the PDP Bill

Q.12. In response to Q.11, if yes, under which present legal framework or law such authority or body or institution can be constituted and what kind of amendments will be required in the said law? Or whether a new law to handle AI and related technologies is a better option? Please justify your response with rationale and suitable examples or best practices, if any.

BIF RESPONSE

The response to this question has been adequately provided under Question 11 above.

Q.13. Whether telecom/ICT industry is facing constraints such as access to data, lack of computing infrastructure, lack of standards, and R&D in the adoption of AI and BD technologies? Please list out all such constraints with adequate details.

BIF RESPONSE

Challenges and Risks being faced by the Telecom Sector in adopting AI & BD is covered in response to Q1 above.

Q.14. What measures are required to make data and computing infrastructure available and accessible to developers and also to make data/AI models interoperable and compatible? Please respond along with examples, best practices and explanatory notes.

BIF RESPONSE

Regulatory Impediments i. Regulatory requirement is an affirmative duty on an organisation to complete and refrain from a set of actions so as to remain compliant with the law. With the advancement in technology and market requirements, sometimes granularity in regulations impedes growth and hinders adoption of emerging technologies. These can be mitigated by understanding the challenges and making necessary regulatory changes or if required, framing new policies.

TSPs are regulated by a number of laws, including the Indian Telegraph Act, 1885 (Telegraph Act), TRAI Act, 1997, the terms of the licence agreement entered into between the TSP and the Government, and rules and regulations framed by the Government and TRAI from time to time. Some of the reasons which may hinder adoption of technologies like AI and big data in telecom sector are:

(a) Bringing more clarity in licence agreement: For instance, in the course of delivering their services, telecom service providers have the ability to gain access to a lot of information and data pertaining to their subscribers. This includes Call Detail Records (CDR), calling patterns, location data, data usage information, etc. Though abovementioned data is personal data of an individual, the ownership rights, authority to use, transfer and delete this data are presently ambiguous. There could be other aspects where clarity is required.

(b) Lack of formal regulation for data: One important aspect of AI systems is data itself. The issue arises due to lack of formal regulation around data handling. It includes the collection, processing, sharing, deleting, etc. On 11 December 2019, the Ministry of Electronics and Information Technology (MeitY) introduced the draft Personal Data Protection Bill, 2019 (PDP Bill) before the Parliament, which was referred to a Joint Parliamentary Committee (JPC) for further consideration. After carrying out a series of consultations with stakeholders, the JPC published its report along with the finalised Data Protection Bill 2021 (DP Bill) on 16 December 2021. In August 2022, The PDP Bill 2019115 was withdrawn after parliamentary committee recommended changes, the Government is now working on a new comprehensive legal framework for the digital ecosystem.

(c) Obsolete KPIs: Improvement of performance of the network might pose risks of non-compliance from the regulator perspective as the system might fail to show improvement in KPIs defined by the regulator. The issue may be due to static and obsolete KPIs which require reform with new developments, else it may hamper growth in the sector.

The role of policy maker is to identify hindrances faced by industry and address the same in an effective manner. Regulatory intervention is required in three scenarios. First, where industry is unable to realise or unleash full potential of AI and BD in the instant case. Second, when direct/indirect harm is inflicted on others. Lastly, when collaboration of stakeholders is required for creating a comprehensive ecosystem for implementation of solutions offered.

Q.15. Whether there is a gap between requirement and availability of skilled AI workforce? If so, what measures are required to be taken to ensure availability of adequate skilled workforce in AI domain? Please respond along with suggestions with supporting details and best practices.

BIF RESPONSE

Finding the right talent Technical skills and data literacy are obviously important for AI and BD. Most enterprises have an abundance of data but leveraging it for AI projects require skills. This includes data transformation to develop and deploy automated data pipelines that deliver high-quality data along with the knowledge of ML concepts and analytics tools to perform analysis. Lack of skill is one such challenge in AI adoption and acquiring new skills will be required for adoption of AI. Also lack of skill impedes overall innovation. As such, importance of skill and expertise is imperative before adopting AI solutions or this would create trust and reliability issues.

Q.16. What initiatives do you suggest to democratise data required to develop AI models in the telecom sector? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Data is essential for adoption of AI as data is the basis for training and validation of AI models. Thus, industry should work extensively to harness data generated from every node of network to support future AI innovations. However, there is a lack of access to dataset.

Various attempts have been made globally to make the data accessible through various initiatives and strategies at national level. Some of these initiatives are listed below: i. USA: High quality datasets are critically important for training many types of AI systems. The National AI Initiative directs Federal agencies to provide and facilitate the availability of curated, standardised, secure, representative, aggregate, and privacy-protected data sets for AI research and development. One of the recommendations by the Working Group on AI (AIWG), formed by FCC, suggests that FCC could begin to explore the feasibility of promoting the development of a data exchange to promote the sharing of privately held data. ii. United Kingdom: In the UK, policy initiatives focus on development of a trustworthy and qualitative data infrastructure. This includes exploring and defining a framework for safe, secure and equitable data transfer, developing a data infrastructure to make available high-quality public data in an open, reusable and accessible format for machine learning. iii. Germany: Germany took policy initiative to create a comprehensive mobility data. The aim is to make available mobility data (real and synthetic training and test data) that can be used across competitors for the research, development, validation and certification of reliable AI algorithms in order to promote the development of autonomous driving in Germany. As per information published on website of The Federal Ministry for Digital and Transport, in spring 2022, offered a new central, standardised and user-friendly way to access the mobility data via mobility library known as the Mobilithek. This platform will be the national access point for mobility data and implementation requirements from delegated regulations on the European ITS Directive and the amended Carriage of Passengers Act. This is a platform for mobility providers, infrastructure managers, transport authorities and information providers to share digital information. iv. Singapore: In June 2019, IMDA released the Trusted Data Sharing Framework to help companies overcome challenges in addressing trust between data providers and develop data to spur the growth and innovation of AI-related apps in the nation, IMDA also set up free and open-source AI libraries. These libraries contain collections of APIs, source codes, databases and more. v. Netherlands: The Netherlands AI Coalition (NLAIC) put forward a proposition of responsible data sharing in AI across organisational boundaries to develop a positive climate and creating a governance model to facilitate data sharing.

Similarly, in India, various government departments and agencies have observed the need to make data available for AI models. Following are the key initiatives taken and recommendations proposed to make data accessible for developing AI solutions in India: i. The Task Force on Artificial Intelligence, constituted by the Ministry of Commerce, recommended setting up digital data banks to ensure availability of cross-industry data and creation of interdisciplinary large data centres in its report published in 2018. ii. A committee

on "Platforms and Data on Artificial Intelligence", was constituted by MeitY in 2018. In 2019, the committee recommended to develop an Open National Artificial Intelligence Resource Platform (NAIRP) which will act as a central hub for knowledge integration and dissemination in AI. It proposes to bring data available with governments onto common platforms in well-defined formats, create anonymised infrastructure in order to make large sets of data available to the public for development and call for investment by government in the development of biasfree dataset. iii. National Strategy on Artificial Intelligence (NSAI) released by NITI Aayog in 2018 highlighted the necessity for the government to explore assistance in building a large corpus of data across domains. Enabling access to high quality and representative datasets for evaluating AI models on ethical principles is also not available many times.

It is obvious from above that multiple initiatives have either been taken or being proposed at national level to make the data accessible for training and validating AI models. These initiatives are generic in nature and applicable for every sector. However, to accelerate adoption of AI in the telecom and broadcasting sector, specific requirements are to be set up by creating data hubs with necessary infrastructures for developing, training and validating AI models. The AI models developed for telecom sector may be used for other sectors also by accessing requisite execution environment to run the AI models.

In addition to setting up data hubs, it is required that people, industry, big corporate and the government share the data available with them. There is also a requirement to establish an authority or a body or an institution whose role should also be to act as manager and gatekeeper for data stored. Its role should also cover to manage the privacy and security of data. Further, authority or body or institution so established may collaborate with various sectors and Government agencies to make the data available for AI. The authority or body or institution may also prepare framework to share the data between different agencies. It may also take initiatives to encourage people, industries, the Government agencies etc. to share data for AI modelling.

Synthetic Data for Securing Privacy: Further, in addressing the concerns of privacy, instead of sharing real data, synthetic or artificially generated data approach may be helpful. Gartner mentions that synthetic data is a class of data that is artificially generated. As real data is always the best source of insights from data, but access to real data is often expensive, imbalanced, unavailable or unusable due to its character of generation and privacy issues. Synthetic data can be an effective supplement or alternative to real data, providing access to better annotated data to build accurate, extensible AI models. When combined with real data, synthetic data creates an enhanced dataset that often can mitigate the weaknesses of the real data. It can be used to train, test, validate new AI system where live data doesn't exist or it is biased. It can also be used to supplement small, existing datasets which was currently being ignored. Further, the organisations can alternatively choose synthetic data when real data can't be used can't be shared or can't be moved. Gartner predicted that by 2030, synthetic data

will completely overshadow real data in AI models. In this sense, development of synthetic data can be a game changer approach.

Also, the latest development in AI, Generative Adversarial Network (GAN), is being extensively used to reduce the need for real data. A synthetic dataset may prove to be more lucrative than real data for AI modelling. The authority or body or institution proposed in subsection can undertake creation, management and other important aspects of synthetic dataset.

Q.17. Whether the authority or body or institution as suggested in response to Q.11 may also be entrusted with the task to manage and oversee collection, cataloguing and storage of data? Whether such authority or body or institution need to be entrusted to generate and make available synthetic data? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

As mentioned in Response to Q11 above, the scope, functions, organisation structure and jurisdiction of the DPA, proposed in the PDP Bill is to oversee all the functions pertaining to consumer data while ensuring data privacy.

Q.18. Whether the legal framework as envisaged in para 3.5.3 and Q.12 should also enable and provide for digitalisation, sharing and monetisation for effective use of the data in AI without affecting privacy and security of the data? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Yes-legal framework should enable and provide for digitalisation, sharing & monetisation for effective use of data in AI without affecting privacy and security of data. In India, NITI Aayog approach paper on AI suggested a need for custodians to manage and implement these principles in AI systems. The custodian may guide sectoral regulators on the same. NITI Aayog also proposed a risk-based approach for adoption of AI applications. Under this approach, adoption of these principles may vary based on the risk associated with each AI applications. NITI Aayog classified risks into following categories and the actions for each category: a. High Risk (likely to cause harm or has a negative impact): Consider increased scrutiny and mandate responsible AI practises. b. Low risk: Effort to minimise the regulatory burden. Self-regulation and awareness campaigns. Supporting structures to enable accountability, transparency and grievance redressal may be required for self-regulation to be effective. c. Areas where the risks are not clear: Regulatory mechanisms may be developed through policy sandboxes and controlled deployments where market reactions and impact could be closely monitored. From a sectoral perspective such as telecom sector, some of the issues might be different and may require to apply principles of Responsible AI in the context of telecom scenario.

NITI Aayog in its approach paper has mentioned that extant regulation will continue to oversee AI-led innovations in domains under their purview for the time being. The approach to handle sector-agnostic risks or challenges associated with AI in the sector will require alignment with the policies and initiatives For this purpose, an authority or a body or an institution may be required to be established which can frame requisite guidelines, take necessary initiatives and oversee the compliance. This authority or a body or an institution may also facilitate sharing of future telecom network capabilities and its role in achieving national objectives for the development and deployment of AI based solutions in other sectors. Also, there will be a need to examine the legal framework under which such authority or a body or an institution can be constituted. Evidently, on the basis of best practices in different jurisdictions as discussed in previous chapter it seems there will be need of a new law to handle AI and related technologies. The body or institution or group so established, may have a mechanism of consulting the relevant stakeholders such as telecom service providers, researchers, consumer groups, associations, organisations, sector regulator, ministries and department concerned

Q.19. (a) Which are the currently used privacy enhancing and privacy preserving technologies facilitating adoption of AI and BD? Are there any challenges in using these technologies? How these challenges can be addressed? (b) Which are the potential technologies likely to be available in near future to further strengthen privacy? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Protecting privacy in an AI-driven world: The approach of data democratisation discussed above poses risk of privacy to customers of the telecom operators. The concern of privacy becomes an unequivocal issue for the telcos and government agencies. One of the ways to ensure privacy of the data is offered by encryption techniques and algorithms as mentioned in para However, adoption of these techniques increases processing overheads, delay in output and above all loss of data utility. Further, the approach of adoption of legal frameworks such as laws or regulations, may be an option to protect the privacy of data which may allow players to use data through a defined process and after taking consent of the users prior to using data for such models. However, it is important to understand that rules and regulations to stifle access and use of data may hinder adoption of AI. On the other hand, relaxed rules and regulations on use of personal data may compromise privacy. These are two extreme sides of the spectrum. It is difficult to find a balanced approach to address this concern through rules or laws. Therefore, a solution has to be worked out by using suitable technology.

To overcome the limitations of data encryption, there are techniques which allow data to remain encrypted while in use and can still be operated upon without jeopardizing privacy. These new techniques are known as “privacy preserving technologies or “privacy enhancing

technologies. These technologies include data anonymization, differential privacy, secure multi-party computation, homomorphic encryption among others.

(a) Data anonymization hides or removes sensitive attributes such as personally identifiable information (PII), so that the subject cannot be identified within the modified dataset. However, hiding or removing the personally identifiable information may reduce the utility of the dataset.
(b) Differential Privacy is another advanced solution of privacy preserving technique in which random noise is added to the true outputs using rigorous mathematical measures. However, the original aggregate dataset and differentially additive noise one are statistically indistinguishable. Thus, a single individual cannot be identified if a statistical query is raised. However, there is a tradeoff between privacy guarantee and utility because adding too much noise and improper randomness may significantly depreciate the reliability and usability of the dataset.
(c) Secure Multi-Party Computation is another privacy preserving technique where any computation can be performed on the overall dataset (owned by individual party) without revealing the individual dataset. For example, a group may want to calculate the average salary of all employees but without revealing their individual salaries. Here multi-party computation may be used.
(d) Homomorphic Encryption enables the ability to perform computation on the encrypted form of data without the need for the secret keys to decrypt the ciphertext. The results of the computation are in encrypted form and can only be decrypted by the requester of the computation. In addition, homomorphic encryption ensures that the decrypted output is the same as the one computed on the original unencrypted dataset.

There are studies that highlight that utilizing the technologies of differential privacy, homomorphic encryption, and secure multi-party computation in designing privacy-serving AI model parameter-sharing schemes, can further enhance privacy. These technologies will, in time, may redefine the way data is used for the benefits of consumers, enterprises and governments in the telecom sector and beyond. For example, these technologies can reshape how operators and technology providers cooperate over the data, but also how future technologies such as Cloud Services, 5G technologies and the Internet of Things will enable benefits of Fourth Industrial Revolution (Industry 4.0) while limiting the potential harm to the society including the loss of individual privacy.

Other studies highlight use cases such as data innovation, data collaboration, data delegation, data monetization etc. which are supported by privacy preserving technologies.

Q.20. Whether the list of technologies provided in response to Q.19 are adequate to handle all the perceived risks and concerns in the AI domain? Or is there a need to develop new

privacy preserving architecture? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

It is felt that the list of technologies provided in response to Q19 are not adequate to handle the perceived risks and concerns in the AI domain. There are apprehensions that powerful tools and techniques are available which can de-anonymise and reveal the dataset that way breaching the privacy of the data. A person attempting to de-anonymise makes use of additional information available from various sources. An article from The Guardian quotes that researcher from Belgium's Université catholique de Louvain (UCLouvain) and Imperial College London have built a model to estimate how easy it would be to de-anonymise any arbitrary dataset. If apprehensions are not allayed, then sharing of data using the data science techniques may not be of any help for all practical purposes as users would be reluctant to share. Hence, there is need to develop and deploy privacy preserving architectures where such architectures may enable AI models to continually learn from data without requirement to share the data and thereby allaying the fear of de-anonymisation at any stage.

Q.21. Whether the next generation telecom network architectures such as AI at edge, federated learning, TinyML or their combination can offer solutions to meet both privacy as well as intelligence requirements? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

(a) Role of AI at edge in end user devices: The advancement in AI chips may further support adoption of AI at edge and FL in telecom sectors for handling privacy. A report by Deloitte highlights that AI chips are physically smaller, relatively inexpensive, and use much less power and generate much less heat. This makes it possible to integrate them into handheld devices such as smartphones as well as non-consumer devices such as robots. By enabling these devices to perform processor-intensive AI computations locally, edge AI chips reduce or eliminate the transaction of large amounts of data to a remote location, thereby delivering benefits in usability, speed, data security and privacy and also thereby reducing power requirements by telecom infrastructure to handle such large data.

(b) The AI chips may also enable the devices to train, test and evaluate the small AI models on the device itself. Thus, the AI chips may also address the computing infrastructure requirements for development of AI solutions. Most of the devices will be having AI chips for their functioning. The telecom industry may also work towards adoption of AI chips at each and every node to the network to enhance the performance of the network.

(c) Role of TinyML at edge: As training of AI models requires high computing infrastructure and the computing capabilities of AI chips at edge devices may be limited, this poses restrictions of development of AI models at edge. In these cases, the

emerging field of TinyML will address these concerns. TinyML is broadly defined as a fast growing field of ML technologies and applications including hardware, algorithms and software capable of performing on-device sensor data analytics at extremely low power, typically in the mW range and below, and hence enabling a variety of always-on use-cases and targeting battery operated devices. TinyML is enabling a new class of low-latency, high-bandwidth applications. ML models are finding yet another home in small, low-powered embedded devices. Following are some i. Low Latency: Since the model runs on the edge, the data doesn't have to be sent to a server to run inference. This reduces the latency of the output. ii. Low Power Consumption: As we discussed before, microcontrollers consume very little power. This enables them to run without being charged for a really long time. iii. Low Bandwidth: As the data doesn't have to be sent to the server constantly, less internet bandwidth is used. iv. Privacy: Since the model is running on the edge, your data is not stored in any servers. As AI learning and model training is moving towards edge, the telecom sector will be one of the beneficiaries of TinyML. Thus, industry may explore the possibilities and applications of TinyML at edge.

Q.22. What type of technological advancements are happening for running the AI models on the end user devices to overcome constraints in respect of processor, memory, battery etc.? Whether special tools, programming languages, and skills are required to be developed to build such AI models? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Following technological advancements are perceived viz.

(d) Role of AI chips in AI at edge in end user devices: The advancement in AI chips may further support adoption of AI at edge and FL in telecom sectors for handling privacy. A report by Deloitte highlights that AI chips are physically smaller, relatively inexpensive, and use much less power and generate much less heat. This makes it possible to integrate them into handheld devices such as smartphones as well as non-consumer devices such as robots. By enabling these devices to perform processor-intensive AI computations locally, edge AI chips reduce or eliminate the transaction of large amounts of data to a remote location, thereby delivering benefits in usability, speed, data security and privacy and also thereby reducing power requirements by telecom infrastructure to handle such large data.

(e) The AI chips may also enable the devices to train, test and evaluate the small AI models on the device itself. Thus, the AI chips may also address the computing infrastructure requirements for development of AI solutions. Most of the devices will be having AI chips for their functioning. The telecom industry may also work towards adoption of AI chips at each and every node to the network to enhance the performance of the network.

(f) Role of TinyML at edge: As training of AI models requires high computing infrastructure and the computing capabilities of AI chips at edge devices may be limited, this poses restrictions of development of AI models at edge. In these cases, the emerging field of TinyML will address these concerns. TinyML is broadly defined as a fast growing field of ML technologies and applications including hardware, algorithms and software capable of performing on-device sensor data analytics at extremely low power, typically in the mW range and below, and hence enabling a variety of always-on use-cases and targeting battery operated devices. TinyML is enabling a new class of low-latency, high-bandwidth applications. ML models are finding yet another home in small, low-powered embedded devices. Following are some i. Low Latency: Since the model runs on the edge, the data doesn't have to be sent to a server to run inference. This reduces the latency of the output. ii. Low Power Consumption: As we discussed before, microcontrollers consume very little power. This enables them to run without being charged for a really long time. iii. Low Bandwidth: As the data doesn't have to be sent to the server constantly, less internet bandwidth is used. iv. Privacy: Since the model is running on the edge, your data is not stored in any servers. As AI learning and model training is moving towards edge, the telecom sector will be one of the beneficiaries of TinyML. Thus, industry may explore the possibilities and applications of TinyML at edge.

Q.23. Considering availability of new privacy preserving architectures as suggested in response to Q.19 and Q.20, what is the likelihood of emergence of new business and operational models? Whether such models will raise issues related to ownership and responsibilities? What do you suggest to address these issues? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Yes-there are likely to be emergence of new business and operational models which will be closely interlinked with issues pertaining to ownership and responsibilities.

With the adoption of next generation mobile technologies, the telecom network may serve industries and societies by acting as a central communication platform. It would support a wide range of services and will bring digital and physical worlds closer than ever. However, operating large numbers of digital services with different requirements will demand a high degree of autonomy in the operational processes.

Q.24. Whether the concept of "Operator Platform" would help in providing AI based solutions in a unified and more equitable manner? Apart from popular federated use cases of edge cloud federation, Cloud XR, Cloud Gaming, whether this concept may also be applied for public service delivery and in making public policies that are data-driven? Whether there is a need to take initiatives for developing and demonstrating advantages of concept of "Operator Platform"? If so, what steps and measures are suggested to launch such initiatives? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Yes-there is a need to develop Operator Platform at Edge for Cross Sector Utilization GSMA, highlights that there is a growing industry consensus that while consumers will be the biggest initial adopters of 5G, the enterprise segment offers significant incremental revenue opportunity for operators in the 5G era. Given the wide diversity of use cases that operators will be tasked to address from healthcare to industrial IoT, it seems logical for operators to create a generic platform that can package the existing assets and capabilities as well as the new capabilities such as Edge cloud, network slicing etc. that 5G makes available. (This will create necessary flexibility required by new breed of enterprise customers.

Operators will collaborate to offer a unified 'operator platform'. This platform will federate multiple operator's edge computing infrastructure to give application providers access to a global edge cloud to run innovative, distributed, and low latency services through a set of common APIs. This common 'operator platform' may help developers of smart end user devices by avoiding the requirement to deal separately with many operators. This common 'operator platform' may also help in offering edge computing in a seamless manner even when user travel from one operator's network to another.

This Operator Platform can also leverage, apart from other things, an enviable position for stringent security, data privacy, residency and sovereignty. Cloud capabilities will be treated as a subset of edge. It is expected that in future, enterprises will require in parallel a simple and universal way to interact with customers and new network and services capabilities. Operators will need to package their solutions as open platforms that can be used by enterprises to deliver services to their customers.

There may be a need to have framework that would ensure users of the platform (developers and application providers) are involved at an early stage in the design and have their needs taken care of. Operator Platform (OP) would enable an operator to place the solutions or applications of enterprises in a proximity to their customers. Exposed capabilities of Operator Platform can be used seamlessly across the federation footprint. Operator Platform may serve as an access point to external application providers for accessing network and service capabilities. Operators will play a key role to grant access to applications closer to the end user fostering the development of new services and solutions that make full use of 5G capabilities.

With the edge and platform concept, key enhancements would be needed to go beyond simple data centers with distributed computing capabilities. Such enhancements may include, capability to federate operators so that edge computing is offered as a unified service by an Operator Platform and capabilities to select or reselect relevant edge computing node for optimizing the performance at a particular location of a cloud service user. Operators may be required to go beyond the standard approach of defining common APIs and data models.

Operators should ensure technology development and its availability based on iterative models for software development instead of specification-based waterfall model. "More running code and less paper" is a recommended principle. It also suggests that operators should not work in isolation and rather they should engage with players that have already solutions or communities on Edge Cloud, moving from a pure Telco initiative to a wider industry initiative.

Footprint of Edge computing infrastructure and its capability may differ from one telco to another while requirements of the end users of the applications may be same or similar. With capabilities of Edge AI in protecting privacy and giving enhanced experience, concept of Operator Platform may be very useful for delivering future services in more equitable manner. With increased digital interactions, this concept may also enable framing data-driven public policies. In order to extract full value of this concept, there may be need to conduct experiments with the involvement of relevant stakeholders.

Q.25. Whether there is a need to create AI-specific infrastructure for the purpose of startups and enterprises in the telecom sector to develop and run AI models in an optimised manner? Whether such an infrastructure should cover various real-world scenarios such as cloud AI, edge AI and on-device AI? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Yes-there is a need for building AI specific computing infrastructure to train and develop an AI model. To accelerate adoption of AI in telecom sector, the industry may use the benefits of such infrastructure to train their AI models by fine-tuning or deriving from foundational models. Similar approaches are useful in development of large AI models by fine tuning or deriving models specific for country requirements.

The computation requirements at each layer of network may be different as the AI models have to perform different type of operations. To fulfil such demands, organisations are adopting Graphical Processing Unit (GPU) or Tensor Processing Unit (TPU) as an efficient computing infrastructure. Further, the adoption of GPU, TPU may also vary based on the area of application as GPU shows better flexibility and programmability for irregular computations, while TPU is highly optimised for large batches and Convolution Neural Networks (CNNs) and has the highest training throughput. Facebook (now Meta) also published that in 2017, it had designed first generation of high computing infrastructure which has 22,000 NVIDIA V100 Tensor Core GPUs in a single cluster. Now, Facebook (Meta) is developing AI Research SuperCluster (RSC) 147 which will increase AI training performance by more than 2.5-fold.

In India, PARAM Siddhi-AI148 is high-performance computing-artificial intelligence (HPC-AI), built on the NVIDIA DGX SuperPOD reference architecture networking. Thus,

organisations are working towards fulfilling the demand of computing infrastructure for different level of applications by developing AI specific infrastructure.

The NITI Aayog proposed to establish India's own AI-first compute infrastructure. It is aimed to facilitate and speed up research and solution development for solving India's societal challenges using high performance and high throughput AI-specific supercomputing technologies. The approach paper on AIRAWAT (AI Research, Analytics & knowledge Assimilation platform) introduced a cloud based AI-specific infrastructure to support varieties of AI workloads and Learning frameworks for user choices. The proposed architecture, with composite compute and storage infrastructure, allows maintaining large data sets (thus eliminating the need for separate data centres and addressing data integrity concerns), and proximity of computing facilities for efficient processing of data-intensive tasks viz. training of algorithms on large (both number and size) datasets.

Democratization of Models: Further, ML ecosystem have witnessed tremendous progress in last few years. The success of large models trained on expansive datasets i.e. foundational models has unlocked high performance across ML models. The coalescence of these foundational models (e.g. BERT, CLIP, the GPTs, Gopher) has democratized access to high-quality, generic architectures. Also, the fine-tuning of foundational models can lead to high performance for downstream tasks. The emergence of foundational models creates network effects i.e. improvements to one model can often flow into its fine-tuned or derived models. The homogenization of models and growing AutoML paradigms also allow some degree of standardization in the ML stack and process, which enables adoption and further innovation of these models. Many countries are investing to build foundational models which requires huge investments. This will reduce the effort to build models from scratch and thereby reduce cost and time. It also brings some degree of standardisation in AI modelling. Thus, to accelerate adoption of AI in telecom sector, the industry may use the benefits of such models to train their AI models by fine-tuning or deriving from foundational models. Similar approaches are useful in development of large AI models by fine tuning or deriving models specific for country requirements.

Q.26. Whether the emerging trends of development of foundational AI models such as GPT-3, Gopher etc. are leading to democratisation of AI space by offering fine-tuned or derived AI models? Whether such a trend will also help in reducing costs for the AI developers? Whether similar approach will help in development of large-scale AI model for the telecom sector? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Kindly refer to our Response to Q7 above

Q.27. Whether there is a need to establish experimental campuses where startups, innovators, and researchers can develop or demonstrate technological capabilities, innovative business and operational models? Whether participation of users at the time of design and development is also required for enhancing the chances of success of products or solutions? Whether such a setup will reduce the burden on developers and enable them to focus on their core competence areas? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Yes- Experimental Campuses on the lines of a Regulatory Sandbox must be conceived which will provide ample opportunities without any hinderances or challenges to experiment with new and innovative use cases, applications & services based on AI. Since success and maturing of AI based operational, technological & business models are heavily dependent on large volumes of relevant data, availability of campuses bereft of any regulatory impedances would be ideal for spurring innovation.

Regulatory Sandbox: The regulatory sandbox may address the complexities and risks associated with deployment of AI solutions. It can also provide necessary environment to test and demonstrate the AI solutions for the industry. Further, there is a need to protect developers during experimentation stage, from any probable violation of existing regulations. It would also be helpful for policy makers to review existing regulations and address such concerns alternative ways. Creation of Regulatory Sandbox may be part of such a setup. AI Regulatory Sandbox provides a controlled environment that facilitates the development, testing and validation of innovative AI systems for a limited time before their live deployment. It also reduces regulatory burden and facilitates experimentation to improvise and boost confidence of operators in AI solutions while deploying in live networks.

Globally, following countries have proposed to establish regulatory sandboxes for this purpose: a. The European Union in its AI Act (AIA) proposed a common framework for AI regulatory sandboxes across Europe to ensure that the regulatory framework is innovation friendly, future-proof and resilient to disruption. b. In May 2020, Colombia's Regulation Communications Commission (CRC) introduced a regulatory sandbox for communication services. Colombia Data Protection Authority launched an innovative regulatory Sandbox on privacy by design and by default in AI projects. c. The UK Information Commissioners Office, ICO introduced the Sandbox service to support organisations which are developing products and/or services that use personal data in innovative and safe ways and where such products and/or services deliver a potential public benefit. In order to develop the Sandbox, the ICO initially launched the Sandbox as a beta phase, for an initial group of participant organisations in 2019 - 2020. d. The Norwegian Data Protection Agency has introduced a regulatory sandbox following the British model. The sandbox establishes a project environment for AI, where private and public companies can get free guidance on personal data protection.

Following may be the possible objectives for adoption of regulatory sandboxes: a. To foster AI innovation by establishing a controlled, safe and testing environment during development and pre-marketing phase. b. To enhance legal certainty for innovators and the competent authorities' oversight, and understanding of the opportunities, emerging risks and the impact of AI use. c. To accelerate access to markets which includes removal of barriers for small and medium enterprises (SMEs) and start-up.

Experimentation mindset is the key to build confidence in both users i.e. telecom operators and telecom subscribers who are directly or indirectly impacted by those solutions. The adoption of regulatory sandbox may help to achieve the goal of AI through experimentation. It should be explored whether regulatory sandbox can provide means to demonstrate the strength of privacy preserving techniques, since it could help in building trust. Thus, the regulatory sandbox may require to be designed and developed for AI in telecom sector along with framing necessary terms and conditions

While user participation is always desirable while developing any solution, often this may not be possible or feasible due to technological complexities involved which either the end user may not be able to follow or understand /appreciate.

Q.28. Whether experiments are required to be backed by regulatory provisions such as regulatory sandbox to protect experimenters from any violation of existing regulations? Whether participation of government entities or authorities during experimentation will help them to learn and identify changes required in the existing regulations or introducing new regulations? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Please refer to response to Q27 above. Yes, participation or involvement of govt entities during the experimental phase would lead to better understanding of the regulations required and/or changes required to be made in the existing regulations.

Q.29. In response to Q.27 and Q.28, whether establishing such a campus under government patronage will enable easy accessibility of public resources such as spectrum, numbering and other resources to the researchers? Whether it would be in mutual interest of established private players as well as startups, innovators and enterprises to participate in such experiments? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Technology has always been a constant source of uncertainty, risks, changes and in many cases disruption. Complexity, uncertainty and the fast pace of the innovation process generate a panoply of regulatory challenges. Technology like AI also poses complexities, risks or constraints such as non-compliance of regulatory regimes, loss of direct control and harm to customers etc. in its adoption. Thus, the operators in telecom sector may have risks in

adopting these technologies for live networks. Further, the operators can develop and test their AI solution on the live network. However, the other players in the ecosystem who desire to develop the AI solutions for the industry may not be able to develop an optimal solution due to non-availability of efficient live network for testing and demonstration. Further, development of an optimal solution requires to consider all the aspects of the network before deploying it live, which requires an environment which can provide similar conditions as available in a live network to test and design an optimal solution. Thus, there is a need to develop solutions which best fit the above requirements for testing and demonstration. Following are the mechanisms which can help in experimentation and demonstration of AI solutions.

Regulatory Sandbox: The regulatory sandbox may address the complexities and risks associated with deployment of AI solutions. It can also provide necessary environment to test and demonstrate the AI solutions for the industry. Further, there is a need to protect developers during experimentation stage, from any probable violation of existing regulations. It would also be helpful for policy makers to review existing regulations and address such concerns alternative ways. Creation of Regulatory Sandbox may be part of such a setup. AI Regulatory Sandbox provides a controlled environment that facilitates the development, testing and validation of innovative AI systems for a limited time before their live deployment. It also reduces regulatory burden and facilitates experimentation to improvise and boost confidence of operators in AI solutions while deploying in live networks.

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Experimentation mindset is the key to build confidence in both users i.e. telecom operators and telecom subscribers who are directly or indirectly impacted by those solutions. The adoption of regulatory sandbox may help to achieve the goal of AI through experimentation. It should be explored whether regulatory sandbox can provide means to demonstrate the strength of privacy preserving techniques, since it could help in building trust. Thus, the regulatory sandbox may require to be designed and developed for AI in telecom sector along with framing necessary terms and conditions.

Evolving Future Business Models-Concept of Lighthouse: In order to reduce cost burden and ease out process for experimentation, a campus with suitable infrastructure may be made available to the experimenter to come and test his/her innovative products or solutions. This concept may be built on similar lines as adopted for accelerating adoption of Industry Revolution 4.0 (4IR). In 2016, the World Economic Forum (WEF) came up with a concept of Lighthouse in order to accelerate adoption of Industry Revolution 4.0 (4IR). Lighthouse shows the way demonstrating how digitally infused operations extend beyond productivity gains for creating a base for sustainable, and profitable growth. It yields increased speed to market through customizable product development which is informed by a better understanding of customer demands; meanwhile, it boosts productivity of both assets and people. While conventional wisdom might presume that this kind of transformation would come at exorbitant cost, lighthouses are showing the opposite trend. The concept of lighthouse may also be adopted with suitable modifications to accelerate adoption of AI related use cases in the telecom sector. The adoption may incorporate design thinking concepts while building a shared infrastructure available to experimenters to develop AI solutions by involving all relevant stakeholders. Focus of the campus may be to provide test infrastructure and offer opportunities for relevant stakeholders and startups to develop new business and operational models. This may also be helpful to departments and ministries including regulators for understanding and identifying changes needed in the existing policies and regulations or for introducing new regulations.

Q.30. Whether active participation in the international challenge programs such as ITU AI/ML 5G challenge will help India's telecom industry in adopting AI? Whether similar programs are also required to be launched at the national level? Whether such programs will help to curate problem statements or help in enabling, creating, training and deploying AI/ML models for Indian telecom networks? What steps or measures do you suggest to encourage active participation at international level and setting up of such programs at national level? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

The risks and constraints with technologies are being addressed by various organisations/companies by organising challenge-based programs. These programs help in improvising the solutions or products by allowing different stakeholders to participate and to demonstrate their products or provide ideas on the solutions. Conducting challenge-based

programs not only resolves the constraints but also helps in building trust on the AI solutions. If the participants are able to disrupt the AI solution, the operator needs to further work on the AI solution to improve its capabilities before launching in a real environment. This process helps in developing an optimal AI solution.

Similar programs need to be launched at national level too as is being done at ITU and other institutions and bodies. Such programs will help to curate problem statements or help in enabling, creating, training and deploying AI/ML models for Indian telecom networks.

Q.31. Whether AI/ML developers should launch bounty programs to establish trust in the public about robustness of measures taken by them to protect privacy in their products or solutions? Whether conduction of such programs will help companies or firms to improve their products or solutions? Whether such programs should be conducted under the supervision of the government or an institution established/assigned for this purpose? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

The risks and constraints with technologies are being addressed by various organisations/companies by organising challenge-based programs. These programs help in improvising the solutions or products by allowing different stakeholders to participate and to demonstrate their products or provide ideas on the solutions. Conducting challenge-based programs not only resolves the constraints but also helps in building trust on the AI solutions. If the participants are able to disrupt the AI solution, the operator needs to further work on the AI solution to improve its capabilities before launching in a real environment. This process helps in developing an optimal AI solution.

Bug bounty programs have been implemented by a large number of organisations. A Chinese telecom service provider, ZTE, launched a bug-bounty program to encourage security researchers and organisations worldwide to identify vulnerabilities in its products and services. Apple Security Bounty, as part of Apple's commitment to security rewards researchers who share critical issues and the techniques used to exploit them.

Similar approach may be adopted in the telecom sector for adoption of AI, where the telecom operators may organise, challenge-based programs or bounty programs to resolve the issues and improve the performance of the AI solutions in the network. This may provide a platform to demonstrate innovative solutions and give opportunities for others to find vulnerabilities or issues in the AI solutions. Solution providers may come up and demonstrate to prove that there are techniques strong enough to protect user privacy while harnessing their data. Such demonstrations build trust on the AI solution so developed and bring recognition to operator's use of smart solutions and products to improve telecom networks. Further, while conducting the challenge or bounty programs, the industry should promote the usage of indigenous datasets. These datasets can be collected or generated based on the requirements

and the nature of the program. Collaboration of telecom with different sectors viz. health, transport, finance etc. may significantly help in achieving the desired results

Q.32. Whether the telecom industry is required to adopt a Machine Learning Operations (MLOps) environment to develop, train, validate and store ML models? Whether there is also a need to establish a DataOps feature store to help MLOps for training purposes? What standardisation is required in terms of interoperability and compatibility for MLOps to function in a federated manner? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Yes-Telecom Industry should adopt a MLOps environment to develop, train , validate and store ML models .

A Machine Learning Operations (MLOps) environment is where ML models are developed, trained, validated and stored. Training is based on data from the DataOps feature store. Training data may also involve feedback from models that are already up and running. Such capabilities of MLOps and tooling may be required to be explored and utilised for development and optimization of AI solutions and products in the telecom sector.

Q.33. Whether active participation in the international bootcamp programs such as MIT Bootcamps, Design Thinking Bootcamp by Stanford University etc. will help India's telecom industry workforce to find international developers community, navigate challenges and learn from experiences of others? Whether similar programs are also required to be launched at the national level? What steps or measures do you suggest to encourage active participation at the international level and setting up of such programs at the national level? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Lack of skill in new and emerging technologies viz. AI & ML impedes overall innovation. Hence new initiatives in skilling and re-skilling in such technologies is very much required.

To develop skills for AI, various graduation/post-graduation courses are provided in many universities. However, to bring new use cases in any sector, it requires sector-specific knowledge and skills as part of the training. In the case of telecom, network engineers typically do not have background of AI that includes mathematical training and experience that is essential in AI, for example data modelling and evaluation, software engineering and system design, ML algorithms and libraries. Also, AI experts may not have technical knowledge of the network. Thus, recruiting people with the right skills is a challenge.

It has also been observed that some organisations and companies have been organising Bootcamps to impart better skills to their employees to improve the overall performance of the organisations. For example, MIT launched a bootcamp program to impart education,

experience by on the job learning. On similar lines, the industry may also organise bootcamp programs for AI & ML to build workforce for new technologies and skill employees for development of solutions or products on AI in telecom sector.

In the telecom sector too, there may be a need to build AI workforce to accelerate adoption of AI. For this purpose, a clear roadmap on capacity building and skilling may be required to be formulated. This roadmap may include an assessment drive to identify professionals with requisite skills in the telecom sector. This assessment will help in understanding where does the telecom sector stands in terms of skilled workforce. This will also guide industry to work in particular areas and direction. After the assessment drive, the roadmap may include upskilling the current workforce to acquaint with use of emerging technologies and attracting new talent to work in the telecom sector. There is also a need to introduce new curriculum related to AI in telecom at graduation level to build AI workforce.

Q.34. Whether the courses or programs related to AI/ML currently being offered by various institutions and universities in India are adequate to meet the capacity and competence required to develop and deploy AI solutions or products in the telecom networks? If not, what additional steps or measures are suggested to fill the gap? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

There is a clear need to introduce new curriculum related to AI in telecom at graduation level to build AI workforce To develop skills for AI, various graduation/post-graduation courses are provided in many universities. However, to bring new use cases in any sector, it requires sector-specific knowledge and skills as part of the training. For example, there are various programming languages used for AI such as Python, R, LISP, Java, C++, Prolog, Go and Julia etc. and different operations require different programming language. In the case of telecom, network engineers typically do not have background of AI that includes mathematical training and experience that is essential in AI, for example data modelling and evaluation, software engineering and system design, ML algorithms and libraries. Also, AI experts may not have technical knowledge of the network. Thus, recruiting people with the right skills is a challenge.

A PWC survey report states that 28% of the firms consider training and recruiting skilled professionals who can work with AI systems, a hurdle. In the telecom sector too, there may be a need to build AI workforce to accelerate adoption of AI. For this purpose, a clear roadmap on capacity building and skilling may be required to be formulated. This roadmap may include an assessment drive to identify professionals with requisite skills in the telecom sector. This assessment will help in understanding where does the telecom sector stands in terms of skilled workforce. This will also guide industry to work in particular areas and direction. After the assessment drive, the roadmap may include upskilling the current workforce to acquaint with use of emerging technologies and attracting new talent to work in the telecom sector.. It has also been observed that some organisations and companies have been organising

Some organisations have set up Bootcamps to impart better skills to their employees to improve the overall performance of the organisations. For example, MIT launched a bootcamp program to impart education, experience by on the job learning. On similar lines, the industry may also organise bootcamp programs to build workforce for new technologies. Stanford University also launches Design Thinking Bootcamps to learn and apply skills to solve real business challenges. On a similar line, the industry may explore to launch bootcamp programs for AI and ML to build students and employees for development of solutions or products on AI in telecom sector.

Q.35. Whether establishing a system for accreditation of AI products and solutions will help buyers to purchase such solutions or products? If yes, what should be the process of accreditation and who should be authorised or assigned with the task of accrediting such products or solutions? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Yes-system of accreditation of AI Products and solutions is required to help buyers not familiar with these products and solutions and also ensures quality and genuineness of the same. The process of accreditation may involve fulfilment of certain requirements that makes the AI solutions more trustworthy. For the purpose of accreditation, an entity or institution may be directed to frame guidelines for accreditation of AI solutions or products.

Building trust on AI systems as a whole may be one of the key enablers for adoption of AI as it may address the concerns of risk or challenges associated with AI. For building trust, the organisations and the Government stresses on the process of accreditation that would go a long way towards increasing public trust in AI. The accreditation of AI solutions is considered a possible key requirement for promoting the use of AI systems in adoption in various sectors. In addition, it can create confidence among citizens, lead to better products and influence the national and international market dynamics.

In order to prevent accreditation procedures from becoming an obstacle to innovation, it is necessary to guarantee certain standards of AI systems, avoid over-regulation, enable innovation and initiate new developments in AI application. Accreditation certifies genuine AI solutions and products. It also builds trust during procurement of AI solutions and services.

Following countries have proposed for accreditation of AI products and solutions to build trust on the AI: i. European Union: The European Economic and Social Committee (EESC) suggests that the EU should develop a certification for trustworthy AI applications, to be awarded by an independent body after testing the products for key requirements such as resilience, safety, absence of prejudice, and discrimination or bias. ii. Singapore-based AI companies are being accredited by IMDA under the initiative Accreditation@SGD177.

Q.36. Whether creating a framework to prepare a list of prequalified suppliers of AI products or solutions will help industry including government agencies to procure AI products or solutions? Whether there is a need to formulate a standard Code of Conduct or guidelines for AI related procurements? What should be the typical elements of such a Code of Conduct or guidelines including guidelines on trusted source and who should be tasked to formulate such a Code of Conduct or guidelines? Please justify your response with rationale and suitable examples, if any.

BIF RESPONSE

Yes, preparation of a list of pre-qualified suppliers of AI products and solutions and guidelines would help to procure AI products and solutions which has the potential to vastly improve governance and meet the needs of the citizens. This would also help safeguard the public from any impact of AI solutions or products adopted in the telecom industry, there is a need to frame procurement mechanisms of AI products or solutions. This will also help in connecting with genuine suppliers. Governments are likely to use the opportunities offered by AI to improve service delivery to the public at large and use AI as policy tools to stimulate the economy.

In India, NITI Aayog has also been working to operationalise the principles of responsible AI to address these risks. However, there is also a need for procurement mechanisms of AI solutions to safeguard the public from any impact by AI solutions being adopted. Various organisations and Countries have been working on procurement of AI products or solutions. Some of these are listed below:

i. The World Economic Forum, in partnership with Deloitte and the UK government's Office for Artificial Intelligence, has developed a toolkit to assist public sector organisations seeking to procure AI solutions. The goals are as under:

a. To help public sector organisations to create clear specifications that address concerns of bias, privacy, accountability, transparency, and proportionality

b. To build dynamic and competitive AI marketplace

c. To establish responsible AI practices.

Canada has developed a similar framework. The framework establishes a pre-qualified list of suppliers who meet all of the mandatory criteria to provide Canada with responsible and effective AI services, solutions or products.. Further AI can also be leveraged in the process of procurement itself as this process gathers data on clients, spend, transactions, pricing, suppliers, contract details etc. Similarly, every stage of the supply chain has incoming and outgoing data that affects the product journey.

Also, some review tasks in procurement are so time consuming that data is only really looked at on quarterly or biannual basis. Most of the organisations possess disparate data obtained from multiple enterprise-wide systems. The adoption of AI can bring together and identify

synergies among them. Identifying patterns and anomalies is how AI gets the most out of the data. Adoption of AI in procurement process may help the entities, agencies, governments in making better decisions by identifying new opportunities, improving operations, automating manual tasks, freeing up time, capturing or applying scarce knowledge, identifying new suppliers or markets and optimizing supplier relationships. However, deploying AI in procurement process may require the guidelines to be followed to have a standard Code of Conduct for adoption.

Q.37. Whether there is a need to prepare and publish a compendium of guidance, toolkits and use cases related to AI and BD, to foster adoption in the telecom sector? If yes, what should be the process to prepare such a compendium and who should be assigned this task? Please justify your response with rationale and global best practices, if any.

BIF RESPONSE

Yes-there is a need to prepare and publish a Compendium of Toolkits and Use Cases related to AI & BD to foster adoption in the telecom sector. This may help guide the industry to adopt AI & BD more extensively. There are several global best practices in this regard, which India will do well to emulate.

a) Singapore: In 2019, Singapore released its first edition of the Model AI Governance Framework, which provides detailed and readily implementable guidance to private sector organisations to address key ethical and governance issues when deploying AI solutions. Infocomm Media Development Authority (IMDA) and Personal Data Protection Commission (PDPC) Singapore, partnered with the World Economic Forum Centre to develop the Implementation and Self-Assessment Guide for Organisations (ISAGO) in January 2020. Its purpose was to help organisations to assess the alignment of their AI governance practices with the Model Framework. It also provides an extensive list of useful industry examples and practices to help organisations implement the Model Framework. The framework also translates principles into pragmatic measures that businesses can adopt voluntarily. For small players with limited resources and capabilities, such guidance provides a clear pathway for adoption.

b) Some organisations and government bodies created toolkits which assist in understanding AI's impact. For instance, AI Toolkit for c-suite executives as part of World Economic Forum's Project, a practical set of tools that can help corporate executives understand AI's impact on their roles, ask the right questions, understand the key trade-offs, and make informed decisions on AI projects and implementation. Similarly, there are tools to test AI maturity level of organisations, tools to assess risk due to algorithms. The assistance in the form of a collection of pragmatic approaches for adoption of AI, or in the form of toolkits to measure readiness and assess alignment with ethical principles, are the approaches to build readiness in industry and bolster adoption of AI.

Q.38. Whether there is a need to establish telecom industry-academia linkages specifically for AI and BD to accelerate the development and deployment of AI products and solutions? Whether there is a need to establish Centres of Excellence (CoEs) for this purpose or it can be achieved by enhancing the role of existing TCoE? Please justify your response with rationale and global best practices, if any.

BIF RESPONSE

Yes-there is need to establish strong linkages between telecom industry and academia specifically to foster development and deployment of AI/ML based innovation and products, preferably with Govt support and incentivisation. Industry academia cooperation could lead to several areas areas where research may help to improve the performance of the network. Thus, for this purpose, Centres of Excellence have been the key focus for many nations to ace the race to become global champions in AI. For instance, the EU Commission's report recommends creation of testing and experimentation sites to support the development and subsequent deployment of novel AI applications. The Commission facilitates the creation of excellence and testing centres that can combine European, national and private investments. Other countries that have done likewise are a) Germany which has created Competence Centres for AI Research b) Finland established Finnish Centre for Artificial Intelligence (FCAI) to promote both AI research, and the use and application of AI and has granted EUR 8.3 million in flagship funding for 2019–2022. c) Denmark allocated DKK 100 million for establishing a Digital Research Centre to research in AI, big data, IoT and IT Security.d) The Federal Government in USA has set up AI Centre of Excellence.

The importance of CoE has also been brought out by NITI Aayog in the discussion paper on National Strategy on AI. Also, many Centres of Excellence and research labs are being set up at India's premier universities to help improve the country's research output. Many of these centres are set up in partnership with major IT organisations where both the academia and the organisations can get an edge in areas of emerging technologies.

CoE may focus on various aspects such as researching methods to mitigate risks from AI, finding ways to preserve user privacy, reducing skill gap and bolster adoption. CoE for AI in telecom may be established with an objective to leverage not just AI and BD but also other emerging technologies in the telecom sector. Further, the academia and startups working in the field of AI and BD may be made part of such CoE. Such Industry-academia partnership may help in advancing research and creating a skilled workforce. To begin with, the aspects of AI for adoption may also be dealt with by Telecom Centres of Excellence (TCoEs) established by DoT as a PPP initiative, in February 2008.

Q.39. Whether there is a need to establish telecom industry-academia linkages specifically for AI and BD for AI related skill development? Please give the suggestions for strengthening the industry-academia linkages for identification of the skill development courses. Please justify your response with rationale and global best practices, if any.

BIF RESPONSE

Detailed Response regarding Industry-Academia interactions given in response to Q38 above

Q.40. Any other issue which is relevant to this subject? Please suggest with justification.

BIF RESPONSE

No Comments