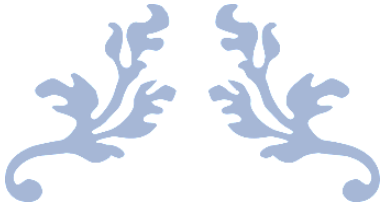

INDIAN ARTIFICIAL INTELLIGENCE STACK

02 nd September 2020

AI STANDARDISATION COMMITTEE
DEPARTMENT OF TELECOMMUNICATIONS

PREFACE

Adoption of Artificial Intelligence (AI) has become a key factor for the development of a country. Technological, economic and military supremacy can only be achieved with access to AI related resources and development of relevant AI solutions. As with any other technological advancement, AI brings numerous opportunities as also challenges. For adapting AI to the Indian environment, across sectors, it is required to evolve uniform standards in this field. This is the only way forward for a more effective adoption by all stakeholders and this also is the biggest challenge facing us.

The Government of India has recognised that an AI driven economy, can transform the lives of millions, i.e., AI is the main driver for the desired socio-economic transformation of India. Leveraging AI for inclusive growth in line with the Government policy of *'Sabka Saath Sabka Vikas'* is one of the core principles identified in the NITI Aayog's National Strategy paper. It is the path for much needed job creation in various sectors, apart from creating new business opportunities and help increasing household incomes.

This, therefore, is an opportune time to discuss the issues related to developing a framework of an Indian AI stack, which this discussion paper proposes. For an inclusive process, there is a need to view the matter from both the demand and supply sides. Hence, the government and private sector players, including manufacturers, service integrators, cloud service providers etc, need to come together and coordinate in the development of an India specific AI stack that can seamlessly cater to all sectors. This way, it can also become the foundation for the next Industrial Revolution.

This paper proposes a stack that seeks to remove the impediments to AI deployment by putting in place a comprehensive framework. A framework that will create an enabling environment to exploit AI productively in various walks of life. This will enable development of suitable AI stack with different mix of layers and interfaces that complements each other and achieve integration. This paper proposes to divide the AI stack in six different layers with appropriate horizontal and vertical integration.

I urge all stakeholders - multilateral institutions, the private sector, various government organisations, etc - to discuss the paper for development of this Indian AI stack and help in crafting, and controlling, our collective AI future through this framework.

I request all to support the initiative taken by the department, by offering your comments on this discussion paper by 03/10/2020. The comments may please be sent to Shri M. Raj Anup ITS ADG, DoT APLSA Vijayawada on the e-mail address: aigroup-dot@gov.in or diradmnap-dot@gov.in.

(A Robert J. Ravi)

Chairman

AI standardisation committee, DoT.

[Dy. Director General, APLSA, Vijayawada]

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ABBREVIATIONS

4IR	*Fourth Industrial Revolution*
AI	*Artificial Intelligence*
AI/ML	*Artificial Intelligence/Machine Learning*
AML	*Anti-Money Laundering*
API	*Application programming interface*
BCG	*Boston Consulting Group*
BCG	*Boston Consulting Group*
CAGR	*Compound Annual Growth Rate*
CERT	*Computer Emergency Response Team*
COMPAS	*Correctional Offender Management Profiling for Alternative Sanctions*
COVID 19	*Corona Virus Disease 2019*
DL	*Deep Learning*
DNN	*Deep Neural Networks*
DNN	*Deep Neural Networks*
DOT	*Department of Telecommunications*
GoI	*Government of India*
GPDR	*General Data Protection Regulation*
GPUs	*Graphics Processing Unit*
IBM	*International Business Machines*
ICT	*Information and Communication Technology*
IOT	*Internet of Things*
MIT	*Massachusetts Institute of Technology*
NITI Aayog	*National Institution for Transforming India*
NKN	*National Knowledge Network*

ABBREVIATIONS

NLP	*Natural Language Processing*
PKI	*Public Key Infrastructure*
R&D	*Research and Development*
RBC - DSAI	*Robert Bosch Centre for Data Science and Artificial Intelligence*
RDI	*Research and Development and Innovation*
Saas	*Software-as-a-Service*
UAE	*United Arab Emirates*
UK	*United Kingdom*
UPI	*Unified payment Interface*
USA	*United States of America*
VM	*Virtual Machine*

1: INTRODUCTION

1.1. Information and Communication Technology (ICT) has revolutionized world over, the way people obtain information, communicate, do business, study and have fun. It has now become an integral part of our lives. ICT has become an essential element contributing to the development of societies, which the stakeholders are able to incorporate and harness them in their daily activities. Recently, it has played an important role in the mitigation of COVID-19 to a large extent, through contact tracing and other applications. It has also helped in reducing its impact in the society through e-learning; tele-medicine; dissemination of information etc.

1.2. The Government of India (GoI) just like the Private Sector and other stakeholders have embraced the reality of Fourth Industrial Revolution (4IR), where everything is going to be digitised through the marriage of physical and digital technologies such as analytics, artificial intelligence (AI), cognitive technologies and the Internet of Things (IoT). This marriage of the physical with the digital allows for the creation of a digital enterprise that is not only interconnected, but also capable of a more holistic, informed decision-making, which is-'*intelligently connected*". In a digital enterprise, data collected from physical systems are used to drive intelligent action back to the physical world. The Business Processes are also being disrupted because of the emergence of technology such as AI, IoT, Cloud Computing, etc.

1.3. Today, AI is transforming the role of ICT from silo implementation to a multi-faceted utility as a form of Artificial General Intelligence capability. AI has the potential to solve some of the most pressing challenges that impact the country and drive growth and development in all core sectors including health care, agriculture, education, finance and public sector applications.

1.4. Through AI as a service, one can apply cutting-edge approaches to digitally transform the enterprise especially in today's changing scenario.

This can help in lowering costs, increasing quality and enabling professionals to deliver higher value through new insights.

1.5. While AI offers huge potential to transform and realign the economy and society, there is an increasing realisation that AI could also exacerbate problems for people[1], without proper safeguards. For AI to be the sustainable revolution there is a need to provide an open environment with safeguards and oversight to guide the future that is being built. Support and partnerships will be required to be unlocked and the scale of innovation on emerging technologies and solutions to be considered.

1.6. Industrialised nations are investing to become world leaders in AI, which is seen as one of the main drivers of 4IR. Currently, the AI market revenue is valued at 3.5 billion dollars and is predicted to reach $26.4 billion dollars by 2023[2] with an increase in CAGR of approximately 40 percent. Most of the countries – Australia, Canada, China, France, Germany, UK and the USA are investing heavily in AI as part of their government initiatives to gain a competitive edge in different sectors. Both the Governments' and businesses can use it for decision-making and can increase their efficiency, profitability and outreach.

1.7. The AI systems can help Governments and organisations to understand, and point out human inconsistencies in decision-making; and reveal ways in which we are partial, parochial and cognitively biased. In such process of recognising the bias, it can help teach machines about common values, which can further help improve AI.

1.8. This information-fed transformation is expected to leverage new possibilities in industries to revamp their operations and provide improved scalability, productivity, efficiency and connectivity. However, this will require new architecture designs and upgraded technologies to make real-time decisions in an efficient manner, to cope with the

[1]http://www.g20-insights.org/policy_briefs/enabling-sustainable-fourth-industrial-revolution-g20-countries-can-create-conditions-emerging-technologies-benefit-people-planet/
[2] Beroe Inc. Report 2019

increasing demands, which will lead to the emergence of "connected intelligence" rather than mere "connected devices". This transformation is expected to revolutionise, but not limited to smart business solutions like smart dust, smart drones, futuristic farming, smart aerospace and smart energy networks.

1.9. AI software can bring invaluable potential benefits to society, with machine-learning being used to enhance and improve services and automate decision-making. AI can help identify and solve complex problems faster and more effectively, and its advantages are infinite in every sector. For Governments, for example, cybersecurity attacks can be rectified within hours, rather than months and national spending patterns can be monitored in real-time to instantly gauge inflation levels whilst collecting indirect taxes. Organisations have found limitless opportunities like self-driving vehicles, self-learning customer support, digital personal assistants and automated investment decisions.

2: AI's IMPACT ON SOCIETY

2.1. The transformative impact of AI on our society will have far-reaching social, economic, legal, political and regulatory implications.

Social impact:

2.2. Social consequences involve those effects, which will directly or indirectly impact our life from individual perspective, community and the society at large. Integration of AI is now transforming our daily life inevitably. There are different products powered by AI being used without even noticing. Google assistant, iPhone's Siri, Amazon's Alexa, Roomba vacuum cleaner, chatbots and many other apps are mostly powered by AI technology. Most of the technology giants are now considering the ethical and social implication that AI will have on the society.

Economic impact:

2.3. The 4IR will see the tremendous effects of AI technology on mainly four sectors viz are the Manufacturing industries, Professional services, financial services, and wholesale and retail. From an economic impact perspective, AI has the potential to drive growth through enabling intelligent automation, labour and capital augmentation and innovation diffusion.

2.4. According to research conducted by Accenture, with top twelve global economic leaders, the AI technology could double the annual economic growth rates in 2035 by changing the nature of the work and creating new relationships between man and machine. The technology will continue to offer amplification and transcend the current capital and labor capacity to propel our economic growth.

2.5. AI has the potential to provide large incremental value to a wide range of sectors globally as well as for India, and is expected to be the key source of competitive advantage for firms. Few of these sectors are explained below:

a) ***Healthcare*****:** AI in healthcare can help in mitigating the problem of high barriers of access to healthcare facilities and in rural areas that suffer from limited availability of healthcare professionals and facilities. This can be achieved through implementation of AI driven diagnostics, personalised treatment, early identification of potential pandemics, and imaging diagnostics, among others.

b) ***Agriculture*****:** AI holds the promise of driving a food revolution to meet the increased demand for food (global need to produce 50% more food to cater to an additional 2 billion people by 2050). It also has the potential to address challenges such as faulty demand prediction, lack of assured irrigation, and overuse / misuse of pesticides and fertilisers. Some use cases include improvement in crop yield through real time advisory, advanced detection of pest attacks, and prediction of crop prices to help efficient sowing practices.

c) ***Smart Mobility, including Transports and Logistics*:** Potential use cases in this domain include autonomous fleets for ride sharing, semi-autonomous features such as driver assist, and predictive engine monitoring and maintenance. Other areas that AI can impact include autonomous trucking and delivery and improved traffic management.

d) ***Retail*:** The retail sector has been one of the early adopters of AI solutions, with applications such as improving user experience by providing personalised suggestions, preference-based browsing and image-based product search. Other use cases include customer demand anticipation, improved inventory management, and efficient delivery management.

e) ***Manufacturing*:** Manufacturing industry is expected to be one of the biggest beneficiaries of AI based solutions, enabling '*Factory of the Future*' through flexible and adaptable technical systems to automate processes and machinery to respond to unfamiliar or unexpected situations by making smart decisions. Impact areas include engineering (AI for R&D efforts), supply chain management (demand forecasting), production (AI can achieve cost reduction and increase efficiency), maintenance (predictive maintenance and increased asset utilisation), quality assurance (e.g. vision systems with machine learning algorithms to identify defects and deviations in product features), and in-plant logistics and warehousing.

f) ***Energy*:** Potential use cases in the energy sector include energy system modelling and forecasting to decrease unpredictability and increase efficiency in power balancing and usage. In renewable energy systems, AI can enable storage of energy through intelligent grids enabled by smart meters and improve the reliability and affordability of photovoltaic energy. Similar to the manufacturing sector, AI may also be deployed for predictive maintenance of grid infrastructure.

g) ***Smart Cities*:** Integration of AI in newly developed smart cities and infrastructure could help in providing enhanced quality of life. Potential use cases include traffic control to reduce congestion, garbage disposal

management and enhanced security through improved crowd management.

h) **Education and Skilling:** AI can potentially solve the quality and access issues in the indian education sector. It can facilitate augmenting and enhance the learning experience through personalised learning, automating and expediting administrative tasks. It can also help in predicting the need for student intervention to reduce dropouts or recommend vocational training.

2.6. Banking and Financial Services sector has been one of the leading sectors in adopting AI in India. Existing and potential use of AI in this sector include improved customer interaction through personalised engagement, virtual customer assistance and chatbots, improved processes through deployment of intelligent automation in rule based back-office operations, development of credit scores through analysis of bank history or social media data, and fraud analytics for proactive monitoring and prevention of various instances of fraud, money laundering, malpractice, and prediction of potential risks.

2.7. The manufacturing sector in India has not been far behind, as reflected in a recent study by BCG, where India was ranked 3rd in the world in AI implementation in manufacturing, ahead of nations such as Germany, with 19% of companies in the sector already using AI to a significant extent.

3: DEFINITION OF AI

3.1. There is no uniform definition of AI. The founder of computer science theory—Alan Turing—believes that if a machine can talk to a person and will be mistaken to be human, then the machine is intelligent. The term "artificial intelligence" was originally coined in 1950's and was a simple theory of human intelligence being exhibited by machines[3]. However,

[3] Bini SA. Artificial intelligence, machine learning, deep learning, and cognitive computing: what do these terms mean and how will they impact health care? J Arthroplast. 2018;33(8):2358–61

John McCarthy first coined the term in 1956, and defined AI as *'the science and engineering of making intelligent machines'*.

3.2. There are several other definitions for AI, a few are deliberated below:

a. NITI Aayog in its discussion paper on "National Strategy for Artificial Intelligence "AI for All" dated June 2018 defines AI as

"*AI is a constellation of technologies that enable machines to act with higher levels of intelligence and emulate the human capabilities of sense, comprehend and act.*"

b. John McCarthy of Stanford university defines AI as

'It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.'

c. University of Louisiana at Lafayette, defines AI as

"Artificial Intelligence is the study of man-made computational devices and systems which can be made to act in a manner which we would be inclined to call intelligent."

d. 'Growing the Artificial Intelligence Industry in the UK' – a research paper defines AI as follows:

'*Artificial Intelligence (AI) describes a set of advanced general purpose digital technologies that enable machines to do highly complex tasks effectively.'*

e. Kaplan and Haenlein define AI as *"a system's ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation".*

f. In the Dartmouth conference 1956, the understanding of AI was that "*the reaction of a machine is like the intelligence of a person in action".*

g. Marvin Minsky, one of the fathers of AI, mentions that AI *"is a science that makes machines need human intelligence".*

h. Nils J. Nilsson from Stanford University believes that AI *"is the subject of knowledge, which is, how to express knowledge and how to acquire knowledge and use knowledge".*

i. Patrick Winston, from Massachusetts Institute of Technology (MIT), believes that AI *"is an intelligent job that studies how to make computers do the past only by talents".*

4: NEED FOR AN INDIAN AI STACK

4.1. In today's era of rapid technological advancement and exponential increase of large data sets ("big data"), AI has transitioned from mere theory to tangible application on an unprecedented scale. AI has become ingrained with the facets of society and often functions invisibly in the background of various personal electronic devices.

4.2. A number of progressing countries in the world have developed a National AI strategy. A detailed list of National Strategies adopted by different countries[4] are placed at Annexure -1.

4.3. Recognising the potential of AI's ability to transform the economy of a nation, Hon'ble Finance Minister, in his budget speech for 2018 – 2019, mandated NITI Aayog to establish the National Program on AI, with a view to guide the research and development. In pursuance of this, NITI Aayog adopted a three-pronged approach:

- Undertaking exploratory proof-of-concept of AI projects in various areas;
- Crafting a national strategy for building a vibrant AI ecosystem in India; and
- Collaborating with various experts and stakeholders.

4 https://futureoflife.org/national-international-ai-strategies/?cn-reloaded=1

4.4. NITI Aayog has collaborated with several leading AI technology players to implement AI projects in critical areas such as education, agriculture and health. It had also formulated a national strategy for AI. For this, it has identified the following barriers that need to be addressed:

- Lack of broad based expertise in research and application of AI;
- Absence of enabling data ecosystems – access to intelligent data;
- High resource cost and low awareness for adoption of AI;
- Privacy and security, including a lack of formal regulations around anonymisation of data; and
- Absence of collaborative approach to adoption and application of AI.

4.5. To address some of these bottlenecks from standardisation point of view, the Department of Telecommunications (DoT) had formed an AI standardisation committee to develop various interface standards and develop the India's AI stack. This stack so developed will be structured across all sectors - ensuring protection of data; data federation, data minimisation; open algorithm framework; defined data structures; interfaces and protocols, proper monitoring, audit and logging; data privacy; ethical standards; digital rights; trustworthiness; etc

4.6. In AI, the thrust is on how efficiently the data is used. If the data is 'garbage' then the output will also be so. For example, if programmers or AI trainers transfer their biases to AI; the system will become biased. The risks of passive adoption of AI that automates human decision-making are also severe. Such delegation can lead to harmful, unintended consequences, especially when it involves sensitive decisions or tasks and excludes human supervision.

4.7. There are a number of real-time examples of the same- like the disaster of Microsoft chatbot Tay, which was AI-powered, which remains a testimony to such use of data. Tay went from family-friendly to foul-

mouthed and had to be pulled in less than 24 hours. Hence, there is a need for ensuring Ethical Standards.

4.8. In another incident in 2016 in USA, the Correctional Offender Management Profiling for Alternative Sanctions (COMPAS) software used by some US courts in predicting the likelihood of recidivism in criminal defendants was demonstrated to be biased since the AI “black box” was "proprietary". This necessitates openness in AI algorithms- an open algorithm framework and a need to enable clearly defined data structures.

4.9. Another case of algorithmic bias is, Microsoft researchers found that the word-embedding algorithms had problematic biases, like associating "computer programmer" with male pronouns and "homemaker" with female ones. This debunks the myth of AI neutrality and sheds light on algorithmic bias, a phenomenon that can reach critical dimensions as algorithms become increasingly involved in each decision in AI. This also increases the need for Trustworthiness.

4.10. The AI software or analytics is a code that learns from the data it analyses, thus increasing its effectiveness and accuracy in predicting future actions. However, it has its drawbacks. As AI learns, to address societal problems, it also develops its own hidden biases. The self-learning nature of AI means, the distorted data the AI discovers in search engines, perhaps based upon “unconscious and institutional biases”, and other prejudices, is codified into a matrix that will make decisions for years to come. In the pursuit of being the best at its task, the AI may make decisions it considers the most effective or efficient for its given objective, but because of the wrong data, it becomes unfair to humans. For example, it may decide that a certain race, gender, or person with a political view are less likely to repay a loan. At this point, humans could interpret this as harmful whereas the AI may interpret it as a logic. The AI may not realise that such biases are incorrect or are causing harm, even if they have a built-in imperative not to harm humans. Hence, there

is a need to avoid black box type of solution, which lacks transparency and ethical values. Thus, there is a need for evolving ethical standards, trustworthiness, and consent framework to get data validation from users.

4.11. Machine learning (ML) and deep-learning (DL) algorithms underlie the most contemporary AI-powered software. In contrast to traditional software, which works on predefined and verifiable rules, deep learning creates its own rules and learns by example. This can enable deep learning to perform many tasks that were virtually impossible with current rule-based software. But it also opens up newer and newer areas of uncertainty that can inherit covert or overt biases.

4.12. ML and DL are considered as an integral part of AI which refers to the automated detection of meaningful patterns in datasets. ML tools aim to increase efficiency of algorithms by ensuring the ability to learn and adapt, based on big-data analytics. DL is defined as a sub-class of ML within the AI-technologies that explores many layers of non-linear information processing for supervised and/or unsupervised features extraction and transformation, and for pattern analyses and classification. In recent years, AI, ML and DL have gained increasing relevance in a multitude of research fields such as engineering, medicine, economics, and business management as well as in marketing.

4.13. The data from which the AI learns can itself be flawed or biased, leading to flawed automated AI decisions. This is certainly not the intention of algorithmised decision-making, which is "perhaps a good-faith attempt to remove unbridled discretion — and its inherent biases." There is thus a need to ensure that the data is centrally controlled including using a single or multiple cloud controllers.

4.14. As AI becomes more intelligent, it becomes more effective at its tasks of prediction and decision-making, but conversely its processes also become less transparent to humans. This "opaque" problem leads to a lack of control and supervision by controllers and users of AI, ultimately

risking progress. Thus, there is a need to ensure unbiased open architecture at Application level.

4.15. The other important factor is the so-called contamination of data. This includes, missing information, inconsistent data, or simply errors. This could be because of unstructured storage of data. Thus, there is a need to ensure proper storage frameworks for AI.

4.16. There is also a need to change the culture so that coders and developers themselves recognise the "harmful and consequential" implication of biases. This goes beyond standardisation of the type of algorithmic code and focuses on the programmers of the code. Since much coding is outsourced, this would place the onus on the company developing the software product to enforce such standards. Such a comprehensive approach would tackle the problem across the industry as a whole, and enable AI software to make fair decisions made on unbiased data, in a transparent manner.

4.17. Thus, there is a need for the development of standards that supplements and informs the system through rigorous guidance. Such standards are particularly important given the potential for inaccurate and inappropriate data to contaminate machine learning. Regulatory standards for data collection, interfaces, storage, analysis, application and customer use are also required. Such standards will provide required guidance to the industries to help in avoiding preventable accidents.

4.18. Any AI without proper safeguards can pose risks to the development of eco-system. Automated decision-making algorithms can bias, lack ethical governance, and limit transparency in its decision-making, causing unfair outcomes and amplify unequal access. In the light of such risks, AI cannot be trusted to operate without proper architecture or a template of stack specially tailored for Indian conditions, on similar lines as the UPI stack. It will also pave way for internationally accepted principles of AI governance, and will facilitate

implementation of standards for the AI developers and coders and with compliance verified through proper algorithmic auditing.

4.19. In the near future, AI will have huge implications on the country's security, its economic activities and the society. The risks are unpredictable and unprecedented. Therefore, it is imperative for all countries including India to develop a stack that fits into a standard model, which protects customers; users; business establishments and the government. Manuel Carabantes[5] found that security and competitiveness concerns mean large companies can tend to hide the algorithms they use to process data. Hence, a well-designed regulatory standard in the form of an open Indian stack in line with internationally agreed principles can instead provide a healthier and safer environment in which AI can evolve. It can control existing risks and can preempt future risks by suitable monitoring and auditing of the AI's design and analytics as part of the stack design. Such an open Indian stack will not deter innovation, but create opportunities and ensure sustainable innovation.

4.20. There is thus a need for developing and codifying procedures and/or constraints on procedures, which should be anchored in an intelligent system's architecture or an open stack. This can either be accomplished by formulating rules, which control the behaviour of an intelligent agent, or as behaviour boundaries that must not be trespassed. Not only transparency would be required, but also procedures, which control and restrict an AI's behaviour to ensure ethical decision-making, may need to be monitored, if required, by an independent agency.

[5] Black-box artificial intelligence: an epistemological and critical analysis - Manuel Carabantes
AI and Society 35 (2):309-317 (2020)

5: PROPOSED INDIAN STACK

5.1. The Proposed Indian AI stack hinges on the five main horizontal layers- the infrastructure layer; the storage layer; the Compute layer; the Application layer and the Data/ Information exchange layer and one vertical layer –the Security and governance layer as show in figure1 below:

The key benefits of this proposed Indian AI stack are:

- Easy interface (vertical or horizontal) with end user application;
- Maintains, a secure storage environment that simplifies the archiving and extraction of data based on the data classification;
- Ensures, protection of data, data federation, data minimisation; open algorithm framework; defined data structures; interfaces and protocols, monitoring, audit and logging; trustworthiness, etc;
- Ensures, legitimacy of backend services, transaction movement etc;
- Provides services through secured gateway services to the customer;
- Protection of Digital Rights and maintaining ethical standards;
- Consent for use of data from customers will be taken through properly framed consent framework;
- Enables provision of safe, secure and trusted AI services to the customer;
- Enables open API integration and facilitates the environment for load balancing, security, failover capabilities, multi-tenant architecture for concurrent users; and
- Enforces the usage of Government Public Key Infrastructure (PKI) services.

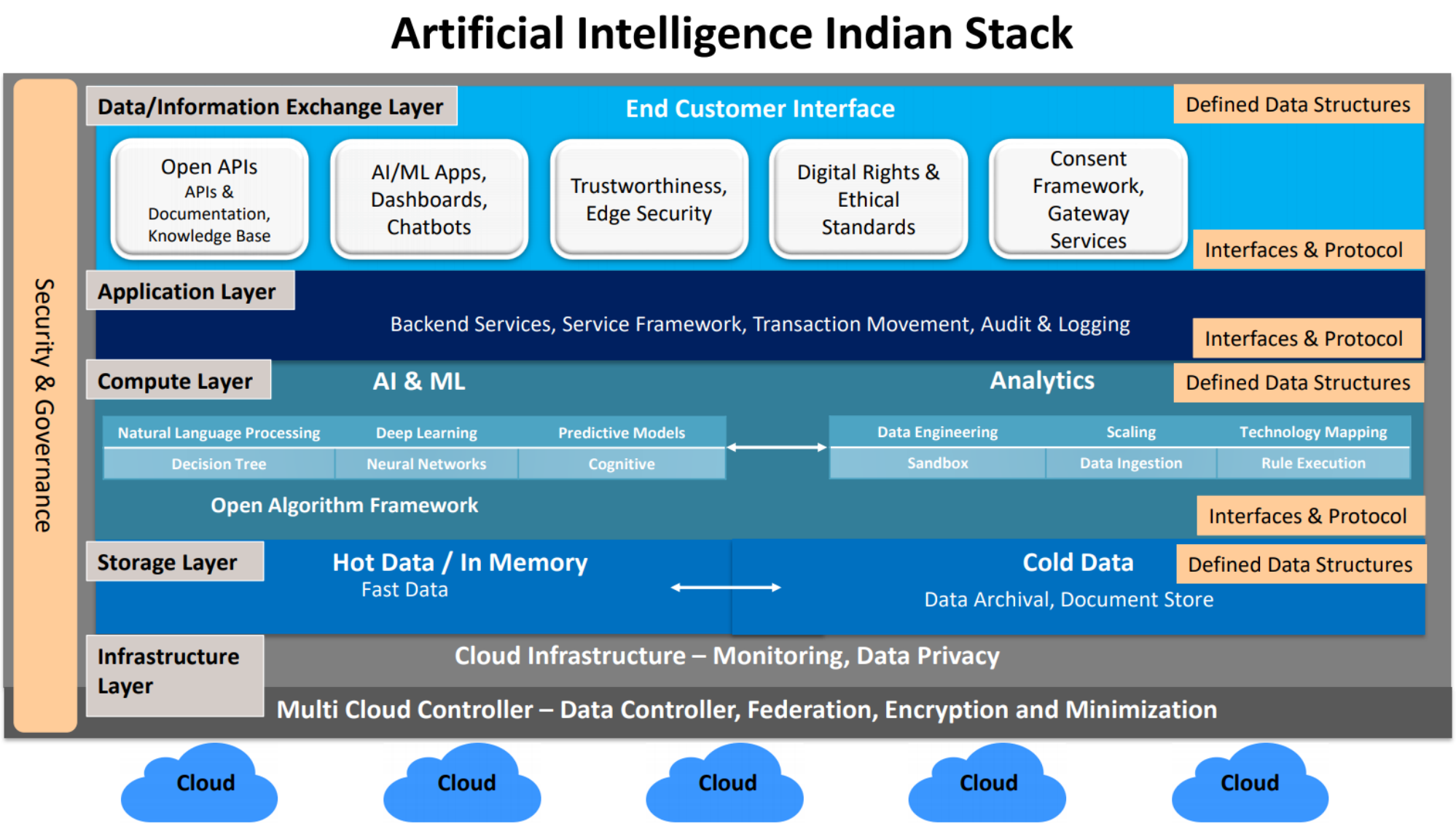


Figure 1: Proposed Indian AI stack

5.2. The *Six* layers are derived from the various activities of AI as tabulated below in Table 1:

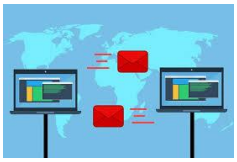
	**Infrastructure Layer** • Ensures setting up of a common Data controller including multi cloud scenarios- private and public; • Ensures federation, encryption and minimization at the cloud end; and • Ensures proper monitoring and data privacy of the data stored.
	**Storage Layer** • Ensures that the data is properly archived and stored in a fashion for easy access when queried; and • Ensures that the Hot Data/ Cold Data/ Warm data are stored in appropriate fashion to ensure fast or slow data access.
	**Compute layer** • Ensures proper AI & ML analytics; • Certain template of data access and processing to ensure open algorithm framework is in place; • Process ensures Natural Language Processing and Decision tree; • Deep learning and Neural networks; • Predictive models and Cognitive models; • Analytics includes; o Data engineering and sandboxing o Scaling and data ingestion o Technology mapping and Rule execution.
	**Application layer** • Ensures that the Backend services are properly and legitimately programmed; • Develop proper Service Framework; • Ensure proper Transaction movement; and • Ensure that proper logging and management is put in place for auditing if required at any point of time.
	**Data / Information Layer** • Provides for End Customer Interface; • Has Consent Framework for data consent from/to customers; • Provides various services through secured Gateway services; • Ensures that Digital Rights are protected and the Ethical standards maintained; • Provides for Open API access of the data and has Chatbots access; and • Provides for various AI/ML Apps.
	**Security & Governance** • This is a cross cutting layer across all above layers that o Ensures that AI services are safe, secure, privately protected, trusted and assured.

Table 1: AI Indian Stack

Data/Information Exchange Layer:

5.3. Through defined data structures and proper interfaces and protocol, the end customer interface is to be defined in this layer. The layer will have to support proper consent framework for access of data by/for the customer. Provision for consent can be for individual data fields or for collective fields. Typically there could be *different* Tiers of consent be made available to accommodate different tiers of permissions. Gateway services will also be enabled in this layer. The layer also needs to ensure that proper ethical standards are followed while ensuring the requisite digital rights. In the absence of a clear data protection law in the country, EU's General Data Protection Regulation (GDPR) or any of the laws can be applied. This will serve as interim measure until Indian laws are formalised.

5.4. It is also required to perform the functions of Trustworthiness and edge security at the customer end. The layer also defines open Application Programming Interfaces[6] (APIs) access for interface to different types of applications. There will also be a Web based User Interface designing tools to create, modify, test and deploy different UI scenarios. The architecture should support multi-tenant architecture facilitating concurrent users.

Application Layer:

5.5. This is a purpose-built layer through which software and applications can be hosted and executed as a service layer. It includes set of tools and services designed to make coding and deploying applications quickly and efficiently.

5.6. In this layer, through proper interfaces and protocol, various application services will be supported. It will support various backend services for processing of data. There will be a defined service framework enabled in

[6] An API is a collection of clearly defined methods of communication between different software components. A Web API is defined by the types of requests that it can handle, which is determined by the routes that it defines, and the types of responses that the clients can expect to receive after hitting those routes.

this layer apart from ensuring proper transaction movement of all data. This will also enable proper audit and logging functions on the stack. API querying for read/write facilities would be provided in this layer. However, permissions for such API calls would be provided in the Data Exchange Layer.

5.7. This layer provides for backend services[7] and to provide a proper service framework for the AI engine to function. It also keeps track of all transaction across the stack, thus helping in logging auditing activities[8].

Compute Layer:

5.8. Through defined data structures and proper interfaces and protocol, the AI /ML process and data analytics happens in this layer. This layer also through a set of defined protocols and templates ensures an open algorithm framework. The AI/ML process could be Natural Language Processing (NLP), Deep learning and Neural networks. This layer defines Predictive models and Cognitive models along with the decision tree. The layer also defines data analytics that includes Data engineering and sandboxing apart from scaling and data ingestion. The technology mapping and rule execution will also be part of this layer.

5.9. Openness in AI development can refer to different things. The main effect of opening existing AI through open-sourcing code and placing related intellectual property into the public domain, would be to hasten the diffusion and application of current state-of-the art techniques. Software and knowledge about algorithms are non-rival goods. Making them freely available would enable more people to use them, at low marginal cost.

5.10. NLP has multifarious applications from computational linguistics to AI. It is generally defined as the computational processing of a text in a natural human language using two primary techniques to accomplish its

[7] The back-end comprises all of the technology required to process the incoming request, process and send the response to the client.
[8] They are a means to examine what activities have occurred on the system and are typically used for diagnostic performance and error correction. They often form the basis of forensic analysis, security analysis, and criminal prosecution.

tasks: syntactic analysis and semantic analysis. With the help of resources like DL and ML operations, AI is capable of comprehending NLP operations and tasks.

5.11. The compute layer also defines a new way to build and deploy Enterprise service-oriented architectures. An extension of DL is deep neural networks (DNNs), which has many layers, which affects computation requirements. As the size of a layer and number of layers increases, so do the requirements. In addition, wide neural networks, which are shallow in nature, can also be useful for many applications. In fact, it is possible to mix them using suitable frameworks.

5.12. Neural networks are also in play with recurrent neural networks, convolutional neural networks, and logistic regression. AI frameworks like Tensorflow, Torch (PyTorch), Caffe, and Keras are empowering data scientists to build complex AI models, solving a wide range of problems in various fields.

5.13. Due to these black-box properties of DNNs, numerous iterations of trial-and-error are required to develop the DNN based applications. One approach to solve this problem is AutoML[9]. This layer helps to provide such transparent computing architecture over which industry could develop their own analytics.

5.14. Compute also refers to the raw computational power required to run these AI/ ML algorithms. One has a wide choice of physical servers, virtual machines, containers, specialized hardware such as GPUs, cloud-based computational resources including Virtual Machines (VMs), containers, and Serverless computing. This layer will provide for a distinction between public, shared and private data sources, so ML algorithms can be applied against relevant data fields.

[9]AutoML is a field of machine learning concerned with automating repetitive tasks such as model selection or hyper parameter optimisation.

Storage Layer:

5.15. Through defined data structures/ proper interfaces and protocol, the data storage happens in this layer. The layer defines the process of data archiving. The process of querying is also defined in this layer. The protocols and the interfaces for Hot Data/ Cold Data/ Warm data and the fashion in which they are stored will be defined to ensure how fast the data is accessed.

5.16. Data storage layer is the most important layer, regardless of size and type of data. To derive value from data, the same need to be processed. To process it efficiently, it needs to be stored in effective manner. As with any raw material, without the right refining process, it is difficult to extract the real value out of it. It is especially when data is in the purview of analytics. Even if best of the tools for data analytics or data engineering are implemented, it is practically not feasible to augment and utilise data and gain repeated value out of it without having the right data storage layer.

5.17. Hence, it is paramount to*:*

- Store Data for a very long time to manage all factors of seasonality and trends;
- Ensure data stored is easily and quickly accessible;
- Ensure that all security measures are in place; and
- The data should be shareable on any device via standard interfaces.

5.18. All of this is desired while maintaining the standards of security. Object-based cloud storage is the key to the realisation of a new data-driven cloud paradigm.

5.19. With focus on setting up a standard storage layer, all subscribers to the platform can leverage the data through multiple functions and flows without worrying to take overhead of storing such mammoth data distributed across various agencies. Having a very clearly defined data structure is the key in making it accessible seamlessly across domains and for various use cases.

5.20. At broader level, the data store is divided into three areas. The division is done to categorise data store and data access basis relevance of data and its usability. The levels have been differentiated according to how crucial the stored data is and how frequently the data will be accessed. Below is the summary of such categorisation:

a) **Fast Data/Hot Data:** Hot data requires the fastest and most expensive storage. This is the layer where data is stored which is frequently used and the response time requirement is relatively very high. Most recent and relevant data is stored here.

To obtain the fast data access required for hot data storage, the data is commonly stored in hybrid or tiered storage environments. The hotter the service, the more likely that it will use the latest drives and fastest transport protocols.

b) **Cold Data:** Cold (or cooler) data is data that is accessed less frequently and can be stored on slower, and consequently, less expensive media storage environments in-house or in the cloud.

It is shifted to the storage layer/partition/bucket, which is not as fast in terms of responsiveness as the Fast Data layer. However, this layer is designed to store data for a very large duration or for archival purpose. That includes data that is no longer in active use and might not be needed for months, years, decades, or maybe ever. Data retrieval and response time for cold cloud storage systems are typically much slower than services designed for active data manipulation.

c) **Warm data:** Warm storage is between Hot and cold storage. The figure 2 below depicts the cold, warm and hot framework. All forms of storage will however have to comply with India's data control and redundancy laws.

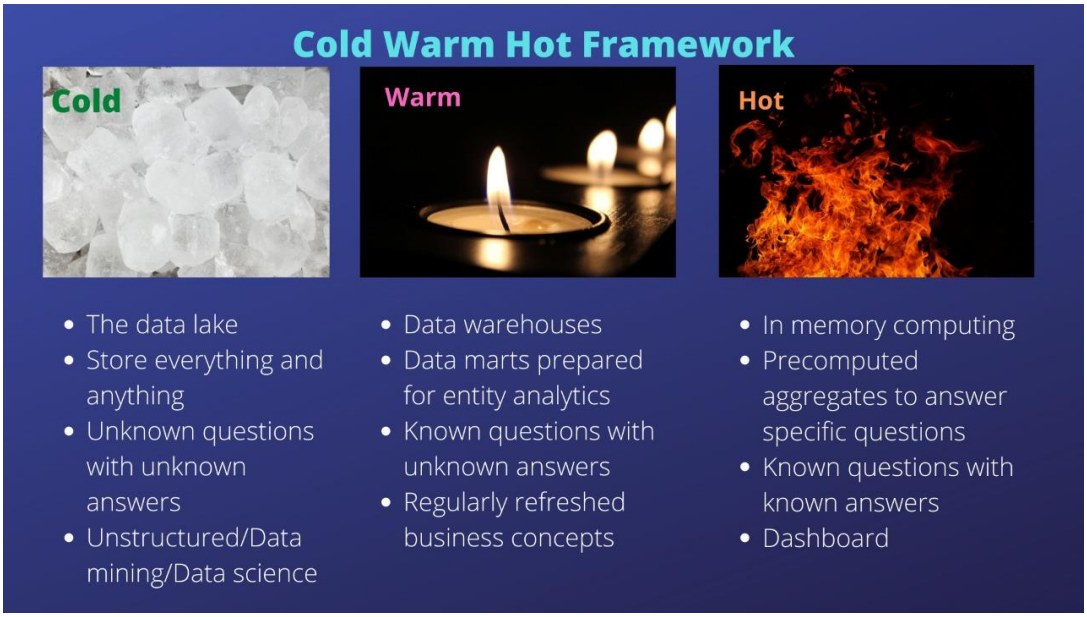


Figure 2: Cold/ Warm/ Hot data storage framework

Infrastructure layer:

5.21. The layer will ensure setting up of a common data controller. This can also involve multi cloud scenarios- both private and public clouds. The infrastructure for data collection is defined in this layer.

5.22. The layer also ensures data federation, encryption and minimisation at the cloud end. This layer also ensures proper monitoring and data privacy of the data stored. The Infrastructure layer of AI stack is the basic root layer of the Indian AI stack over which the entire AI functionality is built.

5.23. ***Multi-cloud controller layer:***

a) NITI Aayog, has proposed an AI specific cloud compute infrastructure, as shown in Figure 3, to facilitate research and solution development in using high performance and high throughput AI-specific supercomputing technologies.

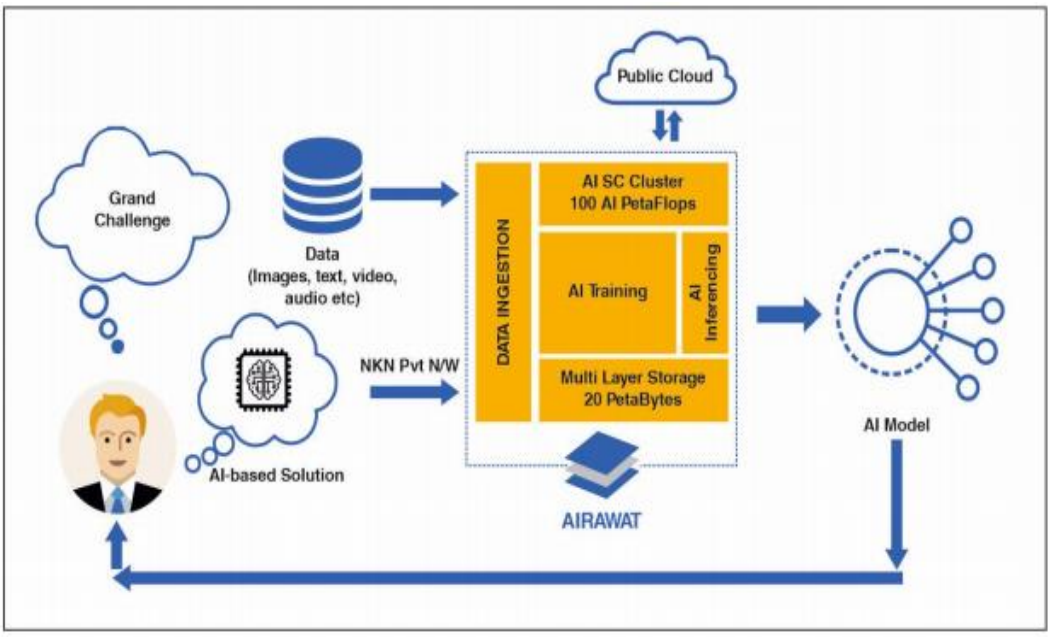


Figure 3:Proposed Architecture of AI specific controller

b) The broad specifications for such proposed cloud controller architecture may include:

- Multi-tenant multi-user computing support;
- Resource partitioning and provisioning, dynamic computing environment;
- ML / DL software stack – training and inferencing development kit, frameworks, libraries, cloud management software;
- Support for varieties of AI workloads and ML / DL frameworks for user choices;
- Energy-saving, high teraflops per watt per server rack space;
- Low latency high bandwidth network;
- Multi-layer storage system to ingest and process multi-petabytes of big data; and
- Compatibility with National Knowledge Network (NKN).

5.24. The Multilayer cloud services model – for integration and compatibility will define both relations between cloud service models and other functional layers as explained below:

- Inter cloud control and management plane – for controlling and managing inter cloud applications, resources scaling and objects routing;
- Inter cloud federation framework – for allowing independent clouds belonging to different cloud providers and administrative domains; and
- Inter cloud operation framework – that includes functionalities for supporting multi-provider infrastructure operation, defines the basic relations of resource operation, management and ownership.

5.25. Computing analytics as explained in the Compute layer involves analysis to mine vast troves of personal data and find correlations, which will then be used for various computations. This raises various privacy issues, as well as broader issues of lack of due process, discrimination and consumer protection.

5.26. The data so collected can shed light on most aspects of individuals' lives. It can also provide information on their interactions and patterns of movement across physical and networked spaces and even on their personalities. The mining of such large troves of data to seek out new correlations creates many potential uses for Big Personal Data. Hence, there is a need to define proper data protection mechanism in this layer along with suitable data encryption and minimisation.

5.27. The layer also defines the multi-cloud data controllers. The data controller will determine the purposes for which and the means by which personal data is processed for use by various layers.

Security and Governance Layer:

5.28. This is the cross cutting layer for all layers that ensures AI services are safe, secure, privately protected, trusted and assured as and when needed for use. Through defined data structures, this layer will ensure the process of security and governance for all the five horizontal layers. It is premised on building a trusted digital ecosystem.

5.29. There is increased vulnerability to cybercrime due to the exponential growth in broadband access and use of wireless technologies. Collecting data is always deemed to improve user experience and product performance over time. Unfortunately, data aggregated, transmitted, stored, and used by various stakeholders may increase the potential for discriminatory practices and pose substantial privacy and cybersecurity challenges. The data processed and stored in many cases include geolocation information, product-identifying data, and personal information related to use or owner identity, such as biometric data, health information, or smart-home metrics. For some applications personal information are also captured through audio or video, or include communication capabilities, such as those used in children's devices.

5.30. Data storage in backend systems can present challenges in protection of data from cyberattacks. In addition to personal-information, privacy concerns, there could be data used in system operation, which may not typically be personal information. Cyber attackers could misuse these data by compromising data availability or changing data, causing data integrity issues, and use big data insights to reinforce or create discriminatory outcomes. When data is not available, causing a system to fail, it can result in damage—for example a smart home's furnace overheats or an individual's medical device cannot function, when required. Data integrity may cause issues that are more substantial. When attackers change data, by scrambling, changing values, or replacing data with their own, information provided to users could be misleading, or can result in change of previously established limits or algorithms directing the device functionality. These types of data misuse can cause property damage and raise personal safety issues in addition to previously established privacy concerns.

5.31. Cloud access security is all about controlling the organisation's information in cloud applications- who is uploading and downloading files; what documents have sensitive information; what documents are

exposed to the Internet; which users have anomalous behavior; what cloud applications are inherently risky; and several other variables.

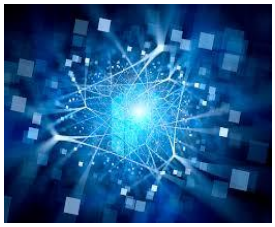
5.32. Due to the overwhelming flow of information, there is thus, a need to ensure encryption at different levels. This may require setting up security dictionary, ability for multi-table join and multi condition query in an encrypted environment etc. Cryptographic supporting is an important dimension of the security layer.

6: LAYERS OF THE INDIAN AI STACK

1. **Infrastructure Layer**
   - *The Infrastructure Layer defines setting up of a common Data controller including different cloud scenarios - multi cloud scenarios; private and public clouds, etc.*
   - *It also defines data federation, data encryption and data minimization at cloud end;*
   - *It ensures proper monitoring and data privacy of the data stored; and*
   - *This layer also harnesses the emergence of AI - to deliver unprecedented products and services in new and emerging sectors.*

Interventions

a. Performs operations of the cloud data controller;
b. Responsible for forwarding data traffic;
c. Manages and Segregates public and private data and ensures common data controller management;
d. Ensures data protection and data privacy;
e. Develop and implement data sharing structures for managing shared public/ private data hubs, data warehouses and data marts;
f. Defines structures for global shared information services and transform information management;
g. Combines data obtained from multiple sources into structured data sets through data federation techniques;
h. Depending on specific tasks, it performs data minimization and handles data in proper areas created;
i. Performs data encryption;
j. Ensures Lawfulness, fairness and transparency;
k. Maintains data integrity and confidentiality;
l. Define, develop and implement structures for shared services (like for Payment, filing, communication, Identity Management & Authentication, Mobile ID, etc.) that complements the core Services; and
m. Takes care of the storage limitation before forwarding it to storage layer.



2. **Storage *Layer***
   - *This layer defines the required storage medium and the form of storage access for the data flowing through the AI; and*
   - *Depending on the classification of data, it will ensure appropriate storage;*

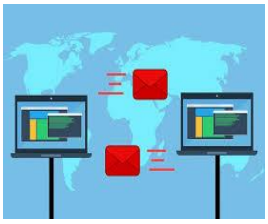
Interventions

a. Segregates data into hot, warm and cold data depending on the requirement;
b. Maintain a secure storage environment;
c. Defines features to ensure archiving and extraction of relevant hot/cold data;
d. Defines structures to ensure – scalability and cost-efficiency;
e. Ensures data durability and software defined storage mechanisms;
f. Defines different architectures suitable for such storage- hybrid/parallel architecture etc; and
g. Defines roles for data locality.

3. **Compute Layer**
   - *This layer defines the computational processes;*
   - *Computation of data as per requirement and encaps to application layer for further output; and*
   - *Defines new way to build and deploy Enterprise service-oriented architectures.*

Interventions

a. Responsible for collecting and analyzing the data;
b. Decides the action to be taken depending on the data received and its requirement;
c. Scaling and normalization of data;
d. Technological mapping of the data;
e. The collected data will be transported to storage layer using data ingestion tools for future analysis;
f. Follows a set of pre-defined procedures for analyzing the data;
g. Uses various Natural Language Processing techniques for processing of the data;
h. Uses Machine Learning, Deep Learning techniques;
i. Use of AI frameworks like Tensorflow, Torch (PyTorch), Caffe, Keras, etc;
j. Define detailed structures for generation of meaningful insights and enable sharing; and
k. Ensures Open algorithm framework.



4. **Application Layer**
   - *Defines the Purpose-built layer through which software and applications be hosted and executed as a service layer; and*
   - *Provides the basis services required for building APIs for Information Exchange layer.*

Interventions

a. Defines the set of tools / services /rules for coding;
b. Provides for Centralized web-based access;
c. Defines management of software upgrades and patches;
d. Application Programming Interfaces allow integration with different applications;
e. Facilitates environment to develop, test, deploy, host and maintain applications;
f. Defines Multi-tenant architecture for concurrent users;
g. Defines Load balancing, security and failover capabilities;
h. Define Tools for billing and subscription;
i. Defines protection of user privacy security;
j. Defines Preservation of event logs related to applications;
k. Defines audit logging for promotion of accountability, reconstruction of events, security and forensics applications, etc;
l. Define the structure of an integrated platform; and
m. Defines Software-as-a-Service(SaaS) or any other uniform services framework that can be used for developing various applications.

5. **Data information exchange Layer**
   - *It defines the interface with the external world and is the topmost layer of the AI stack;*
   - *It is also defines the end customer interface;*
   - *It also defines the trustworthiness and edge security;*
   - *Other services like consent framework gateway; provision for digital rights & ethical standards are defined;*
   - *It includes various options for dashboards; and*
   - *It accentuates and defines the need for integration of different Systems and defines sharing of the common output services and platform.*

Interventions

a. Responsible for interfacing end customer with AI stack;
b. Creates Open API integration for APPs/Dashboards/ chatbots, etc;
c. Responsible for ensuring trustworthiness of the data being transmitted;
d. Ensures ethical standards are developed;
e. Defines Digital rights protection;
f. Near-instant sharing of information and orchestration of tasks;
g. Ensures proper integration avoiding delays, efforts and complexity across security products and vendors;
h. Define procedures for Rationalisation and consolidation of applications to increase interoperability, accessibility and re-usability;
i. Define roles for potential partners in public, private and voluntary & community sectors to promoting greater AI inclusion; and
j. Allows applications to share threat data and steps to ensure proper follow up action.

VERTICAL CROSS LAYER

6. **Security and Governance cross layer**
   - *This cross functional layer defines the assurance that the services are safe, secure, protected, trusted and assured when needed for use; and*
   - *It is also premised on building a trusted digital ecosystem.*

Interventions

a. Establish and enforce the implementation of a National Information Security Framework in light of the emerging technologies;
b. Define cyber security policies and guidelines for AI;
c. Implement a Public Sector Cyber security governance, risk and compliance;
d. Implement Business Continuity Management and Planning;
e. Implement evaluation and certification scheme of Cryptographic products;
f. Implement security quality assurance for AI related equipment and services;
g. Consolidation and inputs to Computer Emergency Response Teams (CERTs) on matter related to AI;
h. Implement a certification service for all providers of critical AI services that is sector-centric (like financial, health, legal, etc.);
i. Initiate and implement a National Data Leakage Protection programme to include an aspect of penalties and auditable digital environment;
j. Develop and enforce the usage of Government Public Key Infrastructure (PKI) services;
k. Develop and operationalize a Digital Forensic Lab for AI; and
l. Enhance collaborations for Cyber Security;
m. Develop suitable encryption methodologies;
n. Develop, implement and enforce compliance to Data Protection and Privacy Legislation (when enacted); and
o. Setup and operationalize Data Protection and Privacy Governance.

7: AI STACK FLOWCHART

7.1. The Figure 4 below shows the schematic flowchart of the sequence of steps involved for the proposed AI stack flows.

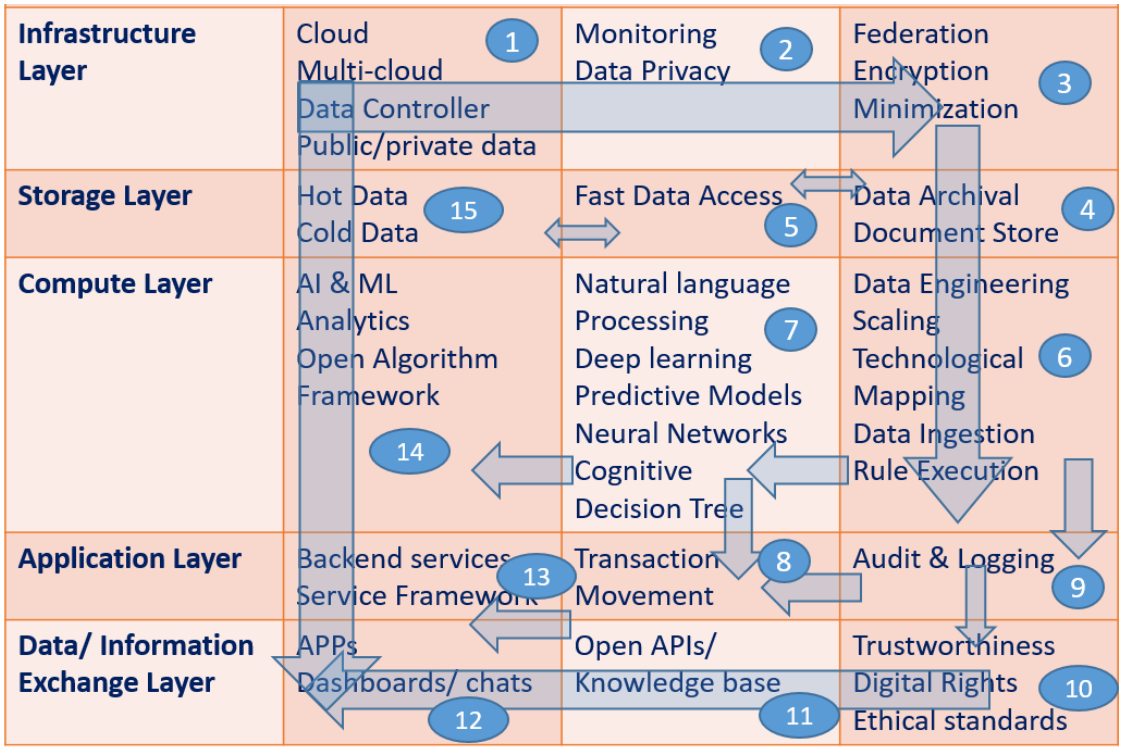


Figure 4:Proposed AI flowchart

7.2. The detailed step-wise explanation is as follows:

1. The input to the multi-cloud data controller will be the generic public/private data available across all sectors;
2. The said data will be monitored for data privacy concerns and sent to next stage for data encryption verification;
3. The input data will be encrypted and stored in the storage layer;
4. The data that flows into the storage layer will be cleaned, refined, and categorised depending on the requirement;
5. The data, so refined will be categorised as Hot/warm/cold data and will be stored accordingly;

6. Data from storage layer will be available to the compute layer in any form, where data scaling, engineering and technological mapping will be done;

7. The data will be processed for various AI/ ML analytics through Deep Learning/ Machine Learning/ Natural language processing techniques, etc;

8. The transaction movement is also clearly defined in this layer to ensure that all transactions are properly recorded;

9. The entire process of Audit logging of the data will have to ensured;

10. Data will then be finally accessed by the end- user through Data/information exchange layer where trustworthiness of the data will be defined for verification. The data will also be defined to ascertain digital rights and ethical standards;

11. The refined data will be available for open APIs/ knowledge base. The data will also be used by various APPs designed through these open APIs for generating the required output;

12. Various feedback mechanism including dashboards, chats etc for future processing will be defined here;

13. The data obtained from Compute layer will be used for developing services framework and the Backend services, that resides in application layer;

14. The processing algorithm will be defined as an open algorithm framework before being accessed by the application layer for movement of transaction; and

15. The movement of data access from the storage layer will be defined in accordance with the need for access- Hot, cold or warm.

Annexure – 1

Some of the countries that have developed AI National Strategy:

a. Argentina: The Argentinian ministry of education, culture, science and technology is developing a national AI plan;

b. Australia: Australia has dedicated $29.9 million in the country's annual budget to promote and guide the development of AI;

c. Austria: Austria has an advisory Robot Council that is developing a national AI strategy;

d. Brazil: Brazil is creating eight AI laboratories and has adopted the OECD AI Principles;

e. Canada: Canada has a national AI strategy called the Pan-Canadian Artificial Intelligence Strategy;

f. Chile: Chile created an expert committee that is developing a National AI Policy;

g. China: China has a national AI strategy, defined under the "New Generation Artificial Intelligence Development Plan";

h. Denmark: Denmark has a digital strategy that includes a focus on AI along with other technologies;

i. Estonia: Estonia is developing a legal framework for the use of AI in its country, including a bill on AI liability;

j. Finland: Finland has an Artificial Intelligence Programme guided by a steering group under the Ministry of Economic Affairs and Employment;

k. France: France has a national strategy for AI called "AI for Humanity," which is outlined in the "Villani Report";

l. Germany: The German Government adopted its Artificial Intelligence Strategy in November 2018;

m. India: India defined a national policy on AI in a working paper titled, "National Strategy for Artificial Intelligence #AIforAll.;

n. Ireland: The Irish government has hosted AI workshops and launched a national AI Master's program;

o. Italy: Italy has an interdisciplinary AI Task Force launched by the Agency for Digital Italy;

p. Japan: Japan has an "Artificial Intelligence Technology Strategy" and has also included AI in its "integrated innovation strategy";

q. Kenya: The Kenyan government created a Blockchain & Artificial Intelligence task force;

r. Lithuania: The Lithuanian Artificial Intelligence Strategy was released April 2019;

s. Malaysia: The Malaysian government is developing a National Artificial Intelligence Framework, and establishing Digital Transformation Labs;

t. Mexico: The Mexican government supported the creation of the white paper, "Towards an AI Strategy in Mexico: Harnessing the AI Revolution";

u. Netherlands: The Netherlands launched the Strategic Action Plan for Artificial Intelligence in October 2019;

v. New Zealand: New Zealand has an AI Forum to connect and advance the country's AI ecosystem;

w. Norway: Norway published a National Strategy for Artificial Intelligence in January 2020;

x. Poland: Poland launched the Artificial Intelligence Development Policy in Poland for 2019–2027;

y. Russia: The President of the Russian Federation released a national AI strategy in October 2019;

z. Saudi Arabia: Saudi Arabia established a government agency called the Saudi Data and Artificial Intelligence Authority in August 2019;

aa. Serbia: The Government of the Republic of Serbia adopted the Strategy for the Development of Artificial Intelligence in the Republic of Serbia;

bb. Singapore: Singapore launched a National AI Strategy in November 2019 and has a national AI program called AI Singapore;

cc. South Korea: South Korea has an Artificial Intelligence Information Industry Development Strategy;

dd. Spain: Spain published an AI RDI strategy March 2019;

ee. Sweden: The Swedish government has released a "National Approach for Artificial Intelligence";

ff. Tunisia: Tunisia has created an AI Task Force and Steering Committee to develop a national AI strategy;

gg. United Arab Emirates: The UAE has a national strategy for AI and was the first country to name an AI Minister;

hh. United States of America: The US launched the American AI Initiative February 2019;

ii. United Kingdom: The UK government launched a Sector Deal for AI to advance the UK's ambitions in AI consistent with its Industrial Strategy, and taking into account the advice of the Parliament's Select Committee on AI; and

jj. Uruguay: Uruguay's industry, mining and energy ministry launched a public consultation of Artificial Intelligence for the Digital Government in April 2019 and is developing a strategy based upon its findings.

Annexure – 2

Committee for standardisation in AI technologies

The Department of Telecommunications (DoT), Ministry of Communications, Govt. of India has formed a committee under the chairmanship of Shri A. Robert J. Ravi, DDG APLSA Vijayawada, for framing standards for Artificial Intelligence (AI) and developing Indian stack for AI on 24/09/2019 with the following members:

1.	Shri Premjit Lal	-	Director (Std) TEC, New Delhi
2.	Ms Preeti Banzal	-	Director (FN) TEC, New Delhi
3.	Shri P S Jadon	-	Director (Radio) TEC, New Delhi
4.	Shri Tejpal Singh	-	Director (DS-II) DoT HQ, New Delhi
5.	Shri Suresh Kumar	-	Director (T), Chennai
6.	Shri Krishna Kumar P	-	Director AP LSA, Hyderabad
7.	Shri Manish Jain	-	Director (ICT) NTIPRIT, Ghaziabad
8.	Shri Rajeev Kumar Tyagi	-	Director (IoT) TEC, New Delhi
9.	Shri Naveen Jakhar	-	ADG (Security) Haryana LSA, Haryana

Co-opted members

10.	Shri D.M. Ezhil Buddhan	-	CGM Broadband Networks, BSNL Bangalore
11.	Shri M. Chandrasekar	-	DDG (R2) WB LSA, Kolkata

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