Telecom Regulatory Authority of India

Consultation Paper on

Digital Transformation through 5G Ecosystem

New Delhi, India

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Written Comments on the Consultation Paper are invited from the stakeholders by 30/10/2023 and counter-comments by 13/11/2023. Comments and counter-comments will be posted on TRAI's website www.trai.gov.in. The comments and counter-comments may be sent, preferably in electronic form on the e-mail: **advadmn@trai.gov.in**. and **vibhatomar@trai.gov.in** . For any clarification/ information, Ms. Vandana Sethi, Advisor (Admin) may be contacted at Tel. No. +91-11-23221509.

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FOREWORD

India is undergoing a rapid digital transformation that is reshaping its economy and society. With the advent of technologies such as 5G, Internet of Things (IoT), Artificial Intelligence (AI), Augmented/Virtual Reality (AR/VR) and Metaverse, India is poised to unlock new opportunities for growth and innovation.

5G services have been launched worldwide in many countries. In India, it was launched on 1st October 2022 and the Telecom Service Providers are aggressively rolling out the 5G network across the length and breadth of the country.

However, development and deployment of new use cases for consumers and enterprises is essential to fully realize the potential of 5G technology. Such applications and use cases involve other associated technologies such as IOT, AI, AR/VR/MR (Mixed Reality), Metaverse etc. Innovators are exploring new ways to apply these technologies to address the challenges of social and economic development and build a smart society. To complement their efforts, an equally innovative policy and regulatory framework is required to address the challenges and issues involved in development and deployment of use cases based on these new technologies.

India is one of the fastest-growing digital economies in the world, with a huge potential for data-driven innovation and value creation. For realizing this potential for overall growth of economy a forward-looking policy framework for data monetization is required.

The Authority has come out with this consultation paper on suo-motu basis to identify the policy challenges and suggest the right policy framework for faster adoption and effective utilisation of new technologies for the holistic and sustainable development of the economy driven by 5G ecosystem.

Chapter – 1

INTRODUCTION AND BACKGROUND

I.   Significance of Fast and Reliable Mobile Broadband Connectivity

1.1   Internet has become ingrained into the daily life of the people across the world. From obtaining information on markets or health, to making mobile payments, the Internet has made each task much easier. Fast and reliable mobile broadband connectivity is essential for achieving the United Nations' Sustainable Development Goals and for fostering innovation and economic growth. India is home to the world's second largest pool of 825 million mobile broadband users, and each mobile data user consumes more than 17 GB of data per month on an average. The dependency on the internet became even more profound in a post-COVID world as it became an integral part of our daily lives. In 2020, the Supreme Court of India identified access to information via the internet as a fundamental right under the Indian constitution.

1.2   In fact, digital services, underpinned by high speed and high-performance internet, are set to become more integral to society in a post-pandemic world. The unconnected populations will be at greater risk of exclusion from many life-enhancing digital services. The mobile industry has been instrumental in extending the internet connectivity to people around the world. At the end of 2022, the number of mobile internet subscribers reached 8.4 billion[1] globally. Mobile ownership and internet usage are expected to keep growing in the future, as mobile technologies are becoming more affordable and accessible than ever before. This upward trend in mobile internet adoption is particularly visible in developing digital markets where mobile networks are the primary means of internet

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[1]Ericssson Mobility Report – Update Feb2023

access. In the first quarter of 2023, mobile internet traffic accounted for almost 58 percent of total web traffic.[2]

1.3 The year 2021 and beyond is witnessing a new era, where working from anywhere has gained a significant traction. Almost every industry is embracing accelerated digital transformation. Organisations have very quickly adapted to the new ways of operating remotely and in a hybrid model. Mainstream use of Artificial Intelligence (AI), Internet of Things (IoT), Augmented/Virtual Reality (AR/VR) technologies in sectors such as education, healthcare, e-commerce has brought up a need of high speed and high bandwidth internet. 5G and beyond communication technologies have the potential to fulfil these requirements.

1.4 India is moving towards digital transformation with the objective of re-imagining and re-inventing every single element of governance. Digital India is an umbrella programme that covers multiple Government Ministries and Departments. It weaves together a large number of ideas and thoughts into a single, comprehensive vision so that each of them can be implemented as part of a larger goal. There are nine pillars supporting the Digital India program.

   i. **Broadband Highways –** include Broadband for all in Urban and Rural areas and National Information Infrastructure.

  ii. **Universal Access to Mobile Connectivity:** Initiative is to focus on network penetration and cover the uncovered villages with project cost of USD 1900 million.

 iii. **Public Internet Access Programme:** BharatNet project provides fibre connectivity to villages. For digital delivery of e-services, 535,000 Common Service Centres have been set up.

  iv. **e-Governance**: Government Business Process Re-engineering using IT to improve transactions and e-services.

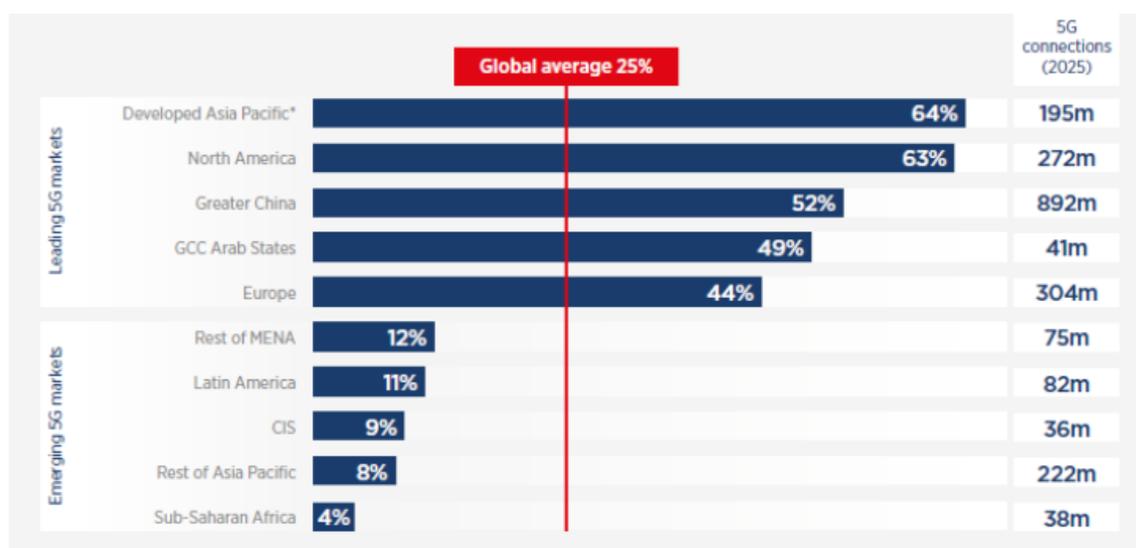[2] https://www.statista.com/statistics/277125/share-of-website-traffic-coming-from-mobile-devices/

v. **e-Kranti - Electronic Delivery of Services:** 31 Mission Mode Projects to establish e-Governance in all Ministries/Departments including e-Courts and e-Prosecution.

vi. **Information for All:** Open Data platform and online hosting of information and documents would facilitate open and easy access to information for citizens.

vii. **Electronic Manufacturing**: Target is net zero import.

viii. **IT for Jobs**: focuses on providing training to the youth in the skills required for availing employment opportunities in the IT/ITES sector.

ix. **Early Harvest Programmes**: consists of those projects which are to be implemented within short timeline.

1.5 Fast and reliable mobile communication technologies are helping the Government in realising the objectives of Digital India programme. It is providing a boost to our economy and empowering the citizens through services like unified payment interface (UPI) and several other innovative G2B and G2C applications. Innovators are exploring new ways to apply technologies to address the challenges of social and economic development to build a smart society. Government and Regulators have a responsibility to ensure that the right policy and regulatory frameworks are put in place to allow these applications to flourish, encourage innovation, and stimulate investment in the economy. With this objective in mind, the Authority has come out with this consultation paper (CP) on suo-motu basis to encourage the innovations and identify the policy challenges in adoption of these emerging technologies.

II. Status of 5G launches and subscriptions worldwide

1.6 According to a recent report released by GSA in January 2023,

i. 515 operators in 155 countries/territories have been investing in 5G networks in the form of tests, pilots, licence acquisitions, planned and actual deployments.

ii. Of those, 243 operators in 96 countries/territories have launched commercial 3GPP-compatible 5G services (mobile or fixed wireless access)

iii. 112 operators are identified as investing in 5G standalone for public networks (including those evaluating, testing, piloting, planning or deploying as well as those that have launched 5G standalone networks).

iv. More than 1700 5G devices have been announced, out of which at least 1400 5G devices are commercially available.

v. 28 more countries and territories are planning 5G spectrum assignments by the end of 2023. This includes 112 operators that offer 5G fixed wireless access (FWA) services.

vi. A GSMA intelligence report predicts that global 5G connections will cross 2billion mark by the end of 2025 (Figure 1.1)

Figure 1.1 : Global 5G connections by 2025

	5G connections (2025)
Global average 25%	
Leading 5G markets	
Developed Asia Pacific* — 64%	195m
North America — 63%	272m
Greater China — 52%	892m
GCC Arab States — 49%	41m
Europe — 44%	304m
Emerging 5G markets	
Rest of MENA — 12%	75m
Latin America — 11%	82m
CIS — 9%	36m
Rest of Asia Pacific — 8%	222m
Sub-Saharan Africa — 4%	38m

Source: GSMA Intelligence

*Australia, Japan, Singapore and South Korea

1.7 5G has become mainstream in many pioneer markets (notably China, South Korea and the US) and is making considerable progress in other countries as well. A new wave of 5G rollouts in large markets with modest income levels (such as Brazil, Indonesia and India) could further

incentivise the mass production of more affordable 5G devices to cater to consumers in lower-income brackets. It could also drive the development of new 5G applications for consumers and enterprises in emerging markets. This is significant as the majority of 5G applications and use cases to date have been focused on more advanced markets.

1.8   Operators around the world began their 5G deployment efforts with the non-standalone (NSA) version of the technology. However, after a slow start, 5G standalone (SA) deployments are beginning to ramp up. As per a GSA report[3], 112 operators in 52 countries and territories are investing in standalone 5G for public networks in the form of trials, plans, paying for licences, deploying or operating networks. At least 37 operators in 22 countries and territories are now understood to have launched public standalone 5G networks, with several more expected to go live in the coming years. The added functionalities enabled by 5G SA are key to delivering on the 5G promise of fully supporting enhanced mobile broadband (eMBB), ultra-reliable low-latency communications (URLLC) and massive IoT use cases.

1.9   Mobile operators are collaborating with vendors and enterprises across different verticals to explore the potential of 5G SA. For example, SoftBank and Honda are working together to test the effectiveness of using 5G SA and a cellular vehicle-to-everything (C-V2X) system to reduce collisions between pedestrians and vehicles. In Spain, Telefónica has announced plans to target three enterprise 5G use cases for its 5G SA network in 2022 - automated guided robot vehicles for use in places such as warehouses; remote maintenance systems using technology such as smart glasses; and drones for site surveillance.

III. 5G deployment in India:

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[3] GSA-Evolution from LTE to 5G January 23

1.10   5G services were first launched in India on October 1, 2022. At present, only Bharti Airtel and Reliance Jio are the two telecom operators offering 5G services in the country. Indian telecom operators have surpassed the three-year 5G network rollout target given to them within six months. They have set up more than 3 lakh sites as of August 2023. It is expected that majority of the towns in the country will be covered by the end of this year.

1.11   India is witnessing a digital revolution since last decade. Rising disposable income coupled with affordable data tariffs are encouraging the people to go digital. Growing smartphone penetration, significant rise in OTT consumption, digital payments, E-commerce are some of the major factors driving this digitization. These drivers enabled the ARPU in India to see a notable rise in the past 4 years, growing at a CAGR of ~21% (figure 1.2). This is expected to further see a healthy rise going forward with the advent of 5G that makes data consumption seamless.

Figure 1.2: Monthly Wireless ARPU during past 4 years
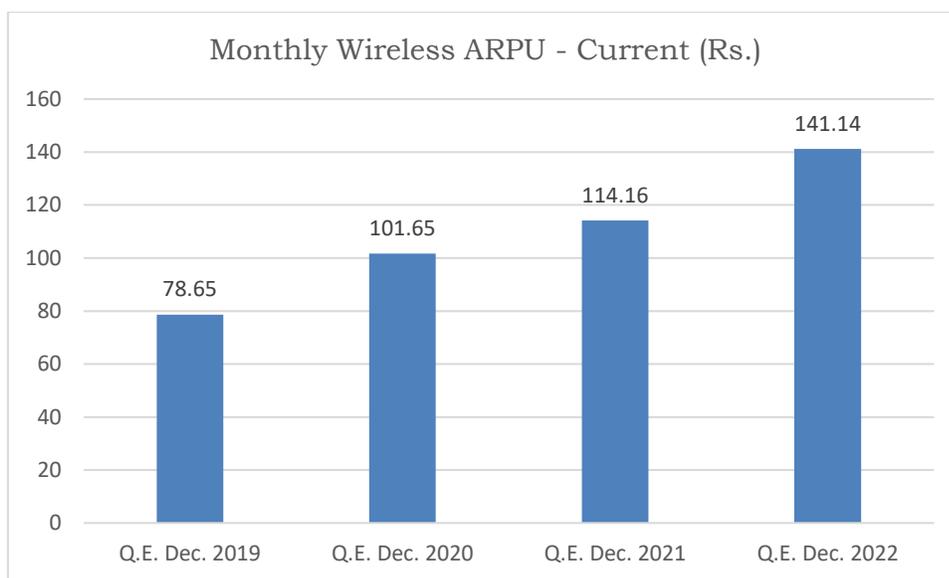
Source: TRAI QPIR

1.12   With this revenue growth trajectory, telecom companies are investing heavily in 5G, fiber and coverage infrastructure across the country. 5G

has significantly enhanced mobile internet speeds in the country. According to Ookla, the median download speed increased from 13.87 Mbps in September 2022 to 50.21 Mbps in August 2023. As a result, India's position on the Speedtest Global Index improved by 71 places from 118th in September 2022 to 47th in August 2023.[4]

1.13   India has developed its indigenous 4G/5G technology stack, which is now ready, and the country is poised to emerge as a significant telecom technology exporter to the world in the coming years. India is holding discussions with 18 countries[5] that are planning to implement its indigenously developed 4G/5G technology stack. 5G based Private Networks have also started being deployed in India. Bharti Airtel has deployed Captive Private Network at Mahindra's Chakan Auto manufacturing facility in partnership with Tech-Mahindra.

Government's Initiative to facilitate the launch of 5G services

1.14   The initiatives by the Government cover a range of factors from building 5G infrastructure and bringing the ecosystem together for effective R&D to helping TSPs to increase investments in 5G.

   i.   5G HIGH LEVEL FORUM - This forum was formed to provide an action plan to realise the 5G vision. The forum released a report outlining the roadmap, suggesting policies, programs, standards and use cases for 5G.

   ii. BHARAT NET - It is government run project that aims to connect the rural India on the optical fibre network and provide it on non-discriminatory basis to all service providers.

   iii. 5G TEST BED - The government has offered indigenous 5G test bed at free of cost to start-ups and MSMEs and at nominal rates to other stakeholders to validate their use cases.

   iv. VEPP PROGRAM - 5G Vertical Engagement and Partnership Program (VEPP) is an initiative to build strong collaboration partnerships across 5G
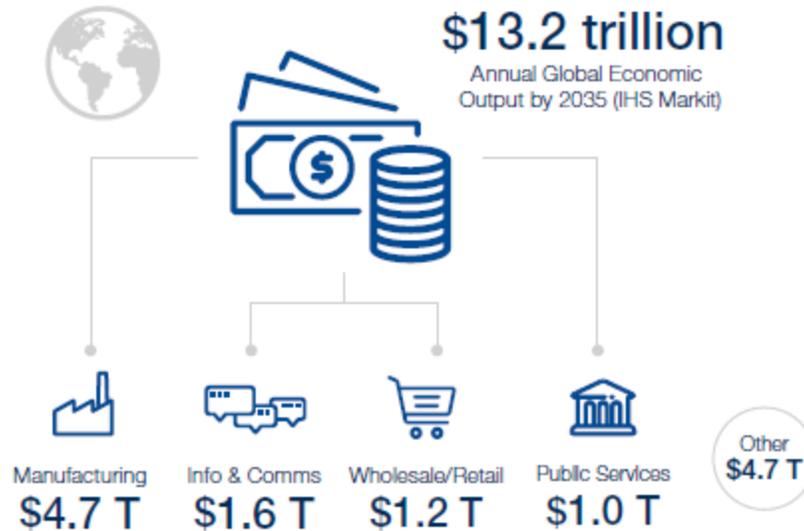
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[4] https://www.speedtest.net/global-index/india
[5] indbiz.gov.in accessed on 2nd March 2023

Use-case ecosystem stakeholders with an exclusive emphasis to address User/Vertical Industry needs. In order to multiply the 5G opportunities across the usage verticals, an Inter-Ministerial Committee is constituted with representatives from various Ministries to facilitate collaborative efforts across stakeholders. VEPP will enable close collaboration between User verticals and 5G Tech stakeholders (Service providers, Solution providers & partner OEMs), which can trigger a multiplier effect to try & fine tune 5G digital solutions in respective economic verticals.

IV. Likely Impact of 5G and associated technologies on Global Economy

1.15 Various studies show that mobile infrastructure continues to have a stable impact on the world economy. The economic dividend of mobile broadband continues to be greater in countries with lower levels of economic development. 5G's faster speed, lower latency, and ability to connect huge numbers of devices than previous generations of mobile technology will certainly result in a more efficient and productive society. There are numerous innovative and promising use cases of the technology for various sectors, e.g., hospitals equipped with 5G devices that enable remote patient monitoring, and smart ambulances that communicate with doctors in real time; digital wallets that connect phones, wearables, autonomous connected cars and other devices to create seamless financial transactions; and 5G-enabled factories in which connections can be maintained among more sensors than ever before.

1.16 Moreover, when 5G is used along with AI, extended reality (XR), edge computing and the Internet of Things (IoT), it will enable business and society to realise the full benefits of these other technological advances.
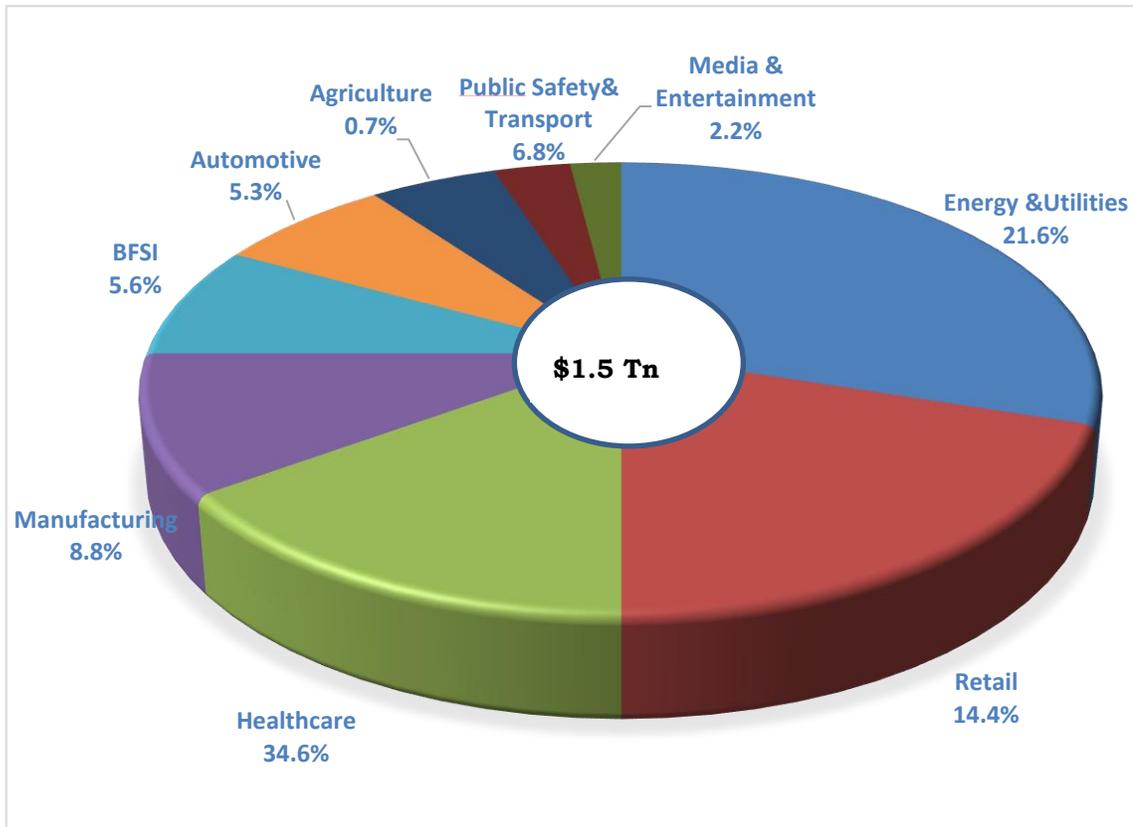
Figure 1.3: Economic and social value of 5G[6]

$13.2 trillion
Annual Global Economic
Output by 2035 (IHS Markit)

Manufacturing	Info & Comms	Wholesale/Retail	Public Services	Other
$4.7 T	$1.6 T	$1.2 T	$1.0 T	$4.7 T

According to a whitepaper released by World Economic Forum (WEF), *5G will be a catalyst for socio-economic growth in the Fourth Industrial Revolution with an estimated $13.2 trillion of global economic value reached by 2035 (See Fig 1.3).*

1.17   5G is expected to benefit the global economy by more than $1.5 trillion in 2030 *(See Fig 1.4)*, initially mostly in developed regions, including East Asia and the Pacific, North America, and Europe. Towards the end of the decade, other regions will also start benefiting from 5G. 5G is expected to benefit all economic sectors of the global economy, although some industries will benefit more than others due to their ability to incorporate 5G use cases in their business.

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[6] Based on IHS Markit, The 5G Economy: How 5G will contribute to the global economy, 2019.

**Figure 1.4: Annual global 5G contribution by industry, 2030**

V. Likely Impact of 5G and associated technologies on Indian Economy

1.18   5G is expected to power up to 2% of India's GDP, amounting to USD180 Billion by 2030[7] , facilitated by increasing market penetration, strengthening economy and sectoral reforms. Sectors such as healthcare, energy & utilities, manufacturing, and retail are expected to benefit the most from large-scale 5G adoption. Effective collaboration between public and private players for creating a skilled workforce and cybersecurity infrastructure, reducing regulatory overlaps, and providing financial incentives, will be needed to ensure that the benefits of 5G are realised across sectors. 5G along with the associated technologies is expected to

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[7] NASSCOM Arthur D Little 5G Report Nov2022

create new value through hyper-connectivity and become a catalyst for digital transformation across industries.

Figure 1.5: 5G Contribution for select Industries in India 2030
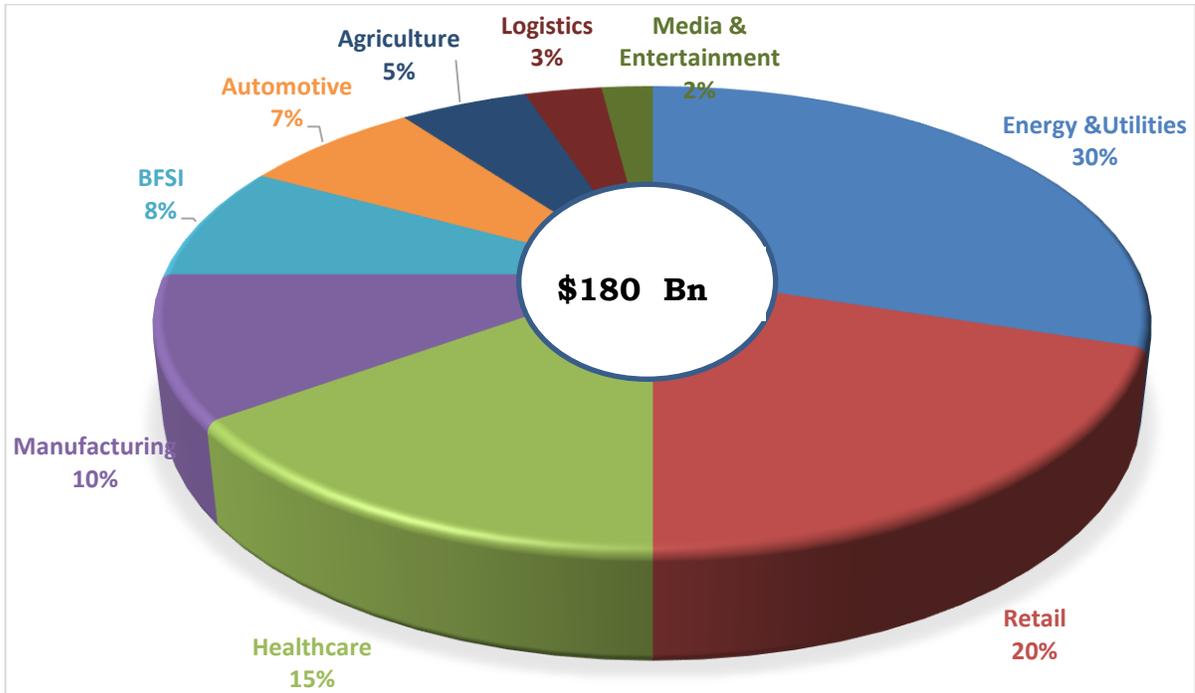
1.19   These technologies are not only transforming India's digital landscape but also creating synergies among them. For example, 5G can provide the backbone for IoT and AI applications that require high bandwidth and low latency. IoT and AI can generate and analyze huge amounts of data that can be used to create immersive and personalized experiences in the metaverse. Metaverse can offer a platform for showcasing and monetizing the innovations and solutions enabled by 5G, IoT and AI. India has a unique opportunity to leverage its strengths in digital infrastructure, talent pool, entrepreneurial ecosystem to become a global leader in digital transformation. By harnessing the potential of 5G, IoT, AI and metaverse, India can accelerate its economic growth, social development and global competitiveness.

1.20   However, achieving this will require effective ecosystem collaboration between TSPs, OEMs, Infrastructure providers, and the Government to increase consumer adoption and market readiness to unlock large-scale benefits of 5G. Adequate infrastructure upgradation and fiberisation for 5G deployment, along with network densification need to be addressed to realise the full benefit of the technology across industries. 5G adoption will depend on factors such as dedicated R&D investments to develop India-specific use cases, enterprise penetration, device affordability, and consumer adoption.

VI.   Collaboration based approach for 5G use cases and Ecosystem

1.21   Telecom industry has been transitioning from different generations of mobile technologies since last few decades and has been pivoting from voice to content to commerce and industrial applications. 5G technology holds the potential to enable unprecedented degrees of flexibility, productivity, and efficiency in various industry verticals. The potential of 5G, combined with artificial intelligence (AI), AR/VR, smart platforms and IoT, can deliver enormous value to consumers, organizations and the society at large. It will also pave the way for developing services for making smart cities, autonomous vehicles, smart factories, etc. However, to realise the true potential of 5G, the ICT industry must come together as an ecosystem for development and deployment of mature use cases.

1.22   The core competency of TSPs today is in providing network connectivity. To realise the potential benefits of 5G, the network needs to transform into a digital platform and be delivered as a service in the digital marketplace. Most of the implementations of 5G use cases will be brownfield implementations where the 5G solution needs to seamlessly integrate with existing business processes, IT systems and operational technologies. TSPs will need to adopt an ecosystem and build trusted and strategic partnerships with other ecosystem players for faster and mass-scale adoption of 5G use cases. Mobile operators across the globe are

collaborating with vendors and enterprises across different verticals to develop and deploy 5G use cases for industry. Chapter 2 of this consultation paper deliberates on need of such collaborations in India for development and deployment of 5G use cases.

VII. Associated Emerging Technologies shaping the Digital Economy

1.23   The use cases and economic benefits discussed in the previous sections cannot be realised with the help of 5G technology alone. Looking at 5G in isolation will make it difficult to understand why this new mobile generation is receiving so much attention. To fully understand the strength of the 5G disruption or inflection point, it is relevant to understand the associated technologies *(Figure 1.7)* that co-create the strong market momentum.

Figure 1.6: Technologies driving the 5G market momentum.[8]

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[8] Source : https://www.ericsson.com/en/blog/2021/9/5g-practitioners-guide-2021-episode2
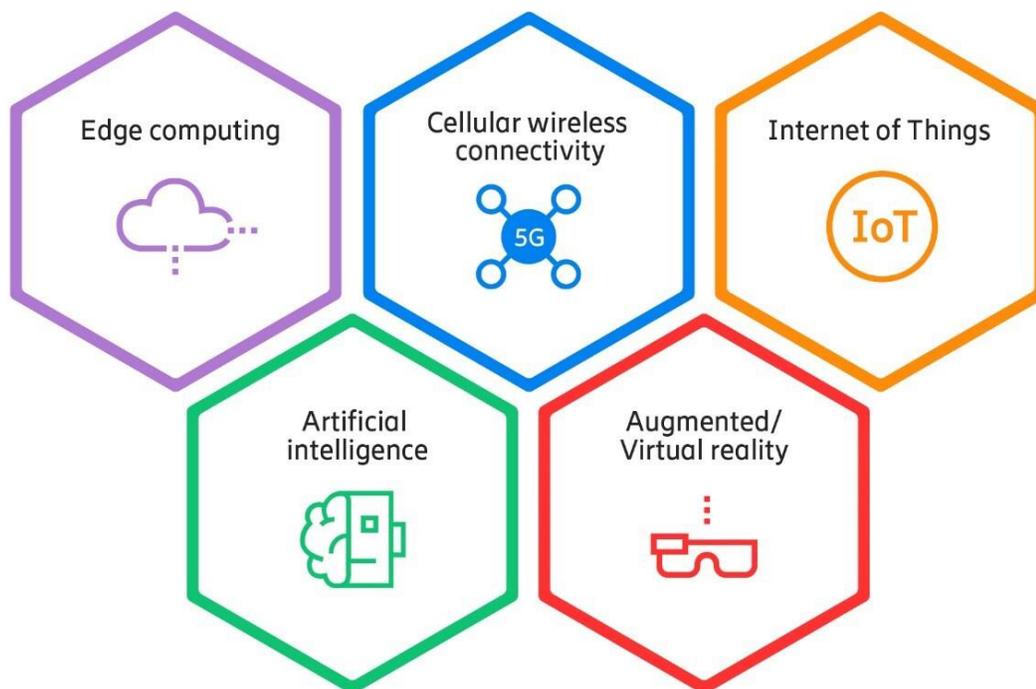
The combined forces of edge computing, IoT, AI, and XR make it even more exciting. These technologies represent a strong cluster together with other technologies piggybacking on them. We can expect the next generation of use cases shaping the digital economy to rely on a combination of these technologies. They have been elaborated further in the following sections.

A. *Edge Computing*

1.24   Edge computing is the logical evolution of the cloud computing model. It is a paradigm that brings computation and data storage closer to the location where it is needed, to improve response times and save bandwidth. The use of edge devices that store and process data locally, rather than relying on centralized data centre or more traditional cloud computing, enables faster decision making. Additionally, real-time processing at the edge makes data more relevant and actionable, helping to deliver better customer outcomes. Enterprises are beginning to develop use cases combining cloud based IoT solutions with edge computing, powered by the increasing availability of superfast 5G internet connectivity, to accelerate data analysis to make better and faster decisions.

1.25   However, edge computing also poses several challenges and issues that need to be addressed by researchers, practitioners, and policymakers. Edge devices and networks have limited resources such as processing power, memory, storage, battery, and bandwidth. Efficient allocation and management of these resources are required to meet the diverse and dynamic demands of edge computing applications. Edge devices and networks may be more vulnerable to cyberattacks and data breaches than centralized cloud systems. The issue has been dealt with in Chapter 3 of this CP in more detail.

1.26   The exponential growth of consumer applications in 5G era and their dependency on edge data centres will create a steep rise in the demand of

power consumption in data centres. A report by McKinsey suggests that data centres are responsible for over two percent of global electricity consumption, which is increasing year on year.[9] Today, rising carbon emissions from data centres are predicted to exceed those of the airline industry. Data centres also pose other environmental impacts beyond energy use and greenhouse gas emissions, such as water use and the generation of electronic waste. Considering the increasing environmental concerns, especially in a power frugal country like India, operating data centres with green and renewable energy and smarter and more efficient cooling system is necessary. There is a need to implement policy measures to encourage more energy-efficient greener data centres for sustainable 5G deployment. The issue has been deliberated in detail in Chapter 3 of this CP.

B. *Artificial Intelligence*

1.27 Artificial Intelligence (AI) is enabling rapid innovation with many potential benefits for society and business. AI is likely to be a big game changer in transforming business and society. According to a PWC study, AI could contribute up to $15.7 trillion[10] to the global economy in 2030, more than the current output of China and India combined. As the adoption of AI accelerates, organisations and governments around the world are considering how best to harness this technology for the benefit of people and the planet. AI has the potential to truly change the world, and this represents not only an opportunity but also a risk. AI depends on large amounts of data, often relating to individuals, and makes inferences based on this data. These inferences may be used to guide decisions that have a significant impact on the things people care about the most – their health, their employment and their access to resources.

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[9] Data Centres turn to green energy to power new facilities, CIO News, ET CIO (indiatimes.com)
[10]https://www.pwc.com/gx/en/issues/data-and-analytics/publications/artificial-intelligence-study.html

1.28   It is therefore necessary that AI is used in a way that protects our fundamental human rights. Citizens need to be confident that AI is being developed and used in an ethical and trustworthy manner. This is a rapidly evolving space, and many governments are in the process of drafting regulations relating to AI. In view of this and upon receiving a reference from DoT, TRAI had initiated a consultation on the subject and has come out with its recommendations dated 20th July 2023 on "Leveraging Artificial Intelligence and Big Data in Telecommunication Sector", wherein it has been recommended that for ensuring development of responsible Artificial Intelligence (AI) in India, there is an urgent need to adopt a regulatory framework by the Government that should be applicable across sectors. The regulatory framework should ensure that specific AI use cases are regulated on a risk-based framework where high risk use cases that directly impact humans are regulated through legally binding obligations. Further, the Authority also recommended the broad tenets of the suggested regulatory framework for AI.

C. *Internet of Things (IoT)*

1.29   The Internet of Things (IoT) refers to the network of physical devices, sensors, and software that collect and exchange data over the internet. Together, 5G and IoT can enable a variety of use cases that can benefit different sectors and industries, such as smart cities, healthcare, manufacturing, agriculture, and transportation. Some of these industry vertical use cases are mentioned below.

i.   5G can support the deployment of millions of IoT devices that can monitor and manage various aspects of urban life, such as traffic, pollution, energy, waste, security, and public services. This can improve the efficiency, sustainability, and liveability of cities.

ii.   5G can enable remote monitoring and diagnosis of patients using wearable IoT devices and sensors that can transmit vital signs and medical data in

real time. This can reduce the need for hospital visits and improve the quality and accessibility of healthcare services.

iii. It can also facilitate the automation and optimization of industrial processes using IoT devices that can communicate and coordinate with each other. This can increase productivity, quality, safety, and flexibility of manufacturing operations.

iv. 5G can enable precision farming using IoT devices that can collect and analyze data on soil, weather, crops, and livestock. This can help farmers optimize their inputs, outputs, and practices to increase yield and reduce environmental impact.

v. 5G can enable connected and autonomous vehicles that can communicate with each other and with the infrastructure to optimize traffic flow, reduce accidents, and enhance mobility.

IoT Challenges and Need for Consultation

1.30 However, 5G enabled IoT also poses some challenges and risks that need to be addressed and regulated. 5G enabled IoT devices can be vulnerable to cyberattacks that can compromise their functionality, data integrity, and privacy. This can have serious consequences for critical infrastructure, public safety, and personal information. 5G enabled IoT devices can collect and process large amounts of personal and sensitive data that can reveal user behaviour, preferences, location, and identity. This can raise ethical and legal issues regarding data ownership, consent, access, and protection.

1.31 There is immense scope of development of 5G enabled IOT use cases across various industry verticals. Such use cases have a potential to alter the traditional methods of farming, manufacturing in micro, small and medium enterprises (MSMEs). However, such innovations and uptake of 5G enabled IOT based applications require awareness and skill development in the corresponding sectors. A concerted effort towards skill

development and awareness will go a long a way in promoting innovations and realization of potential of 5G enabled IoT use cases in rural / MSME sectors.

1.32   As discussed above, 5G enabled IoT use cases involve multiple stakeholders across different sectors and jurisdictions that may have different standards, policies, and regulations. This can create challenges for interoperability, compliance, accountability, and governance. Therefore, 5G enabled IoT use cases offer significant benefits for various domains but also require careful regulation to address the potential challenges and risks. A balanced approach that considers the technical, social, economic, and ethical aspects of 5G enabled IoT is needed to ensure its responsible and sustainable development and deployment. Chapter 3 of this consultation paper deals with all these aspects related to IoT.

D. *Metaverse (Augmented / Virtual / Mixed Reality (AR/VR/MR))*

1.33   The metaverse is a term that refers to a virtual reality space where users can interact with a computer-generated environment and other users. It is often seen as the next evolution of the internet, where social connection, work, education, entertainment, and commerce can take place in immersive digital spaces. It creates an immersive space for interactions that are enabled by a range of technologies—including, but not limited to augmented reality (AR), virtual reality (VR), Mixed reality (XR), artificial intelligence (AI), internet of things, and digital twins. It has the potential of creating a simulated real-life environment where people can talk, work, and play using specialized glasses, headsets, controllers, and related resources. The Metaverse is currently all the rage in the digital world because of its seemingly endless potential and objectives.

Metaverse Challenges and Need for Consultation

1.34 Industry players and investors are overwhelmingly looking for new use cases and monetisation opportunities from metaverse. Some estimates suggest that the metaverse market could be worth up to US$13 trillion by 2030[11]. The size of the metaverse will make it hard to ignore and denotes its influence over the way people will live, work and play. Many things that people do today on the internet, may soon be done in the metaverse instead. When any market receives investment in millions of dollars of hard-earned money, legal and regulatory frameworks become a necessity to ensure a degree of ethics, trust, and diligence. Ensuring trust and transparency in metaverse is essential to instil confidence among the consumers for its adoption. If appropriate and timely steps are not taken today for forging trust and safety for the digital spaces where we live, work and play, the next generations may inherit a digital world polluted by predators, hate speech and mistrust. Hence, it is important that the regulators across the world get on board sooner and put in place necessary guidance or frameworks fit for metaverse. Then only its benefits will be visible across the economies and societies. Chapter 4 of this consultation paper delves into the requirement of a regulatory framework for Metaverse in India.

E. Robotics

1.35 Artificial Intelligence, Machine Learning, IoT and Robotics are working together and creating wonders for solving the problems of mankind and humanity. With massive and low-latency connectivity, 5G can revolutionize the robotics industry. It will pave the way for a new generation of robots, controlled via wireless rather than wired communications links and exploiting the vast computing and data storage resources of the edge cloud. Armed with these capabilities, robots can be

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[11] https://www.precedenceresearch.com/metaverse-market

precisely controlled dynamically in near real time and be connected to people and machines locally and globally. In short, 5G will fully enable applications such as the "factory of the future" and many, many others that were previously beyond the capabilities of both cellular and robotics technologies.

1.36   Some of these use cases are discussed below.

i.   Robots are already ubiquitous in manufacturing, of which the auto industry is perhaps the most obvious example. They can carry out a large number of tasks in the manufacturing process, allowing their human counterparts to be employed in other areas. This enhances safety – particularly where dangerous chemicals are involved.

ii.   5G-equipped robots could help feed the world's ever-growing population through advances in agriculture. The "untethering" of robots via 5G and GPS-based geolocation will allow them to perform functions that are impossible today. Robotic farm equipment could drastically cut the amount of labour needed to grow crops. All of these can be attributed to the power of 5G, which provides a constant flow of real-time data on soil conditions, pests, and weeds for the robots to analyse, calculate, and execute.

iii.   Autonomous vehicles hitting the streets in near future too will be robots on wheels, executing instructions from a vast array of sensors to make decisions and perform functions, presumably a lot more accurately, reliably, and faster than humans. Gyrocopters and other unmanned vehicles also fit in this category.

iv.   Healthcare is another sector where robotics has immense potential. The robots will not only perform functions such as transferring things from one place to another in a hospital, aided by 5G communications and the cloud, but they will also enable telesurgery in which operations are orchestrated remotely by doctors and performed locally by robots.

v.   In agriculture, robots could wander through fields monitoring growing conditions and sending video and other sensor information back to a computer located virtually anywhere, or even perform activities such as spraying, pruning, and harvesting. A company called FFRobotics[12] has developed what it calls a fresh fruit robotics harvester that combines robotic controls with image processing software algorithms that allow it to find and distinguish between saleable and damaged produce as well as between fruit that is either not yet ripe or dead.

1.37   5G-enabled robotic technologies have the potential to transform industries and improve the quality of life for people around the world. However, the successful deployment of these technologies requires regulators and policymakers to address a range of challenges, including cybersecurity, privacy, safety, and workforce development. By proactively addressing these challenges and working collaboratively with industry stakeholders and international partners, policymakers can help ensure that the benefits of 5G-enabled robotic technologies are realized in a safe, responsible, and equitable manner.

F.   Drones

1.38   Drones, also known as unmanned aerial vehicles (UAVs), are increasingly becoming an essential technology for various industries worldwide. From agriculture to logistics and disaster management to surveillance, drones are being integrated into numerous sectors for improved efficiency and cost-effectiveness. With the advent of 5G networks, the potential for drones to revolutionize the way we live and work is immense. However, the widespread adoption of drones also brings forth several policy challenges. In the Indian context, where the drone market is experiencing significant

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[12] https://www.mouser.in/applications/robotics-and-5g/

growth, addressing these challenges is crucial to harness the benefits of UAVs.

1.39   Drones hold immense potential for transforming various sectors in India, with some of the most significant applications being[13],[14]:

i.   Agriculture: Drones can be utilized for crop monitoring, pest management, and precision agriculture practices, which can help increase crop yield and reduce input costs for Indian farmers.

ii.   Disaster Management: India is prone to various natural disasters, such as floods, cyclones, and earthquakes. Drones can play a critical role in disaster management by providing real-time aerial imagery, assessing damage, and assisting in search and rescue operations.

iii.   Infrastructure Monitoring: Drones can be used to monitor and inspect critical infrastructure, such as roads, bridges, and power lines, ensuring timely maintenance and reducing the risk of accidents.

iv.   Healthcare: In remote and inaccessible areas, drones can be utilized for the rapid delivery of medical supplies and vaccines, significantly improving healthcare services for rural populations.

v.   Military: Drones can be used to provide air support to ground troops, targeting enemy positions with precision-guided munitions.

VIII.   Digitisation, Monetization and sharing of Data

1.40   India is currently experiencing a digital boom, with widespread access to affordable mobile internet. Simultaneously, the Indian government has embraced the use of information technology for delivering numerous e-Governance projects in the last two decades. These include two types of projects, one where government-owned non-personal data is created

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[13] "Use Drones to Monitor Infrastructure Projects: PM Narendra Modi." The Economic Times, 2 May 2017, https://economictimes.indiatimes.com/news/politics-and-nation/use-drones-to-monitor-infrastructure-projects-pm-narendra-modi/articleshow/58471207.cms.
[14] Santhanam, Vignesh. "How Drones Could Change the Future of Healthcare Delivery." World Economic Forum, 8 May 2020, https://www.weforum.org/agenda/2020/05/medical-drone-delivery-india-africa-modernize-last-mile/.

based on anonymising interactions with Indian citizens, and the second type involving purely non-personal data processing that does not involve any individuals at any stage. The latter may include weather, traffic, military, scientific, commercial and economic research data processed by the government in a digital medium.

1.41 Data is a valuable economic and social resource offering enormous opportunities for citizens, businesses, and governments. With increasing digitization and engagement, the volume of data is also increasing exponentially, providing opportunities for better governance, service delivery and innovation in sectors critical for societal transformation. Data processed across various sectors thus presents enormous economic potential. India data monetization is projected to grow at a CAGR of 7.68% to attain a market size of US\$5.725 billion by 2027, from US\$3.411 billion in 2020.[15] If India wants to fulfil its ambition of achieving a \$5 trillion economy, it must develop the capability of harnessing the value of data.

Challenges and Need for Consultation

1.42 Government and the Authority has taken several initiatives to ensure protection of users' data. "Digital Personal Data Protection Bill, 2023", was passed by the parliament on 9th August 2023[16] and Digital Personal Data Protection Act, 2023 came into effect from 11th August 2023. In May 2022, the government has published the draft 'National Data Governance Framework Policy (NDGFP), which promises to ensure that any anonymized data and non-personal data from both the private or government entities can be accessed by the 'research and innovation eco-system', in a safe and accessible manner. The objective of this policy is to derive economic value from its data, following the National Data Sharing and Accessibility Policy notified in 2012. It is important to define what type

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[15] https://www.knowledge-sourcing.com/report/india-data-monetization-market

[16] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1947264

of data can be monetized and how it can be used. If it is something that is completely non-personal such as data related to climate or some geospatial information, then there are fewer concerns, but when it gets linked to individuals, a large part of the concern comes up. These concerns have been dealt with in Chapter 5 of this consultation paper.

Structure of the Consultation Paper

1.43 The Consultation Paper (CP) comprises of six chapters. This chapter introduces the subject and sets the context for present consultation. Chapter 2 of the CP raises concerns about the need of ecosystem or collaboration-based approach for development and deployment of 5G use cases. Chapter 3 discusses the issues relating to adoption of Internet of Things (IoT) use cases. Chapter 4 of this paper delves into the benefits and regulatory challenges posed by the Metaverse. Chapter 5 deals with the issues related to digitisation, monetization and sharing of data and finally Chapter 6 summarizes the various issues for consultation.

Chapter – 2

ECOSYSTEM FOR 5G USE CASES

I. Evolution of Mobile Technologies

2.1. The evolution of mobile technologies has been driven by the continuous "chase" for higher data rates, higher capacity, lower delay, better spectrum efficiency and flexibility, high level of QoS provisioning, diversified mobile speed and greater coverage over cellular. It resulted in GPRS/EDGE (2.5/2.75G) evolving to UMTS (3G) to HSPA (3.5G) to HSPA+ (3.75G), then to 4G LTE, LTE-Advanced and LTE-Advanced Pro, finally evolving to 5G NR, and continuing further to 5G-Advanced and later (around 2030) to 6G. From 3G onwards, the ITU makes umbrella specifications for Network, devices and services for a particular generation of mobile technology, called IMT.

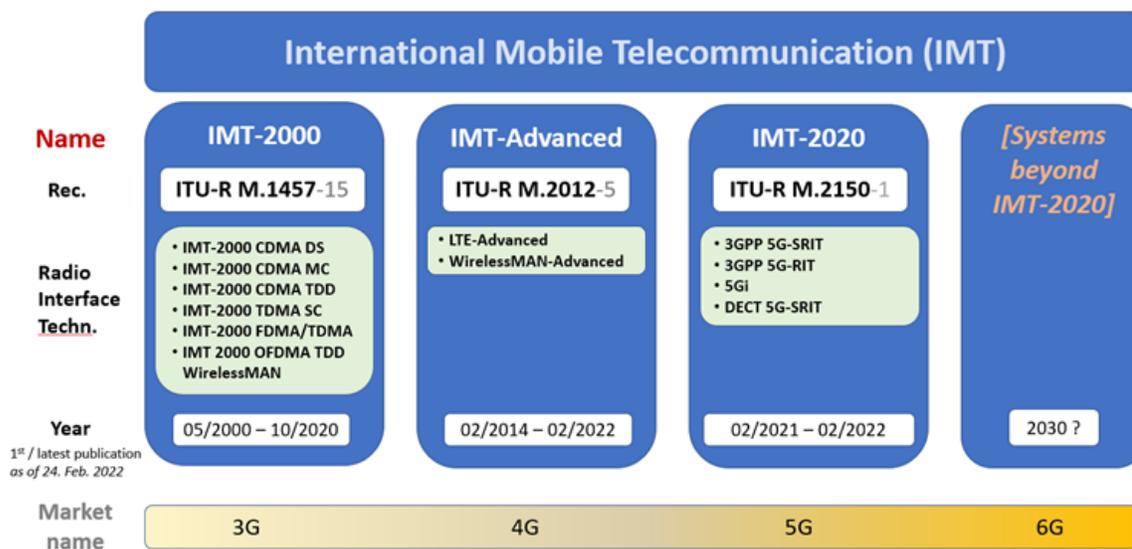**Figure 2.1 IMT-Family and naming conventions (source: ITU)**

Figure 1.1 shows ITU umbrella specifications for 3G (IMT-2000), 4G (IMT-Advanced) and 5G (IMT-2020), and technologies that were accepted by the

ITU under each such umbrella. Each such umbrella included stricter requirements than the previous, thus ensuring continuous progress in mobile systems.

2.2.   The enhancements in key capabilities from IMT-Advanced to IMT-2020 is shown in figure 1.2. For example, IMT-2020 can deliver minimum peak bitrate of 20 Gbit/s in downlink, and 10 Gbit/s in uplink. Bitrates experienced by individual mobile users are to be 100 Mbit/s or higher. Also, connection density in IMT-2020 is increased ten times as compared to IMT-Advanced, which is set to support minimum 1 million connections per square kilometer in 5G systems. This includes smartphones, IoT devices, and all other IMT-2020/5G devices. Another important enhancement is support for user plane latency as low as 1 ms, which is needed for the envisioned critical services in IMT-2020 (i.e., 5G) systems.

Figure 2.2: Enhancements from IMT-Advanced to IMT-2020
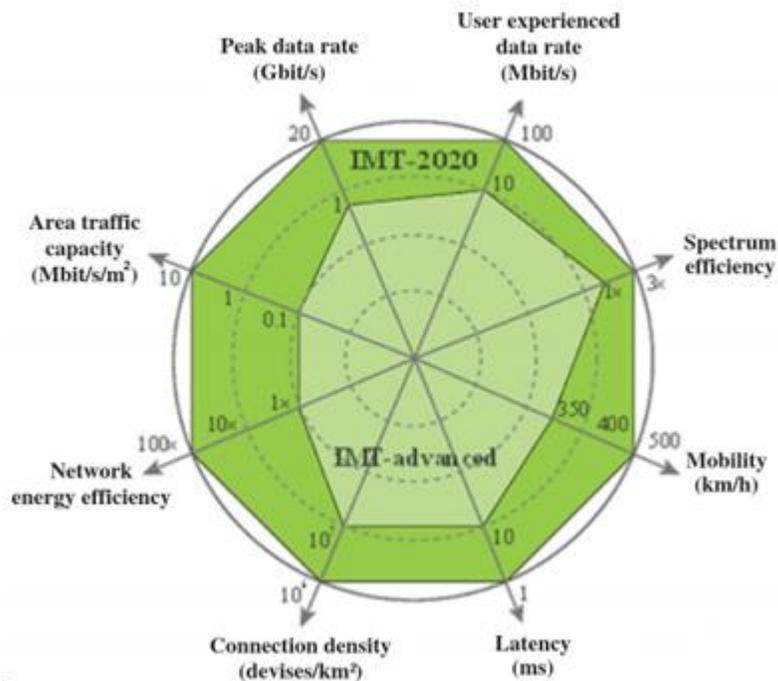
Source: ITU

2.3.   To have a much better understanding, these enhancements are also presented in tabular form.

Table 2.1: IMT-2020 vs. IMT-Advanced by ITU (source: ITU)

	IMT-Advanced	IMT-2020
Minimum peak bitrate	Downlink: 1 Gbit/s Uplink: 0.05 Gbit/s	Downlink: 20 Gbit/s Uplink: 10 Gbit/s
Bitrate experienced by individual mobile device	10 Mbit/s	100 Mbit/s
Peak spectral efficiency	Downlink:15bit/s/Hz Uplink: 6.75 bit/s/Hz	Downlink:30bit/s/Hz Uplink: 15 bit/s/Hz
Mobility	350 km/h	500 km/h
User plane latency	10 msec	1 msec
Connection density	100 thousand devices per square kilometer	1million devices per square kilometer
Traffic capacity	0.1 Mbit/s/sq. m.	10 Mbit/s/sq. m. in hot spots

2.4. The deployment of 5G is happening in two modes, i.e. 5G Non-Stand-Alone (NSA) architecture and 5G Stand-Alone architecture. According to 3GPP, the 5G NSA architecture will have 5G RAN, 5G New Radio (NR), and 4G LTE access and network core. On the other side, the 5G SA architecture is characterized by dedicated 5G RAN base stations, small cell base stations, and a 5G core (5GC) network. While the NSA architecture only supports LTE services but has improved 5G capabilities such as lower latency as well as higher bitrates. SA architecture can take full advantage of 5G end-to-end network capabilities supported by NR and 5GC, providing customized service, especially to vertical industry, in an effective and efficient way. New features, including service-based architecture, end-to-end network slicing, and MEC (Multi-access Edge Computing), can be enabled according to specific requirement of each

service, providing customized superior 5G user experience. These features are discussed in detail in the following section.

II. 5G and Beyond

2.5. The 5G New Radio (NR) and 5G Core (5GC) evolution is continuing in 3GPP toward 5G Advanced, to ensure the success of 5G systems globally and to expand the usage of 3GPP technology by supporting different use cases and verticals. AI/ML will play an important role in 5G Advanced systems, in addition to other technology components, to provide support for extended reality (XR), reduced capability (RedCap) devices, and network energy efficiency. 5G and beyond networks are expected to ensure better quality of service, very high data rate, improved network security, high capacity, low latency, and low cost. In order to meet these objectives, several key enabler technologies have been proposed including massive multiple input multiple output, small cells, multi-access edge computing, software defined network, heterogeneous networks, network slicing, cloud radio access network, ultra-dense network, energy efficiency, and spectrum sharing.

2.6. The next generation mobile technology i.e., sixth generation or 6G technology, currently under development, is anticipated to make several major leaps forward. It is expected to become available in 2030 providing truly omnipresent wireless intelligence. With speeds almost 100 times faster than 5G, it will enhance and drive new communication applications. These technological advances will impact user experience and transform economies and lives everywhere. It will very likely include intelligent network management and control, and integrated wireless sensing and communication. 6G will make it possible to move freely in the cyber-physical continuum (Metaverse), between the connected physical world of senses, actions and experiences, and its programmable digital representation.

2.7.   In India, The Department of Telecommunications constituted a Technology Innovation Group on 6G (TIG-6G) on 1st November 2021 with members from various Ministries/Departments, research and development institutions, academia, standardization bodies, Telecom Service Providers and industry to develop Vision, Mission and Goals for the 6G and also develop a roadmap and action plans for 6G in India. The TIG-6G in turn constituted six Task Forces with industry, academia, R&D institutions and Government as members on Multi-Disciplinary Innovative Solutions, Multiplatform Next Generation Networks, Spectrum for Next Generation Requirements, Devices, International Standards Contribution and Funding Research and Development.

2.8.   Based on the reports of the Six Task Forces, a Bharat 6G Vision Document has been prepared by the Technology Innovation Group on 6G. The Vision for 6G is fully aligned with the national Vision of Atmanirbhar Bharat and will seek to empower every Indian to become Atmanirbhar (self-reliant) in their lives. The research and start-up ecosystem will be tapped to bring innovations and new ideas to the table. Adequate provisions for financial support will be made available. The Mission will be completed in two phases - Phase 1 from 2023-2025 (2 years) and Phase 2 from 2025-2030 (5 years).

2.9.   The objectives of Bharat 6G Mission is to

   i.   Facilitate and finance Research and Development, design and development of 6G technologies by Indian Startups/Companies/Research bodies/Universities;

   ii. Enable India to become a leading global supplier of IP, products and solutions of affordable 6G telecom solutions;

   iii. Deploy 6G technologies to act as a powerful force multiplier for India@2030;

iv. Enable inclusive and significant enhancement in the quality of living experience of citizens in India and across the world.

III. 5G Special Features

2.10. The ITU has defined three standard 5G service profiles – Massive Machine to Machine-Type Communications (mMTC), Ultra-Reliable Low-Latency Communications (uRLLC) and Enhanced Mobile Broadband (eMBB). These profiles are expected to meet the requirements of most industrial applications and are driving the adoption of 5G for industrial use cases.

i. Massive Machine to Machine-Type Communications (mMTC): Providing connectivity to IoT devices and machines on a large scale with connection density of 1 million devices per square km. mMTC supports extremely high connection densities, enabling industrial-scale IoT.

ii. Ultra-reliable low-latency communication (uRLLC): With uRLLC, 5G will be able to connect controllers, switches, sensors, and actuators at latency and reliability levels equivalent to those of a wired connection. 5G's URLLC service profile addresses several critical applications in different industries and scenarios, such as for manufacturing, automation, and autonomous equipment or vehicle operation.

iii. Enhanced Mobile Broadband (eMBB): Very High Speed broadband on Cellular Network with data rates of the order of 20 bps.

The special features that enable 5G to meet the requirement of these service profiles are discussed below:

A. Service Based Architecture

2.11. Compared to previous generations the 3GPP 5G system architecture is service based. That means wherever suitable the architectural elements are defined as network functions that offer their services via interfaces of a common framework to any network functions that are permitted to make use of these provided services. This architectural model, which further adopts principles like modularity, reusability and self-containment of

network functions, is chosen to enable deployments to take advantage of the latest virtualization and software technologies.

2.12. The service-based architecture (SBA) provides capability exposure by making 5G Core Network functionalities available to third parties such as service providers and vertical industries outside the operator's domain. This feature is provided by the Network Exposure Function (NEF). The interface provided by the NEF to third parties can be regarded as one of the essential membranes through which 5G communicates more closely with vertical industries than mobile networks of earlier generations did. 5G service exposure by the NEF is based on so-called RESTful APIs.

2.13. The Network Functions (NFs) forming the SBA communicates with each other via Service Based Interfaces (SBI). So, this way the 5G Core Network internal communication obeys the same principles as the functional exposure, thus allowing a harmonized and holistic technological approach of the complete 5G system. This is fully in-line with the progressive paradigms which are at the heart of a wide range of services used by end-customers as well as for the automation of whole industries.

B. Multi-access Edge Computing (MEC)

2.14. Multi-access edge computing (MEC) enables telecom operators and third-party service provider's content and functions to be hosted close to User Equipment's (UE) access point of attachment. MEC brings significant reduction in end-to-end latency and load on transport network. Unified MEC in IMT-2020 networks is like Platform As A Service (PAAS) functions to ensure the quick integration of storage, computing, network and security capabilities, and to build up an ecosystem for operator's and third-party's services and applications. An MEC application runs on top of the virtualization infrastructure and can interact with the MEC platform to provide and deploy MEC services.

2.15.   The 5G network will enable a variety of services, including enhanced mobile broadband (eMBB) based services, massive machine type communications (mMTC) based services and ultra-reliable low latency communications (URLLC) based services. Therefore, mobile edge cloud in 5G network is required to be very efficient, personalized, intelligent, reliable and flexible. MEC involves multiple actors, such as network operators, service providers, application developers, and end-users. Stakeholders need to ensure interoperability and compatibility among different MEC platforms, services, and applications, as well as alignment with existing and emerging standards and regulations. MEC involves dynamic allocation and optimization of resources, such as computing, storage, bandwidth, and energy, at the edge of the network. Stakeholders need to define the resource management and orchestration strategies, algorithms, and tools for MEC applications and services.

2.16.   However, the most significant challenge posed by MEC that needs to be addressed by researchers, practitioners, and policymakers is the security and privacy. MEC is more vulnerable to cyberattacks and data breaches than centralized cloud systems. MEC involves processing and storing data at the edge of the network, which may raise concerns about data protection, confidentiality, and integrity. Another challenge is minimizing the energy consumption and environmental footprint of MEC. Stakeholders need to suggest policies and mechanisms for overcoming these challenges related to MEC. All these issues have been deliberated in detail in Chapter 3.

C. Network Slicing

2.17.   5G network will enable a variety of services, including enhanced Mobile Broadband (eMBB) services, massive Machine Type Communications (mMTC) based services and Ultra-Reliable Low Latency Communications (URLLC), on the same infrastructure of network and computing resources.

Network operators have traditionally provisioned multiple different networks to cope with different requirements in terms of service characteristics, functionalities, and performance. Network slicing enables 5G network operators to create logically partitioned networks providing customized solutions for different market and business scenarios.

2.18. According to the ITU's definition - network slice is a logical network that provides specific network capabilities and network characteristics. Network slices enable the creation of customized networks to provide flexible solutions for different market scenarios which have diverse requirements, with respect to functionalities, performance and resource allocation. The behaviour of a network slice is realized via Network Slice Instance(s) (NSIs). A Network Slice Instance (NSI) is composed of a set of Network Function Instances (NFIs) running over the allocated resources. An NSI constitutes a logical network that provides specific network capabilities and characteristics. The underlying physical infrastructure is abstracted as network, storage, or computing resources with the help of network virtualization based on SDN, NFV, and cloud computing technologies.

2.19. There are different possible uses of network slicing in 5G. For example, one network slice can be allocated for mobile Internet traffic from an operator's own subscriber (via eMBB network slice) and another network slice can be allocated for the similar traffic (i.e., mobile Internet access) for a virtual mobile operator which is using the same 5G network infrastructure. For 5G services that require very low latencies and high reliability, a separate network slice (or slices) can be allocated (e.g., URLLC slices), where different slices can be created for different end customers (e.g., one slice for one enterprise, another network slice for other enterprise, and so on).

2.20.   SDN, NFV and network slicing also enables offering customized services with different requirements on QoS. During the 5G era, network slicing will allow mobile operators to create virtual data pipelines for each data service. This means that QoS will be assured for every service. It may be noted that this approach is not jeopardizing the Internet network neutrality, which is also valid in mobile networks, but it is more targeted to extension of mobile services portfolio to other verticals, such as mission critical services, connected cars, industry automation, etc. Ultimately, the technology allows mobile operators to develop unprecedented business models.

IV.   **Use Cases in various Industry Verticals**

A more elaborate analysis of sector-wise use cases of these emerging technologies is presented below.

A.   **Healthcare**

2.21.   5G boosted by advances in robotics, drones, IoT and AI—will enable the emergence of a new, connected healthcare ecosystem. This ecosystem will use 5G connectivity to meet patient and provider needs accurately, conveniently, cost-effectively and at a massive scale. According to PwC study 5G-powered healthcare applications will add US$530bn to global GDP by 2030. 5G could enhance healthcare applications in the following ways:

i.   *Remote Patient Monitoring*: Smart wearables with sensors will constantly track patient's vitals, detect faults in medical devices and relay this information to a cloud platform monitored by doctors to prevent adverse health issues. Medical data collected from almost 1 Mn devices per-sq-Km via 5G will enable Internet of Medical Things (IoMT) where hospitals will function as modern data centers and offer customized consultations for patients rapidly.

ii. *Telemedicine:* Online consultations and digital prescriptions equipped by 5G will bridge the doctor-patient gap and provide secure, quick and enhanced healthcare in rural areas.

iii. Remotely operated robotic surgeries, AR/VR assisted medical procedures, robotic aids capable of performing CT scans and remote diagnosis. XR tools will enable immersive visualization and medical training such as using haptic gloves with sensors to learn complex procedures online.

iv. Drone enabled medical service delivery: 5G enabled drones can increase speed of delivery of medicines/vaccines, expedite collection of medical samples.

Thus, 5G will expand the reach and effectiveness of remote health monitoring and telemedicine programmes in far-flung and rural areas also, which don't have easy access to hospitals.

B. Education

2.22. In the post-pandemic era, the digitalisation of educational landscape has accelerated manifold. Most classrooms have adopted some form of virtual learning, requiring video conferencing and other devices. 5G allows educational delivery to be faster, more reliable, and smoother. With 5G, video conferencing platforms will improve in quality and reliability around the globe. Students will be able to download videos and learning materials faster and even have holograms of guest speakers in their classroom without dips or delays. Also, since 5G allows more data to be transferred, communication among peers for group projects will happen faster almost as if people across geographies are sitting in the same room.

2.23. Some skills, such as lab work and hands-on experiences, require extra tactile stimulation to create the same level of learning online as in real life and real-time. Those interested in learning new skills and visualizing abstract concepts in an interactive way can benefit from the integration of AR and VR into immersive classrooms. 5G will provide a greater network

capacity and seamless experience that allows learners to explore complex concepts through zooming, pinching, and even touching. Further, haptic responses (that reproduce the feeling, touch, or motion of interacting directly with a physical object) could introduce tactile forms of learning to a classroom through traditional video conferencing platforms, making interactions richer.

2.24. It is a general belief that one-size-fits-all approach for education could hinder growth. 5G has the capability to change that. It will improve personalization by creating intelligent systems to understand the unique needs of each student and create targeted learning journeys. For example, virtual teaching assistants could allow cohorts to access different sets of lessons and assessments depending upon the profile and preferences of learners.

2.25. As 5G expands to reach more aspects of daily life, it will make learning on-the-go easier, providing greater responsiveness and speed across all devices, especially mobile. It can provide the flexibility to busy students and professionals who need to learn outside the classroom. 5G will accelerate the promise of democratizing access to quality education in inclusive and affordable ways, thus providing a level playing field, especially for under-resourced communities.

C. Agriculture

2.26. 5G will revolutionise the agriculture sector by realising precision agriculture, achieving best cost realisation, optimising utilisation of crop and livestock resources, smart management and ensuring best price for the end users. 5G enabled drones can be deployed for remote sensing of farms and spraying fertilizers/ pesticides/insecticides. The goals are profitability, safeguarding the environment and sustainability. Precision agriculture is a strategy for enhancing productivity. This strategy increases accuracy and throughput at all levels with reduced cost and

labour through automation, remote sensing, data analytics utilising 5G. With the help of 5G enabled IOT devices, data from numerous sources is collected, updated frequently and sent to the cloud in real time. In the cloud, data is analysed using AI/ ML algorithms to present actionable insights to the farmers. The sources may be soil moisture, weather, seed genetics, crop condition, plant health, historical yields, soil pH level, crop prices collected from the market etc. The actionable insights can be regarding crop to be planted, type of seed to be sown, timing of plantation, type of fertilizer, quantity and timing of fertilizer application, pests infecting the field, type and amount of crop protection products to apply, Irrigation, harvesting and selling of crops.

2.27.   5G enabled drones, equipped with multispectral sensors, can be used to analyse the nutrient status of crops by Digital soil Mapping. This data is integrated with weather and other agronomic information for applying an optimal quantity of fertilizer precisely at a specified area. Drones scan and detect pests, diseases and weeds and apply pesticides at target areas after the data is analysed by an AI algorithm. 20 per cent of global GHG (Greenhouse Gases) emissions are contributed by agriculture. Soil nutrients are lost due to excessive usage of chemicals. Usage of chemicals can be reduced, without impacting the yield, by deploying 5G powered drones as described above. Drones can collect and deliver information about field status and crop stage. As 5G supports high bandwidth, the 5G enabled drones can collect high resolution quality video data and relay it faster.

2.28.   Autonomous agricultural vehicles are another use case in agriculture. Farmers can monitor tractor's status from their cell phone which provides images and live data of the tractor. Tractors can be fitted with 5G enabled devices which allow operators to adjust remotely tractor's speed, depth of soil penetration and distance between seed rows. Driverless farm equipment will provide more flexibility and efficiency and save labour cost.

2.29. Another use case in farming can be Livestock monitoring and management. India has highest cattle population with more than 300 million[17] cattle and is the country with the largest consumption of dairy products. But our cattle productivity is less with daily milk yield per cattle of about 4 litres, whereas the same is about 30 litres in US.[18] Technology can help in increasing the productivity of the cattle. Each year farmers lose significant amounts of money due to animal illness. Using 5G enabled sensor devices, farmers can monitor pests and diseases in farm animals and act. These sensor devices can be fixed to the ear of the animal and farmers can find out remotely whether the animal is in heat stage or sick. Sensor devices can be fixed on its stomach to find out how good its digestive system is. Animal's behaviour, health, feeding patterns, food and water quality, hygiene levels can be monitored. Their location in the farm can be tracked and traced. Livestock reproductive cycles and the calving process can be tracked for safer and successful deliveries.

D. Industrial Manufacturing

2.30. 5G technologies provide the network characteristics like low latency and high reliability that are key for addressing manufacturing use cases. It has the potential to address the key challenges in digitalization for industrial manufacturing. 5G networks offer manufacturers and telecom operators the chance to build smart factories and truly take advantage of technologies such as automation, AI, IoT and augmented reality for troubleshooting.

2.31. Modern factories have advanced machines and robots equipped with a wide array of sensors connected to high-powered analytics engines in the cloud. They help in accomplishing tasks such as assess performance, manage production schedules, maintain supplies and orchestrate all the

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[17] India: cattle population 2023 | Statista
[18] Milk per animal, 2021 (ourworldindata.org) (Source: FAO,UN)

activities on the factory floor. 5G will eliminate the need of wired connectivity and supplement the high-speed manufacturing environment with a far greater degree of flexibility. 5G-enabled factory will have the capacity to maintain connections among far greater number of sensors than either wired or previous wireless facilities.

E. Digital Financial services

2.32.   5G technology has the potential to greatly impact the financial sector by providing faster, more secure, and innovative financial services. Financial institutions are already exploring and investing in 5G technology to stay ahead of the competition and deliver better services to their customers. Following are some of the key benefits that 5G can offer to the financial industry:

i.   With 5G, financial institutions can process transactions at high speeds, reducing latency and improving efficiency. This enables real-time processing of payments and instant transfer of funds. It will enable consumers to solve their queries in real time and help financial institutions attain ability to scale service provision even while downsizing branches.

ii.   5G technology offers improved features such as network slicing, which allows for the creation of secure and isolated virtual networks for sensitive financial transactions. This reduces the risk of cyberattacks and improves overall security.

iii.   5G's high speeds and low latency, combined with its ability to support new technologies such as virtual and augmented reality, will open up new opportunities for the creation of innovative financial products and services. For example, virtual reality experiences could be used to provide financial advice or investment simulations, while augmented reality could be used to assist with the analysis of financial data.

iv. 5G's high speeds and low latency will greatly improve mobile banking experiences, enabling customers to access financial services from anywhere, at any time. This will result in increased convenience for customers, as well as increased opportunities for financial institutions to reach new markets.

F. Automotive Sector

2.33. 5G technology has the potential to transform the automotive sector and revolutionize the way we drive and interact with our vehicles. Some of the key benefits and applications of 5G in the automotive sector include:

i. Enhanced Connectivity: 5G technology will provide vehicles with high-speed and low-latency connectivity, enabling real-time communication and data transfer between vehicles, road infrastructure, and cloud-based systems. This will enable advanced features such as improved traffic management, predictive maintenance, and advanced driver assistance systems.

ii. Improved Autonomous Driving: 5G will enable vehicles to receive real-time information about their surroundings, including traffic conditions, road hazards, and other vehicles, allowing for enhanced autonomous driving capabilities. This will improve the safety and efficiency of autonomous vehicles and help accelerate their widespread deployment.

iii. Remote Vehicle Management: 5G technology will enable remote vehicle management, allowing automakers and dealers to remotely diagnose, troubleshoot, and update vehicles, reducing the need for costly maintenance visits.

iv. New Business Models: 5G technology will enable the creation of new business models and services, such as connected car insurance, in-car entertainment and commerce, and location-based advertising.

v.   Improved Energy Efficiency: 5G will enable real-time communication and data transfer between vehicles and the grid, allowing for improved energy management and more efficient charging of electric vehicles.

G. Energy Sector

2.34.   5G technology has the potential to revolutionize the way that Energy and utilities sector, such as electric and water companies, operate. Some of the key benefits and applications of 5G in the energy sector include:

i.   Improved Network Connectivity: 5G technology will provide smart utilities with high-speed and low-latency connectivity, enabling real-time communication and data transfer between grid assets, such as sensors, meters, and substations. This will improve the efficiency and reliability of the energy and water networks, reducing downtime and costs.

ii.   Advanced Analytics and Predictive Maintenance: 5G technology will enable Power stations, Oil refineries and coal mines to collect and analyze large amounts of data from grid assets, allowing for the use of advanced analytics and machine learning to improve operations and prevent failures. This will enable predictive maintenance, reducing the need for costly repairs and downtime.

iii. Enhanced Grid Management: 5G enabled Smart Grid solutions can reduce transmission and distribution losses, peak load management and improve QoS, reliability & integration with renewable energy sources. Ultra-low latency can help automate power flow switching, load management and voltage stabilization.

iv.   Improved Customer Engagement: 5G technology will enable smart utilities to provide customers with more information and control over their energy and water consumption, improving customer engagement and satisfaction.

v.   New Business Models: 5G technology will enable the creation of new business models and services, such as demand response, time-of-use

pricing, and virtual power plants, which can help improve the efficiency and reliability of the energy grid while reducing costs.

H. Smart Cities

2.35. Smart cities are urban areas that use information and communication technologies to enhance the quality of life, efficiency of services and sustainability of resources. The 5G-based ubiquitous sensor network will become the cornerstone of smart city and one of the key infrastructures for the Internet of Everything, where people, machines, and things become deeply integrated. Featuring ultra-high speed, ultra-low latency and massive connectivity, 5G will provide all-round support to the innovation and development of smart city with the help of following use cases:

i. *Smart Transportation* - 5G can enable vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, which can provide real-time information and alerts to drivers and pedestrians about traffic conditions, road hazards, collisions and other emergencies. 5G can also support advanced driver assistance systems (ADAS) and autonomous driving, which can reduce human errors and improve driving performance. 5G can enable traffic monitoring and control systems, which can collect and analyze data from various sources such as sensors, cameras, drones and vehicles. 5G can also enable dynamic traffic routing and optimization, which can adjust traffic signals and lanes according to the traffic demand and situation. 5G can also support smart parking solutions, which can help drivers find available parking spaces and pay for them conveniently. 5G can support wireless charging and battery management for EVs, which can extend their range and lifespan.

ii. *Smart Security* – 5G will enable facial recognition, biometric authentication, video surveillance and blockchain that can enhance the safety, privacy and trust of citizens and businesses. 5G can support high-resolution video streaming from thousands of cameras and sensors across

a city, providing a comprehensive and dynamic view of the situation. AI can analyze the video data and alert the authorities of any suspicious or abnormal activities, such as violence, vandalism, or traffic accidents.

iii. Smart emergency response: 5G can facilitate the coordination and communication between different emergency services, such as police, fire, and medical teams. 5G can also enable remote diagnosis and treatment of injured people using telemedicine and wearable devices.

iv. *Smart Waste management* - Waste management is one of the major challenges faced by urban areas around the world. The traditional methods of waste collection and disposal are inefficient, costly, and harmful to the environment and public health. To address this problem, smart waste management has emerged as a promising solution that leverages IoT and 5G technologies to optimize waste management processes and improve service quality. Smart waste management involves using IoT-enabled smart waste sensors that are attached to waste bins or containers. These sensors can monitor the fill level, weight, temperature, and location of the waste, and transmit this data to a cloud-based platform via 5G networks. The platform can then analyze the data and provide real-time information and insights to waste management operators, such as optimal collection routes, schedules, and frequencies, based on factors such as traffic conditions, weather, and demand patterns. Smart waste management can bring multiple benefits to cities, such as reducing operational costs, increasing efficiency and productivity, enhancing environmental sustainability, improving public health and safety, and creating new business opportunities and revenue streams. Some examples of cities that have implemented or are planning to implement smart waste management using 5G are Singapore, Fukuoka, San Diego, Vienna, and Brisbane.

v. *Environmental Monitoring and Pollution Control* – Environmental monitoring and pollution control are essential tasks for ensuring the health and well-being of humans and ecosystems. By leveraging 5G

technology, environmental monitoring and pollution control can achieve higher levels of accuracy, granularity, scalability, and automation. 5G can enable the deployment of high-resolution sensors on satellites, drones, balloons, or vehicles to collect real-time data on air quality, water quality, land use, biodiversity, climate change, and natural disasters. The processing and analysis of large volumes of environmental data can be done at the edge of the network, improving the speed, accuracy, and security of environmental decision-making. Meaningful insights from complex environmental data can be extracted using AI to detect anomalies and patterns, predict future scenarios and trends, and provide recommendations and solutions.

V. Need of Collaboration based approach or Ecosystem for 5G

2.36. In Ecosystem strategy multiple stakeholders join hands for development of some technology or service. They are interdependent on other players and work in a coherent manner for providing solutions to users and customers. 5G promises to empower digitalization of many verticals, and for the sake of making it a success for all its stakeholders, applying ecosystem thinking can be a very powerful means. A telecom service provider can provide 5G service which co-exists with Information Technology (IT) service, system integration, software, and cloud services. When entering the industry verticals' domain, providers of 5G services could collaborate with domain specific providers.

2.37. A collaboration-based approach or ecosystem has several advantages:

i. It fosters innovation and creativity by allowing the various domain experts to leverage their respective strengths and capabilities, such as cloud computing, edge computing, artificial intelligence, and network slicing.

ii. It reduces costs and risks by sharing resources, expertise, and responsibilities among the partners, as well as by creating economies of scale and scope.

iii. It enhances customer satisfaction by offering customized and differentiated solutions that meet the diverse and dynamic needs of various segments and industry verticals.

iv. It supports social and environmental sustainability by promoting the development and deployment of cost-effective, energy-efficient, and secure 5G products and solutions.

2.38. Hence, the cross-sector collaboration in a 5G ecosystem will be required for (a) 5G network provisioning / deployment and (b) adoption of 5G use cases in different industry verticals. The 5G network deployment ecosystem includes all necessary providers, operators and suppliers needed to deliver 5G services to the customers. Similarly, the 5G use case ecosystems are composed of other players that assume roles necessary to develop and adopt 5G use cases. Manufacturing, Healthcare, Education and Automotive sectors are some of the industry verticals of 5G use cases ecosystem. Both these ecosystems and the associated challenges have been discussed in detail in the following sections.

VI. Ecosystem for 5G network Deployment

2.39. As discussed earlier, 5G is not just expected to enhance the mobile broadband capacity but will also improve reliability and latency in the network giving rise to innovative use cases in the long term. In traditional telecom markets, the network and service provisioning roles have been performed by the TSPs being those Mobile and/or Fixed-network Infrastructure Providers. While established TSPs can undoubtedly play a key role in the 5G provisioning business at initial stages, the assumption of the complete end-to-end (E2E) 5G provisioning solely by them may not be practical to be followed throughout all stages of 5G deployment. At some point 5G deployment ecosystems can emerge in various formulations, expectedly with the TSPs maintaining the core service provisioning and sharing of some activities and roles with other stakeholders. In fact, 5G provisioning needs an ecosystem approach,

rather than working in siloes, where TSPs need to partner with other industry stakeholders. Examples of such partnerships or collaborations along with practices being followed in the global marketplace and way forward are discussed in the following sections.

2.40. Cross-sector collaboration for infrastructure creation could either be in the beginning of the infrastructure development itself or at later stage by leveraging the existing assets of other sectors such as Power, cable TV, Road transport authorities, Railways, Metro Rail etc., which will provide improved connectivity, affordability, and sustainability. A clear roadmap is required for cross-sector infrastructure sharing along with setting up of an institutional framework to build synergies among these infrastructure sectors.

2.41. In the telecom sector, collaboration is not a new phenomenon. It has proven its worth when there was need of more towers to provide 3G services and the TSPs started collaborating within the sector for infrastructure co-creation and sharing. Independent infrastructure providers created towers and ducts that were shared and used by multiple TSPs. Now the outlook needs to shift from within the sector to collaboration with cross-sectoral partners like Smart Cities, City Municipalities, Airport/Port owners, DISCOMs etc. to use their street furniture for network deployment. Collaboration models involving state, local bodies and private sector are necessary for provisioning infrastructure in municipalities, rural areas and national highways for speedy rollout of 5G access and backhaul networks.

2.42. As there will be hundreds of thousands of small cells to be deployed on the available street furniture, ensuring power supply to the installed equipment in a cost-effective manner will be another challenging task. In addition to this, the administrative difficulty in applying for permission for individual street furniture is also an area of concern. To address this a

mechanism for simplified bulk approval is required to be developed. Most of the street furniture are established and owned by the electricity authorities only and therefore the rental, RoW charges and approval of permission for using street furniture shall fall in their jurisdiction. Cross-sector collaboration between the Telecom and Power sectors will be required along with intervention from Telecom Regulator and Electricity Regulator to resolve this issue of power supply at site for 5G small cells. The initiatives taken by TRAI and Government for establishing and encouraging such collaborations are discussed in the following sections.

A. Initiatives taken by TRAI

2.43.   TRAI has taken initiative for cross-sectoral collaboration between the Telecom and Power sectors. At the behest of TRAI, Forum of India Regulators (FOIR) had constituted a working group on Cross Sector Collaborative Regulation for rolling out the 5G network in the country using the transmission and distribution network of power utilities. The FOIR Working Group has a representation of Telecom Regulatory Authority of India (TRAI), Central Electricity Regulatory Commission (CERC), State Electricity Regulatory Commissions (SERCs), Distribution Companies (DISCOMs), Telecom licensees, Infrastructure Providers category- I (IP-I) and had a provision to co-opt experts from other organizations as well. The working group submitted its recommendations on cross sector collaboration for Aerial/underground fiber deployment, 5G Small Cells deployment, smart metering, smart grid monitoring and on issues related to rapid infrastructure creation and faster rollout of 5G services. The report of the subgroup was discussed in FOIR and also in the Forum of Regulators (FOR) which resulted in identification of action points including SERCs regulations on revenue sharing between DISCOMs and consumers for income other than core business; single bill for multiple connections issued to the telecom service provider and

payment for all the commutative bills at one go, separate tariff slab for energy consumed by the telecom service providers.

2.44.   TRAI has taken an initiative to form a Joint Committee of Regulators (JCOR) consisting of Telecom Regulatory Authority of India (TRAI), Reserve Bank of India (RBI), Securities & Exchanges Board of India (SEBI) and Ministry of Consumer Affairs (MoCA) to study future regulatory implications in the digital financial world and to collaboratively work on future regulations. The JCOR is working on various cross sectoral issues of Telecom and Financial sector including framing of joint action plan to curb financial frauds using Telecom resources. Representatives from Ministry of Home Affairs and Department of Telecommunications also regularly participate in the JCOR meetings and apprises the committee about the ongoing regulatory challenges. The committee tracks how regulatory frameworks are evolving in the digital economy and dives deep into policy trends.

2.45.   Countries need to recognize that they need to transition away from regulatory interventions and policies discussed and implemented in silos within one agency or ministry. Going forward, regulatory and policy development frameworks should be implemented cross-sectionally in a collaborative fashion. Recognizing its importance, the International Telecommunication Union (ITU) has been advocating in the past years the need to implement a new approach to ICT regulation, labelled fifth generation collaborative regulation. The underlying premise of such an approach is the need for countries to migrate to a regulatory and policy framework based on the collaboration among multiple sectors. In this context, ITU has developed G5 benchmark index to measure how countries transition to a holistic digital collaborative regulation and policy making in the digital economy. Due to the regulatory initiatives taken in India, it has been categorized as a country having advanced stage of

collaborative regulation in the G5 benchmark index, which is the highest category.

2.46. For the deployment of Small Cells using street furniture, TRAI initiated four pilot projects[19] one each covering a Port, Airport, Metro line and a congested city area in a smart city. These pilots have been carried out at Deendayal Port Kandla, Delhi International Airport, Nama Metro Bengaluru, and Smart City Bhopal. The objective of these pilot projects was to understand and analyze the technical and logistical challenges in future deployment of small cells over street furniture and to ensure complete synergy among all stakeholders. Based on learnings from these pilots and further consultations, TRAI has issued comprehensive recommendations dated 29th November 2022 on "USE OF STREET FURNITURE FOR SMALL CELL AND AERIAL FIBER DEPLOYMENT". The emphasis of these recommendations is to create a regulatory framework which facilitates collaboration and participation among various departments, central and state agencies, local bodies, and service providers to ensure successful and rapid rollout of small cells and optical fiber using street furniture.

2.47. The Authority has time and again emphasised the need of cross sector collaboration through various recommendations. For example, for creation of centralised National Portal for RoW permissions to facilitate expeditious rollout of telecom and other essential utilities infrastructure, through its recommendations on 'Roadmap to Promote Broadband Connectivity and Enhanced Broadband Speed'[20] dated 31.08.2021, the Authority has recommended that:

"*wherever Appropriate Authorities, i.e. different Central Government Departments, States, Union Territories, Local Authorities and their agencies,*

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[19] https://trai.gov.in/sites/default/files/Pilot_Report_29112022.pdf
[20] https://trai.gov.in/sites/default/files/Recommendations_31082021.pdf

have already established the web based portals for grant of RoW permissions, the same should be integrated with the proposed national portal for RoW permissions."

2.48. Based on the above Recommendations, "GatiShakti Sanchar Portal"[21] has been launched. This portal is a collaborative institutional mechanism between all stakeholders including Central and State/UT Government(s), Local bodies, and Service Providers to facilitate the Right of Way (RoW) Application Process through a single interface. The GatiShakti Sanchar Portal is also integrated with the Ministry of Railways, Ministry of Road, Transport & Highways, and Ministry of Defence. Shortly, it will be integrated with the Ministry of Environment, Forest, and Climate Change.

2.49. To further strengthen this collaborative initiative, the Authority in its recommendations dated 29th November 2022 on "Use of Street Furniture for small cell and aerial fiber deployment" has reiterated its earlier recommendations dated 31.08.2022 to expand this portal to integrate other utility providers also like water, electricity, gas. TRAI has also received a reference from DoT for auction of E and V bands for backhaul and currently working on it. Radio waves in E band, which falls in 71-76 GHz and 81-86 GHz, and V band, that is 57-64 GHz, can transmit data at very high speeds, and very much suitable for 5G backhaul.

2.50. The Authority in its Recommendations dated 20th February 2023[22] on "Rating of Buildings or Areas for Digital Connectivity" has recommended a collaborative approach, wherein the Central Government may work with State Governments/ UTs for incorporation of suitable provisions for Digital Connectivity Infrastructure (DCI) development in the respective bye-laws or other relevant laws of the State Governments/ UTs. In the same recommendations, establishment of Council of DCI (CoDCI) has also

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[21] https://gatishaktisanchar.gov.in/
[22] https://trai.gov.in/sites/default/files/Recommendation_22032023.pdf

been suggested under the Department of Telecommunications (DoT), in collaboration with the Ministry of Housing and Urban Affairs (MoHUA), All India Council for Technical Education (AICTE), National Skill Development Council (NSDC), Telecom Sector Skill Council (TSSC), and Construction Skill Development Council (CSDC) or any other organisation/institution as deemed appropriate. The CoDCI shall be responsible for taking all decisions in respect of certification, registration and capacity building of DCI Professionals.

B. Initiatives taken by Government

2.51. The Government has taken several initiatives for digital infrastructure development in the recent past as enumerated below:

i. USOF initiatives like BharatNet project has been rolled out to provide nationwide digital connectivity infrastructure in rural areas. Under BharatNet program, 1,91,000 Gram Panchayats (cluster of villages) have been covered and 104,600 Public Wi-Fi hotspots have been installed for universal connectivity.

ii. Mobile services in uncovered villages in North-eastern Region (NER) and Border Areas, 4G mobile saturation in remote and rural India and Island connectivity through submarine OFC has helped in provision of quality and affordable mobile and digital services across the rural and remote areas of the country.

iii. To ensure ease of doing business and creation of infrastructure at lower costs, a Centralized National Portal for obtaining Right of Way (RoW) called "GatiShakti Sanchar" Portal for cable laying and tower installation has been started. States and other central ministries are also integrated with this portal.

iv. Street furniture has been included in RoW portal for faster 5G rollout.

v. Sharing of Active and Passive Infrastructure among Service Providers have been permitted to enable them to expand their network coverage and improve the quality of service, while reducing capital expenditure and operating costs, especially in remote and rural areas.

vi. For improved security of network, a mechanism has been established to procure equipment from Trusted Source only. With robust cyber security measures, India ranked 10th in ITU's Global Cybersecurity Index (GCI).

viii. USOF has also launched Telecom Technology Development Fund (TTDF) Scheme in October 2022, which aims to fund R&D in rural-specific communication technology applications and form synergies among academia, start-ups, research institutes, and the industry to build and develop the telecom ecosystem. Additionally, the Scheme aims to promote technology ownership and indigenous manufacturing, create a culture of technology co-innovation, reduce imports, boost export opportunities and creation of Intellectual Property.

VII. Ecosystem for 5G Use Cases

2.52.   5G technology holds the potential to enable unprecedented degrees of flexibility, productivity, and efficiency in various industry verticals. The potential of 5G, combined with AI, AR/VR, smart platforms and IoT, can deliver enormous value to consumers, organizations, and the society at large. It will also pave the way for developing services for making smart cities, autonomous vehicles, smart factories, etc. Thus, 5G vision extends beyond mobile broadband connectivity and provides an opportunity to Telecom Service Providers (TSPs) to transform themselves into a Digital Service Provider. Telecom industry has been transitioning from different generations of mobile technologies since last few decades and has been pivoting from voice to content to commerce and industrial applications. However, to realise the true potential of 5G beyond the eMBB use cases,

the ICT industry and all the vertical industries must come together as an ecosystem for development and deployment of mature use cases.

2.53. The core competency of TSPs today is in providing network connectivity. To realise the potential benefits of 5G, the network needs to transform into a digital platform and be delivered as a service in the digital marketplace. Most of the implementations of 5G use cases will be brownfield implementations where the 5G solution needs to seamlessly integrate with existing business processes, IT systems and operational technologies. TSPs will need to adopt an ecosystem and build trusted and strategic partnerships with other ecosystem players for faster and mass-scale adoption of 5G use cases. Mobile operators are collaborating with vendors and enterprises across different verticals to develop and deploy 5G use cases for industry. Some such collaborations happening across the globe are discussed below.

A. International Experience:

2.54. Mobile operators are collaborating with vendors and enterprises across different verticals to explore the potential of 5G stand-alone (SA) network. For example, SoftBank and Honda are working together to test the effectiveness of using 5G SA and a cellular vehicle-to-everything (C-V2X) system to reduce collisions between pedestrians and vehicles. In **Spain**, Telefónica has announced plans to target three enterprise 5G use cases for its 5G SA network. They are automated guided robot vehicles for use in places such as warehouses; remote maintenance systems using technology such as smart glasses; and drones for site surveillance.[23]

2.55. **South Korea**'s 5G ecosystem brought together government ministries, legislative bodies, telecom operators, vendors, research institutes and

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[23] GSMA Mobile Economy 2022 report

other stakeholders such as trade unions, civil society groups at the very early stages of the 5G buildout. This led to an environment of cooperation and tremendous technology breakthroughs and cost benefits. Future technologies were tested in an evolved beta market, technology standards were established, and a strong market adoption strategy was created well in advance of the commercialisation. Subsequently, telecom operators in South Korea introduced 5G-powered services and each operator offered unique content and experience use cases. Some of them included:

i. South Korean Telecom's TReal and eSpace have built platforms where baseball fans can access real-time data and stats by pointing their smartphone camera at a baseball player. They can point a VR headset at the field and watch the game from eight different angles.

ii. LG U+ Idol Live that allows K-Pop fans to enjoy a concert as they would do in a real theatre.

iii. South Korean Telecom's 5G-AI Machine Vision, a smart factory solution that uploads high-resolution, multi-angle photos to a cloud server via a 5G router, instantly identifying defective products on a conveyor belt.

Applications like these have spiked the data consumption in the country and led to increased average revenue per user (ARPU).

2.56. **Singapore** has become the first country in the world to be fully covered by standalone 5G. The island nation now has achieved over 95% of 5G nationwide coverage. It has managed to achieve these three years ahead of scheduled target, which was by the end of 2025.[24] As part of its earlier 5G innovation efforts, IMDA supported seven 5G innovation use-cases in strategic areas such as cloud gaming, urban mobility, smart estates, industry 4.0 and maritime operations. In 2019, IMDA has partnered with

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[24] https://techwireasia.com/2022/07/singapore-is-first-in-the-world-for-nationwide-5g-coverage

the Maritime & Port Authority of Singapore ("MPA") and PSA[25] Singapore, to test and commercialize maritime 5G use cases, starting with the remote pilotage of vessels that are entering the port of Singapore. This will significantly enhance service efficiency, improve resource utilisation and transform the role of a harbour pilot from a physically demanding job to remote operations while enhancing safety. Other maritime 5G use cases include shore-to-ship delivery, where drones can send critical components to vessels out at sea instead of having ships dock at the berth for urgent inspections and repairs.[26]

2.57.   In **Hong Kong**, HKT, one of the leading telecom operator in the country, is working with enterprises to integrate different technologies like 5G, AI and cloud computing to help them transform their operations. For example:

i.   HKT is working on a wide range of smart campus and smart building projects. These require a building to be equipped with 5G enabled sensors to detect and regulate temperature, humidity, lighting, appliances and air quality and also AI-based energy saving algorithms to help buildings minimise energy usage.

ii.   HKT provides end-to-end services to accelerate enterprise digital transformation – from consulting and solution design to project implementation and delivery. Their Enterprise Managed Services also offer multi-skilled supports catering IT operations and end user support requests.

iii.   HKT is also maintaining a strong partnership with OEMs across many technology domains, including fibre networks, 4G and 5G networks, and for enterprise services such as cloud, storage, networking and Wi-Fi. They

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[25] Container transhipment hub
[26]https://www.imda.gov.sg/Content-and-News/Press-Releases-and-Speeches/Press-Releases/2021/Singapore-accelerates-5G-adoption-and-commercialisation-with-new-30m-fund

are working together to co-create products and services like a 5G solution integrated with Wi-Fi, Bluetooth and an IoT connectivity platform.

2.58. **Australia** is a global leader in 5G rollout. By the end of 2021, Australia's Mobile Network Operators (MNOs) had installed around 4,000 operational 5G base stations across the country. 5G innovation has accelerated in Australia due to collaborations and co-investments between companies and across industries. Telstra recently collaborated with Ericsson and Microsoft to begin 5G-enabled edge compute trials earlier this year.[27] Similarly, Australian technology companies M2M Connectivity and ARQ Group formed a partnership to deliver digital twin technology for mining companies looking to use 5G to increase production efficiency and lower operational costs.[28]

2.59. There are several such examples of telecom operators showcasing and developing the 5G use cases for industries[29], like

   i. one such 5G use case is the "Alba Iulia Smart City", which has been developed in collaboration with Orange, and has seen congestion monitoring, parking sensors, and smart waste management introduced in the Romanian city.

   ii. O2 has also now announced a project to trial driverless cars in London using its 5G network. The UK's second-biggest phone network has partnered with the Smart Mobility Living Lab - a research organisation comprised of experts from the Transport Research Laboratory (TRL), DG Cities, Cisco, and Loughborough University - to develop what it claims to be the 'most advanced driverless testbed in the world'.

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[27] Telstra collaborates with Ericsson to begin 5G-enabled edge trials
[28] M2M and ARQ target mining sector with 5G-ready technology (m2mconnectivity.com.au)
[29] 5G use cases: 31 examples that showcase what 5G is capable of | 5Gradar

iii. At the Consumer Electronics Show in January 2020, Samsung and BMW showcased the companies' efforts in connected cars, revealing the 5G TCU (Telematics Control Unit). The TCU will be included in the BMW iNext.

iv. Huawei, in partnership with Thailand National Broadcasting and Telecommunication Commission (NBTC) and Siriraj Hospital, has launched a new project to use 5G-powered self-driving vehicles to deliver medical supplies.

v. Fox Sports has trialed 5G at golf's US Open with Intel, AT&T, and Ericsson allowing its team to broadcast the event, while 5G was used to capture some events at the 2018 Winter Olympics. Verizon and Sony have also joined hands to demonstrate how 5G can enhance live sports broadcasts.

vi. Irish startup Manna has partnered with Cubic Telecom to fly 5G-connected delivery drones in Ireland and England.

vii. In the US, mobile network Verizon has partnered with specialist glass maker Corning, the maker of Corning Gorilla Glass, to investigate how 5G can improve the factory environment.

viii. 5G has even made its way into the operation theatre, when Telefónica, with the help of a hospital in Malaga, already presented the first assistance system for surgery that runs entirely on 5G technology. The showcase took place at the IV Advanced Digestive Endoscopy Conference, where Telefónica broadcasted medical training sessions live, and in 4K quality. It achieved this with "almost no latency".

ix. Centrica Storage and Vodafone have entered a partnership that will build the "gas plant of the future" at their Easington site, providing a 5G-ready mobile private network (MPN) for the facility, which will be the first of its kind in the UK's oil and gas sector.

x. Hyperbat, one of the UK's largest independent vehicle battery manufacturers, has partnered with BT, Ericsson and NVIDIA to create 'digital twins' of products. It will enable remote teams to connect, collaborate, and interact using a virtual 3D engineering model. This digital twin project will be a world-first, which will allow design and engineering teams to walk around, and interact with, a 3D life-size model in real time.

xi. AeroFarms, a global leader in indoor vertical farming and Nokia Bell Labs have partnered to combine their expertise and expand their joint capabilities in cutting-edge networking, autonomous systems, and integrated machine vision and machine learning technologies. This partnership is expected to further enhance its capabilities as an industry-leading operator of world-class, fully connected smart vertical farms that grow the highest quality plants all year round.

B. Initiatives taken in India:

2.60. The Department of Telecommunications launched "5G Hackathon" in collaboration with MeitY, NITI Aayog, Start-up India and other stakeholders to identify and promote India specific 5G use cases in different industry verticals like Healthcare, Education, Governance, Banking, Finance, Insurance, Cyber Security, Enterprise transformation, Industry 4.0, Agriculture, Livestock, Smart Cities & Infrastructure etc. The main objective of the "5G Hackathon" was to bring all the players together in the ecosystem such as tech companies, mobile operators, manufacturers, developers to work together and convert their ideas into workable products and solutions. During phase 1 of 5G Hackathon, 100 best ideas have been selected in different sectors mentioned above. These 100 selected applicants were awarded Rs. 1.0 Lakh each. Thereafter the 5G Hackathon entered into phase 2, wherein these ideas were converted into workable products and services under the mentorship of Industry and

academia and 30 best products have been selected and awarded in Phase 2 on which the further progress is being made.

2.61. The Authority in its recommendations dated 11th April 2022 on "Auction of Spectrum in frequency bands identified for IMT/5G" had recommended formation of a 5G-dedicated Inter-Ministerial Working Group (IMWG), under the Chairmanship of Member (Technology), DoT comprising Ministry of Electronics and Information Technology, Department for Promotion of Industry and Internal Trade, Ministry of Information and Broadcasting, Department of Space, Ministry of Finance, Ministry of Education, Department of Science & Technology, Ministry of Micro, Small and Medium Enterprises (MSME) and Niti Ayog. A digital cell comprising of these ministries was recommended with dedicated technical manpower to formulate the use of digital technologies like 5G, IoT, M2M, AI etc. and development of relevant and affordable sector-specific use cases involving start-up companies, entrepreneurs, application providers etc.

Inter-ministerial Collaboration for 5G use case test labs

2.62. Government of India is setting up 100 test labs in collaboration with 14 other ministries and departments to explore 5G use cases for the respective industry verticals leveraging communication technologies such as 5G/4G-Adv and IoT. The 14 ministries taking part in the 5G use case test labs are: Ministry of Mines, Ministry of Power, Ministry of Agriculture, Ministry of Education, Ministry of Urban Development, Ministry of Railways, Ministry of Road Transport and Highways, Department of Water, Ministry of Tourism, Ministry of Heavy Industries, Ministry of Health and Family Welfare, Ministry of Housing and Urban Administration, Ministry Electronics and IT, and the Department of Science and Technology. The following use cases have been identified for time-being:

i. For Ministry of Housing & Urban Affairs, where the role of ICT will be explored in the smart cities mission;

ii. For Ministry of Power, where use cases of smart grids and smart metering will be explored for the National Smart Grid Mission;

iii. For Ministry of Education the role of ICTs to further expand the New Education Policy will be discussed;

iv. For Ministry of Jal Shakthi (water resources), use cases for water conservation, augmentation & preservation, smart water & sewage management will be looked at; and

v. For Ministry of Railways- Rail-Track Safety, Trackside Systems -video analytics, Intelligent Transport, Collision avoidance, Freight Management/Asset tracking will be explored.

2.63. The expected outcomes are possible collaborations among stakeholders (solution providers, user agencies, OEMs) to conduct pilots for reasonably matured use cases. The ministries in collaboration with the Ministry of Communications will work on ideas, technologies, prototyping, fine-tuning of use cases identified by the Vertical Ministry. However, looking at the initiatives being taken globally, it appears that a more comprehensive approach is required to study the prospects of 5G use cases in India covering the technical, regulatory, policy, and socio-economic aspects by engaging relevant stakeholders from different sectors. Hence, the issues which stakeholders need to deliberate upon are as follows:

Q.1. Is there a need for additional measures to further strengthen the cross-sector collaboration for development and adoption of 5G use cases in India? If answer is yes, please submit your suggestions with reasons and justifications. Please also provide the best practices and lessons learnt from other countries and India to support your comments.

Q.2. Do you anticipate any barriers in development of ecosystem for 5G use cases, which need to be addressed? If yes, please identify those barriers and suggest the possible policy and regulatory interventions including incentives to overcome such barriers. Please also provide

the details of the measures taken by other countries to remove such barriers.

2.64.   India being a developing nation, the primary challenge in implementing 5G use cases in sectors like, Agriculture, Healthcare, Education etc. is addressing the digital divide, creating awareness, and ensuring that citizens in rural and remote areas have access to the necessary technology and infrastructure to adopt these use cases. At the same time, they need to be convinced that adoption of these use cases will make their job easier and more efficient. They need to be aware of the benefits and risks such as improved efficiency, convenience, and quality of life, as well as data breaches, cyberattacks, and ethical issues. Policymakers should aim to invest in providing the infrastructure, capacity building and awareness programmes for creating awareness among the citizens and provide a conducive environment for adoption and promotion of these use cases. In view of the above, the question arises is:

Q.3.   What are the policy measures required to create awareness and promote use of 5G technology and its infrastructure so that the citizens including those residing in rural and remote areas may benefit from the 5G use cases and services to create new economic activities and increase employment opportunities and thereby promote economic growth of the country?

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Chapter – 3

5G ENABLED IOT: OPPORTUNITIES AND CHALLENGES

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I. Introduction

3.1   The Internet of Things (IoT) is a paradigm that has been gaining traction in recent years, fuelled by the rapid advancements in communication technologies, particularly 5G. It refers to the interconnected network of physical devices, vehicles, appliances, and other items embedded with sensors, software, and network connectivity that enables them to collect, exchange, and analyze data. IoT technologies have the potential to transform various sectors and improve the quality of life of citizens. However, the effective implementation and propagation of these technologies face several policy challenges that need to be addressed.

3.2   One of the key areas where IoT technologies have been making significant strides is in smart cities. Smart cities leverage IoT devices to facilitate intelligent traffic management, waste management, public safety, energy efficiency, and smart parking, among other applications. IoT devices can collect data from various sources, such as sensors embedded in roads, buildings, and public infrastructure, and use this data to make informed decisions that improve the overall functioning of the city. In addition, IoT technologies can help to reduce the environmental footprint of urban areas by optimizing energy consumption and promoting the efficient use of resources.[30]

3.3   In the healthcare sector, IoT technologies can revolutionize patient care by enabling remote patient monitoring, telemedicine, and smart medical

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[30] Drepaul, Nicole A. "Sustainable Cities and the Internet of Things (IOT) Technology: IOT Technology Improves the Development of Smart Cities' Infrastructures and Reduces over-population Stresses." *Consilience*, no. 22, 2020, pp. 39–47. *JSTOR*, https://www.jstor.org/stable/26924960. Accessed 12 Apr. 2023.

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devices. Through connected wearables and sensors, healthcare professionals can monitor patients' vital signs, track medication adherence, and provide personalized care even from a distance. IoT technologies can also play a pivotal role in agriculture by enabling precision farming, livestock monitoring, and smart irrigation systems. Farmers can use IoT devices to collect real-time data on weather conditions, soil moisture, and nutrient levels, allowing them to make informed decisions about when and how to plant, fertilize, and irrigate their crops.

3.4   Despite the numerous benefits and potential applications of IoT technologies, several policy challenges must be addressed to ensure their effective implementation and propagation. One of the most significant challenges is ensuring the privacy and security of the vast amount of data generated and transmitted by IoT devices. Interoperability and standardization are also crucial policy challenges that must be addressed to facilitate the effective implementation and propagation of IoT technologies. Moreover, the rapid deployment of IoT technologies can have significant implications for the labour market, as automation and increased efficiency may lead to job displacement in certain sectors. Finally, ethical considerations must also be kept in mind when implementing and propagating IoT technologies.

3.5   The advent of 5G technology has been a game-changer for numerous sectors enabling faster, more reliable, and efficient Internet of Things (IoT) applications. These applications span a wide range of industries, including smart cities and infrastructure, Industry 4.0 and smart manufacturing, healthcare and remote patient monitoring, smart homes and buildings, and agriculture and precision farming. IoT enabled applications hold tremendous potential to transform various sectors and improve the quality of life for citizens. However, to ensure the effective implementation and propagation of these technologies, regulators and policymakers need to address a range of policy challenges, including data privacy and security,

spectrum management, interoperability and standardization, environmental impact, workforce displacement, and ethical considerations. By proactively addressing these challenges and fostering collaboration between stakeholders, the responsible and sustainable growth of the IoT ecosystem can be ensured and its full potential can be unlocked for the betterment of society.

II.   IoT Use Cases across Industry Verticals

3.6   According to a report by Statista, IoT technology holds significant potential across industries. The study predicts that there will be around 50 billion IoT devices connected by 2030. As the IoT continues to unroll globally and spread across sectors, some industries are leading investments in this revolutionary technology, changing how we live and work.

A.   Healthcare

3.7   The pandemic made Healthcare professionals and patients realise the importance of digital healthcare technologies firsthand. A report by S&P Global found that telehealth patient volumes increased by almost 4,000% in the year 2020 by June. This growing acceptance suggests that digital telehealth is here to stay. 5G connectivity will take it to the next level. High speed and ubiquitous, 5G will give medical professionals the ability to provide round the clock care to patients in hazardous or remote areas. Wearable monitors will be used to track patients' vital signs. And in the process, patients will be able to get away from the need for time-consuming in-person hospital appointments and consultations. There should be considerable cost reduction. According to eMarketer, 5G could save the healthcare industry $600 million in 2021—with annual global savings reaching nearly $94 billion by 2030.

3.8   Further ahead, there is the prospect of even more dramatic interventions like remote surgery. The first experiments have already happened. In Birmingham UK, a doctor used a zero-latency 5G connection to perform a procedure. The clinician viewed the patient through a VR headset to guide

a paramedic through the process with haptic glove technology. Elsewhere, even more ambitious projects are underway. In Korea, KT Corporation and Samsung Medical Centre are building a 5G private network to enable a 'smart hospital'. It will provide support for digital diagnostics, surgical education, AI-enabled care for inpatients, and even an autonomous robot for an operating room. The two companies say the delivery robot can remove contaminated materials and bring in surgery supplies. This will reduce the risk of infection. 5G-enabled connectivity will enable the robot to exchange data with minimal latency.

B. Education

3.9 India is an emerging player in the global education industry, with one of the world's largest networks of higher education institutions. With this exponential growth, the market size of the education industry was about 117 billion U.S. dollars across India in financial year 2020, which is estimated to rise to 225 billion U.S. dollars by financial year 2025 in the country.[31] The IoT is transforming the education sector and enabling educational institutions to become Wi-Fi-enabled smart learning environments. IoT allows educational institutes to increase safety in campuses, improve the quality of education, saves teachers from the tremendous paperwork, and keep track of enrolments.

3.10 Smart technology has the potential to make schools safer. Facial recognition analytics through well-featured CCTVs, for example, can track students' entry and exit from the classroom and school grounds. This measure also helps to keep intruders and other unauthorised individuals out of schools. Furthermore, smarter security cameras can be relied upon to monitor hallways and building perimeters in order to keep students safe and ensure a safe learning environment for them. Educational institutions can provide substantial levels of security by connecting everything from

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[31] https://www.statista.com/statistics/1286064/india-education-industry-market-size/

security cameras to school buses that enable real-time information sharing and quick emergency response.

3.11   IoT can also help in conserving energy in educational institutions and thereby addressing the global warming concerns. Installing sensors and actuators in taps and lights can automatically switch them off in the absence of human beings. RFID tags in students ID cards can record attendance of students daily. IoT can also be helpful in monitoring the health of students and staff. IoT also helps in storing information such as blood pressure, medical history, allergies, prescription details to take necessary treatment in case of an unfortunate accident.

3.12   Smartboards have made learning interactive by projecting images. Words and numbers on textbooks and blackboards do not explain the concepts as easily as smartboards. Consequently, IoT training is also becoming a part of teachers' skills. IoT enabled smart devices make learning easier for students with sensory disabilities. For instance, they can convert verbal speech to sign language and vice versa. Similarly, transcripts convert voice to text, so that students with a hearing disability can read out the notes, and text to voice helping blind students.

C.   Agriculture

3.13   Agriculture industry has always been very receptive to technical innovation. It has become quite technology-driven and industrialized by embracing the IoT. The growth of IoT use in Agriculture is seen from the report by Statista, which presents the worldwide IoT market size of the agriculture sector in 2018 as 14.79 billion USD. It is projected to reach almost 30 billion USD by 2030. The term Smart agriculture denotes the application of IoT solutions in agriculture. It uses IoT sensors to collect environmental and machine metrics. The data can help farmers to make informed decisions and improve just about every area of their work – from livestock to crop farming.

Use Cases of IoT in Agriculture

i. Smart Irrigation Systems – Smart irrigation systems use IoT sensors to monitor soil moisture levels and weather conditions, optimizing irrigation scheduling to conserve water and improve crop yields. For example, drip irrigation based on intelligent inputs has the potential for much greater efficiency and water conservation.

ii. Crop Monitoring and Precision Agriculture - IoT devices and sensors can be used to monitor crop health and environmental conditions, enabling farmers to make data-driven decisions about fertilization, pest control, and other agricultural practices.

iii. Agricultural Drones - Agricultural drones are equipped with sensors and cameras. They are used for imaging, mapping, and surveying farms. Drones can be used to collect aerial data on crop health and environmental conditions, providing farmers with valuable information for decision-making. Besides the surveillance capabilities, drones can perform a variety of tasks that previously required human labour like planting crops, fighting pests, agriculture spraying, crop monitoring, etc.

iv. Greenhouse Automation - Farmers usually use manual intervention to control the greenhouse environment. IoT sensors help them get accurate real-time information on greenhouse conditions like lighting, temperature, soil condition, and humidity.

v. Monitoring climate conditions - Weather stations combined with smart farming sensors collect data from the environment and send it to the cloud for analysis. It is further used to map the climate conditions, choose the right crops, and improve their capacity.

vi. Cattle monitoring - IoT-enabled livestock tracking and health monitoring systems allow farmers to monitor the location, health, and behaviour of their animals, improving animal welfare and farm productivity.

Thus, IoT, edge computing, blockchain, machine learning, robotics and drones are helping farmers unlock new efficiencies, eliminate waste and develop new ways to track commodities from the farm to the market.

3.14   Behind all of these impactful applications and use cases is, of course, 5G technology. For farmers, the particular benefit of 5G is its reach into remote areas. Rural areas will likely get a low band 5G, which will have less capacity but will extend into previously unserved areas. It will still have very low latency and be able to connect massive networks of industrial sensors. This will give farmers the ability to monitor remote livestock and crops constantly and in real time, without the need to physically visit. Meanwhile the high data throughput of 5G will enable a different set of benefits.

D.   Energy (Gas, Electricity)

3.15   As per an industry report[32], the global value of IoT in the Energy market was 20.2 billion USD in 2020. It is expected to increase to 35.2 billion USD by 2025. IoT has started revolutionizing most aspects of the Energy sector from generation to transmission to distribution and impacting how energy companies and customers interact. As per another report[33], IoT is deployed by **45%** of Energy companies to monitor asset performance and being used by **43%** of Energy companies to enhance customer experiences. **40%** of Energy companies have reported an overall boost in productivity with use of IoT. Smart grids, Resource optimisation, advanced automation, Remote assets monitoring and management, Process optimization, Grid balancing, disaster prevention, Smart decision making and Innovative power solutions are some of the IoT enabled use cases transforming the energy sector.

3.16   IoT sensors can monitor and control energy consumption and production in real time, reducing waste and costs. For example, smart thermostats can adjust the temperature based on occupancy and weather conditions, saving energy and improving comfort. IoT devices can enable the integration of renewable energy sources into the grid, creating

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[32] IoT in energy market size forecast 2020-2025 | Statista
[33] How IoT Is Impacting 7 Key Industries Today (forbes.com)

decentralized and resilient networks that can operate independently or in sync with the main grid. For example, smart meters can measure and communicate energy usage and generation, facilitating demand response and load balancing.

3.17   IoT devices can enhance the performance and security of the power grid, detecting and preventing faults, outages and cyberattacks. For example, smart transformers can monitor and regulate voltage, frequency and power quality, improving grid stability and efficiency. IoT devices can automate various processes and operations in the energy sector, such as data collection, analysis, decision making and action. For example, smart valves can regulate the flow of oil and gas based on sensor data, optimizing production and preventing leaks.

3.18   IoT based solutions can reduce hazards and increase safety for both workers and the power plants. Sensors installed all around the plant can notice any leakage or damage and can send alerts to a mobile application and the staff takes the necessary precautions. Instead of waiting for the plant to cause serious injuries and irreversible losses, IoT can notify the staff members beforehand of any risks. This helps in ensuring smooth running of processes and increase in safety.

E.   Industry 4.0 & Beyond

3.19   150 years ago, the manufacturing sector went through a sudden transformation; the production line was born. Before this, artisans used to make most products on their own. Mass production and assembly lines drastically improved the speed – and decreased the cost – of making everyday items. Today, again, manufacturing is on the brink of similar change because of IoT-enabled smart production, also known as Industry 4.0 or the industrial IoT. Currently, the manufacturing industry is the most prominent investor in the IoTs.

3.20   In this new age, a factory's traditionally linear systems become dynamic and interconnected. Smart machines work together to do much more than

merely physical work. Instead, they collect, share and analyse data in order to:

i. Keep track of products and assets - Factory managers are able to track parts as they move through the assembly process using smart sensors. This gives them a real-time view of stock situation and this visibility will extend across the entire supply chain. The Industrial IoT will give them potential access to real-time data from their transport and logistics partners.

ii. Monitor product quality - The addition of environmental sensors inside factories could help companies improve the quality of their goods. The sensors can send alerts when quality deteriorates below 'optimal'.

iii. Predictive maintenance - Machine downtimes are costly. With the clever use of sensor data, it is possible to detect when a machine is showing signs of malfunction before it ceases to work completely. This raises the prospect of proactive repair – also known as predictive maintenance resulting into reduced downtime, longer equipment life spans and safer factory environments.

3.21 With the addition of 5G always-on connectivity and miniature-embedded sensors, 'dumb' products can be provided with the ability to feed information back to the factory. This way, quality issues can be detected. More than that, the factory can learn about routes to market and customer choices – and then use these insights to make better products in the future. For example, in 2020 pharmaceutical company Bayer announced a printable NB-IoT-based tracking label, which costs just a few euros, to monitor its products through the supply chain.

F. **Automotive Sector**

3.22 The IoT in the automotive industry allows connected cars to stay in real-time communication with the surrounding connected ecosystem. This is making advanced innovations possible and steadily transforming the automotive industry in the following ways:

i. IoT-enabled in-vehicle infotainment systems provide services like music streaming, navigation, voice assistance, hands-free calling, etc.

ii. IoT solutions constantly monitor vehicle condition to predict potential issues. IoT sensors gather real-time data on fuel consumption, engine temperature, fluid levels, run time, etc. This data is then analyzed to detect pre-failure conditions and alert the driver in advance. This approach to maintenance, compared to traditional scheduled check-ups, can help avoid unnecessary expenses and save time and efforts while also helping prevent vehicle breakdowns.

iii. Integrated IoT sensors help connect cars and enable vehicle-to-vehicle (V2V) interaction. Cars can share relevant information like location, route, speed, etc. This feature helps prevent accidents and makes roads safer. In case of emergency, drivers of other cars in proximity may be notified to take preventive measures or slow down their car. V2V connection also helps emergency vehicles navigate through traffic.

iv. IoT enabled semi-autonomous vehicles can take partial control of driving, braking, parking, or lane changing. IoT solutions and integrated in-vehicle cameras help smart vehicles calculate the safest and most efficient course of action to provide driving assistance and reduce the likelihood of road accidents.

v. IoT enriches fleet management with new advanced functionality, making it more cost-efficient and reducing the need for manual operations. The IoT devices integrated into vehicles collect real-time data about vehicle speed, location, load, fuel consumption, driver behaviour, etc. Gaining insights from this data with the help of IoT analytics solutions, fleet management operators can automatically calculate the most optimal routes, monitor the driving habits of their employees, screen vehicle performance, and leverage predictive maintenance to avoid business disruptions.

G. Smart Cities

3.23 IoT can be used in many ways to make cities more efficient ranging from managing the traffic, controlling air pollution, handling waste management, creating smart buildings, planning for natural disasters, etc. An overview of the most popular use cases that are already implemented in smart cities across the globe has been provided below.

i. *Smart traffic management* uses different types of sensors, and fetch GPS data from drivers' smart phones to determine the number, location and the speed of vehicles. At the same time, smart traffic lights connected to a cloud management platform allow monitoring green light timings and automatically alter the lights based on current traffic situation to prevent congestion. Additionally, using historical data, smart solutions for traffic management can predict where the traffic could go and take measures to prevent potential congestion.

ii. *Smart parking solutions* uses GPS data from drivers' smartphones or road-surface sensors embedded in the ground on parking spots to determine whether the parking spots are occupied or available and create a real-time parking map. When the closest parking spot becomes free, drivers receive a notification and use the map on their phone to find a parking spot faster and easier instead of blindly driving around.

iii. *Connected Public transportation* employ IoT technology to improve the reliability, safety, and convenience of public transport by providing real-time information to passengers and operators about the location, schedule, and status of public transports.

iv. *Smart Waste management* solutions enabled by IoT help to optimize waste collecting schedules by tracking waste levels, as well as providing route optimization and operational analytics.

v. *Environmental monitoring solutions* allow tracking parameters critical for a healthy environment to maintain them at an optimal level. For example, to monitor water quality, a city can deploy a network of sensors across the water grid to measure the contamination level in the water supplied to the

citizens and connect them to a cloud management platform. When the contamination level reaches a certain threshold, the solution alerts maintenance teams, who then start fixing the issue. Similar information can be gathered with respect to the air quality also and recommendations can be made for the citizens.

vi. *Smart Public Safety* solutions offer real-time monitoring, analytics, and decision-making tools. Combining data from acoustic sensors and CCTV cameras deployed throughout the city with the data from social media feed and analyzing it, public safety solutions can predict potential crime scenes. This will allow the police to stop potential perpetrators or successfully track them.

III. Policy Challenges and Issues for Consultation

3.24 5G enabled IoT use cases hold tremendous potential to transform various sectors and improve the quality of life for citizens. These applications span a wide range of industries, including smart cities and infrastructure, Industry 4.0 and smart manufacturing, healthcare and remote patient monitoring, smart homes and buildings, and agriculture and precision farming. However, the widespread adoption of these applications comes with various policy challenges that need to be addressed. These policy challenges and issues for consultation with the stakeholders are discussed below.

A. Creating Awareness

3.25 The Internet of Things (IoT) is a rapidly evolving field that offers many opportunities and challenges for developers as well as users. IoT use cases in India are diverse and span across various domains such as agriculture, healthcare, education, smart cities, and more. However, to fully leverage the potential of IoT, there is a need of skill development for both developers and users. Developers need to acquire skills such as programming, data analysis, cloud computing, security, and device management to create effective and reliable IoT solutions. They also need to understand the specific requirements and constraints of different IoT use cases in India,

such as low bandwidth, power consumption, scalability, and interoperability.

3.26 India being a developing nation, the primary challenge in implementing IoT applications in sectors like, Agriculture, Healthcare, Education etc. is addressing the digital divide and ensuring that citizens in rural and remote areas have access to the necessary technology and infrastructure to adopt these systems. At the same time, they need to be convinced that these technologies are not going to affect their employment, but will make their job easier and more efficient. They need to be aware of the benefits and risks of IoT, such as improved efficiency, convenience, and quality of life, as well as data breaches, cyberattacks, and ethical issues. Policymakers should aim to invest in providing the infrastructure, capacity building and awareness programmes for upskilling of the citizens and provide a conducive environment for adoption and promote the use of these smart IoT enabled solutions.

In view of the above, the question arises is:

Q.4. What are the policy measures required to promote use of IoT technology and its infrastructure so that the citizens including those residing in rural and remote areas may benefit from these 5G enabled IoT smart applications and services to create new economic activities and increase employment opportunities and thereby promote economic growth of the country?

3.27 There is a need to create awareness among citizens about the benefits of IoT enabled smart applications and use cases in various industry verticals to ensure its adoption at large scale.

Q.5. What initiatives are required to be taken by the Government to spread awareness among the citizens about IoT enabled smart applications? Should the private companies / startups developing these applications need to be engaged in this exercise through some incentivization schemes?

B.   UpSkilling for Industry 4.0 & beyond

3.28   As Industry 4.0 model gains ground across manufacturing and service industries, the future is set to be greatly transformed. Characterised by the convergence of digital technologies cutting across the physical and digital worlds, Industry 4.0 will make many jobs and ways of working redundant while many others will be created afresh. But what separates Industry 4.0 from the previous revolutions is the unprecedented speed and spread of technological change. The skill sets that were in demand till a few years ago are now becoming obsolete. India's largest HR challenge is to upskill a large number of industrial employees to enable them to understand the benefits and consequences of adopting this use case.

3.29   Working persons in the industries must be provided opportunities to reskill or upskill for ascertaining that they remain relevant for the new roles in the age of automation. In such a scenario, the industry, academia, and the government need to play a bigger role in enabling the emergence of an Industry 4.0-compatible workforce. Such skilling initiatives can be fast-tracked via subsidies, tax incentives, and other supportive measures for MSMEs to acquire the requisite Industry 4.0 talent.

In view of above, the question arises is:

Q.6.   Industry 4.0 encompasses Artificial intelligence, Robotics, Big data, and the Internet of things and set to change the nature of jobs.

(a)   What measures would you suggest for upskilling the top management and owners of industries?

(b)   What measures would you suggest for upskilling the workforce of industries?

(c)   What kind of public private partnership models can be adopted for this upskilling task?

Please reply with proper justification and reasons and also by referring to the global best practices in this regard.

C.   MSMEs and Industry 4.0 & beyond

3.30 Micro, small, and medium enterprises (MSMEs) play a pivotal role in the growth of manufacturing sector in a nation's economy. In the current post-pandemic period, it is difficult for any nation to envisage significant industrial growth without implementing radical transformation in their MSMEs. MSMEs are considered the pillars of Indian economy due to their considerable contribution to GDP, exports and employment generation. Contribution of the MSME sector to the Gross Value Added (GVA) in the country's GDP has been around 30% over the past few years.[34] MSME sector accounted for 49.5% of India's total exports in FY 21. 12.33 Million people were employed by MSMEs as on 1st June 2023.[35]

3.31 India has an estimated 633.88 lakh unincorporated non-agriculture MSMEs in the country engaged in different economic activities, of which 324.88 lakh MSMEs are based in rural areas and 309 lakh are from urban areas, engaged in different economic activities.[36] Figure 3.1 shows the distribution of MSMEs activity wise.

Figure3.1: Distribution of MSMEs Sector Wise
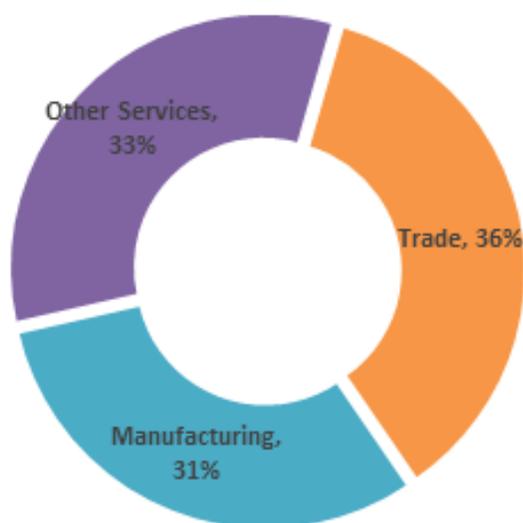
Source : MSME Annual Report 2022-23

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[34] https://www.ibef.org/blogs/india-s-msme-sector
[35] https://udyamregistration.gov.in/Government-India/Ministry-MSME-registration.htm
[36] MSME Annual Report 2022-23 published on 14th March 2023

3.32 Hence, a major chunk of MSMEs is engaged in manufacturing. The share of the MSME manufacturing in All India manufacturing during the year 2019-20 was 36.9%.[37] It also created many employment opportunities. Original Equipment Manufacturers (OEMs) rely heavily on the MSME suppliers to keep their supply chains running smoothly. Also, the 'AtmaNirbhar Bharat' initiative is heavily dependent on MSMEs, especially the strategic sectors that have critical implications on our national priorities. In the current competitive environment, the MSMEs will have to keep pace with the changes in support systems, manufacturing processes, skillsets, customer service needs and technology for their sustainability.

3.33 Technology intervention is pushing manufacturing to a new level of operation in the form of Industry 4.0. Under the umbrella of Industry 4.0, operational digitization, interacting machines, robots, automation, data analytics and swift data-driven intelligent decisions are the critical integrating pillars. Industry 4.0 transform manufacturing operations to become more efficient, productive, and profitable. The continuously increasing global competition is compelling companies to expand and connect internal manufacturing processes with the external supplier processes and customer expectations. Industry 4.0 (I4.0) leverages the data intelligence to eliminate system wastes and add more value to the end-customer.

3.34 Various studies have indicated that there are many challenges that MSMEs are facing to embrace I4.0.[38] The major challenges are:

   i. Lack of a constructive push or nudge by enterprise owners or top management or parent company for this futuristic transformational leap,

   ii. Fear of the likely resource pressures- finance, technology, human-talent, infrastructure, and new operational skill,

   iii. Fear of exorbitant cost of transitioning from the existing state to the new

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[37] https://www.pib.gov.in/PressReleasePage.aspx?PRID=1744032 posted on 9th Aug2021

[38]https://www.entrepreneur.com/en-in/growth-strategies/indian-msmes-aiming-to-embrace-industry-40-fears-and/431323

I4.0 state of operation,

iv. Potential concerns in Information technology related capabilities in terms of investment, operation, interoperability, cyber security, etc.

v. Fear of embracing this radical I4.0 approach which is still to provide tangible and visible deliverables and has a risky return on investment.

Initiatives taken in India

3.35 The Government's focus on MSME was reflected in the union budget for the fiscal year 2023-24, in which Rs.22,138 crore was allocated for the ministry of MSME. As per SBI report released in January 2023, incentives provided by the emergency credit line guarantee scheme are boosting the credit flow to the MSME.

3.36 The "Gramodyog Vikas Yojana Grant" is provided by Government of India to meet the developmental needs of the Village Industry sector which comprise six broad groups such as Agro Based & Food Processing Industry (ABFPI), Mineral Based Industry (MBI), Wellness & Cosmetics Industry (WCI), Hand Made Paper, Leather & Plastic Industry (HPLPI), Rural Engineering & New Technology Industry (RENTI), and Service Industry. Budgetary allocations under Gramodyog Vikas Yojana are also provided for supporting activities such as Science & Technology (V.I.), Capacity Building (Training to artisans), Publicity & Propaganda, Economic Research (EcR), Information Technology (IT), Audit, Estate & Services and other supporting activities.

3.37 CHAMPIONS (Creation and Harmonious Application of Modern Processes for Increasing the Output and National Strength) portal was launched by Hon'ble Prime Minister on 1st June, 2020. It is an ICT based technology system for making the smaller units big by helping and handholding them. A network of control rooms, with central Control Room in the office of Ministry of MSME New Delhi and 68 State level control rooms, is created. They have been providing every possible support on a local level to MSMEs in the areas including finance, market access, technology upgradation, skill development etc.

3.38   Under AatmaNirbhar Bharat Package, the Government of India announced to set up an INR 10,000 crore Fund of Funds for MSMEs. This fund, which is called Self Reliant India (SRI) Fund has the objective of supporting Venture Capital (VC) / Private Equity (PE) firms to encourage them to invest in the MSME segment. This Fund will address the equity funding challenges of MSME sector and give them a thrust to break their barriers, encourage corporatisation and allow them to grow to their full inherent potential to become global champions. It is expected that the initiatives of SRI Fund shall provide significant liquidity nearly INR 50,000 cr to MSME sector, thereby enabling economic growth of the country.

3.39   Ministry of MSME has developed a robust skilling eco-system to meet the demands of skilled workforce in the various emerging and traditional sectors in different segments of enterprises. The Ministry has been organizing a number of skill development programmes/ courses for the existing and potential entrepreneurs, in order to build their capacity. The objective of these training courses is to fill up the gap of requirement of skilled workforce in the MSME sector in consonance with the changing landscape of the MSME Ecosystem and its present challenges in India. Skill training programmes are conducted by a network of institutions under the Ministry i.e. Khadi & Village Industry Commission (KVIC), Coir Board, National Small Industries Corporation Ltd. (NSIC), National Institutes for MSME (ni-msme) and MSME – Technology Centres (TCs). The intake eligibility for the training programmes ranges from school drop out to M.Tech. level. Various levels of courses, viz. certificates, diploma, advance diploma, post graduate diploma and post graduate courses are offered by these institutions.

3.40   The Authority in its recommendations dated 11th April 2022 on "Auction of Spectrum in frequency bands identified for IMT/5G" has emphasised that timely intervention and hand holding of MSME sector will help India to increase its share in the international value chain system and play a

significant role in the Indian and global digital economy. The Authority recommended that:

DoT should take up the matter with Ministry of MSME to carry out a study to find out the actual details about the level of acceptance and adoption of 5G based industrial automation and digital technologies by the MSME sector in the country as compared to other industries. Based on the learning from such study, appropriate schemes, including interest subvention scheme, for upgradation of plant and machinery, may be devised to facilitate the MSMEs to overcome various constraints and move towards industrial automation. In this regard, budgetary provisions (if required), may be created by the Ministry of MSME.

3.41 Despite all these initiatives taken by the Authority and the government, MSMEs in India have so far not shown an enthusiastic response to this fast-approaching digital transformation. Whereas, in developed economies of the world these enterprises are adopting Industry 4.0 package and are capturing the benefits across the entire manufacturing value chain—increasing production capacity and reducing material losses, improving customer service and reducing delivery lead times, achieving higher employee satisfaction and reducing their environmental impact. In spite of having high potential, most MSMEs are confronted with barriers in embracing I4.0 practices in India. Many of them are still hesitant to step out of their comfort zone, ignorant of the adverse impact of not adopting I4.0 in the highly competitive business journey ahead.

In view of this, the inputs of stakeholders are sought on the following:

Q.7. What are the policy, regulatory and other challenges faced by MSMEs in adoption of Industry 4.0. Kindly suggest measures to address these challenges. Provide detailed justification with reasons along with the best practices in other countries.

D. Security

3.42 Ensuring effective security practices is essential in the development and design stage of IoT devices. Principles such as confidentiality, reliability, safety, availability, robustness, survivability, authenticity, resilience, identity management, access control, accountability and utility play a key role in the development of security of the IoT connected devices. With an increase in the demand for IoT devices, developers and manufacturers have more focus on increasing the quantity of devices instead of ensuring the quality of devices. This results in mass manufacture of cheap and low standard IoT devices, making it security vulnerable and weak. Since the IoT arrangements also include making of similar devices, the homogeneity expands the potential impact of any single security weakness to all the devices having the same features.

International Experience

3.43 In 2019, lawmakers started regulating the Internet of Things, especially network and device security. The most recent regulation frameworks impacting the IoT in Europe and the United States are summarised in the following table:

Table 3.1: Regulatory Frameworks for IoT Security

Region	Cybersecurity
EU	The EU Cybersecurity Act Effective June 27 2019, and became law in the European Union and the UK. The NIS Directive (IoT infrastructure) became effective May 24 2018, in the EU and the UK. Each country will have to pass a law.
USA	The IoT Cybersecurity Improvement Act of 2020, signed on December 4 2020. The bill gives NIST, the National Institute of Standards and Technology, the authority to manage IoT cybersecurity risks for devices acquired by the federal government.
California	The California IoT cybersecurity law SB-327 became effective on January1,2020

3.44 The **EU** Cybersecurity Act came into force on 27th June 2019, and became law in the EU and the UK. The Act strengthens the European Union Agency for Network and Information Security (ENISA) mandate to help Member States address cybersecurity threats. ENISA is developing cybersecurity certification framework that the European Commission will validate. The European Cybersecurity Certification Framework will enable the issuance of cybersecurity certificates and statements of conformity for ICT products, services, and processes. They will be recognized in all EU Member States. Initially, manufacturers and vendors will be able to have their products and services meet the EU cybersecurity standards voluntarily. The certification may eventually be made mandatory. Compliant IoT devices will undoubtedly be labelled. In the long run, consumers and businesses may favour these compliant products and services.

3.45 In September 2022, The **European Union** has proposed a cybersecurity regulation called "Cyber Resilience Act" (CRA)[39], which is a positive step towards standardizing security measures and protocols for digital products, especially for IoT. The Cyber Resilience Act has a few key factors which makes it crucial for IoT development and security.

   i. Part one (Manufacturing) - The Act specifies that any digital products (including connected devices for IoT) be manufactured in a secure manner.

   ii. Part two (Distribution) - Even if a product is designed to be secure, vulnerabilities and backdoors can always be introduced to them at a later stage. The Act specifies the need to deliver the products safely.

   iii. Part three (Access) - The Act also underlines the need for access management by appropriate control mechanisms, including but not limited to authentication, identity or access management systems.

   iv. Part four (Data Protection) - The CRA doubles down on EU's GDPR requirements for data protection, and asks of device manufacturers to only

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[39] https://digital-strategy.ec.europa.eu/en/library/cyber-resilience-act

collect data which is relevant and store, transmit, or process this data with extreme caution.

v. Part five (Defensive security) - The most important detail in the CRA are the security requirements, which ask all digital elements to have the ability to avoid attacks, limit them in case they occur, or fight them off. It also includes logging and patching requirements.

Thus, CRA expects ALL data to be handled with utmost importance and caution, not just personal data. This is what sets the CRA apart from GDPR. Also, it is important to note that any violations in regard to data protection will invoke heavy penalties for both GDPR and CRA for IoT device providers.

3.46 The **UK** has just passed the "Product Security and Telecommunications Infrastructure Act 2022"[40] , effective on or before 6th May2023. First part of this Act will help ensure that all consumer smart products have good security to protect against cyber-attacks. The new UK legislation covers the following three main security requirements:

i. Consumer IoT devices will not be allowed to have universal default passwords. This makes it easier for consumers to configure their devices securely to prevent them being hacked by cyber criminals.

ii. Consumer IoT devices will have to have a vulnerability disclosure policy. This means manufacturers must have a plan for how to deal with weaknesses in software which means it's more likely that such weaknesses will be addressed properly.

iii. Consumer IoT devices will need to disclose how long they will receive software updates. This means that software updates are created and released to maintain the security of the device throughout its declared lifespan.

The duties of various entities like manufacturers, distributers, importers etc.

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[40] https://www.legislation.gov.uk/ukpga/2022/46/contents/enacted

have been defined. The person responsible for enforcing the provisions of this Part, and of regulations made under it, is the Secretary of State. Failure to compliance could result in heavy monetary penalties.

3.47 In **United States,** there is neither a national IoT cybersecurity regulatory framework nor a comprehensive set of standards. In 2019, the IoT Cybersecurity Improvement Act was introduced and the bill was passed on December 4 2020. This act sets minimum security standards for IoT devices procured by the federal government. The private sector has been left unregulated. The act gives the National Institute of Standards and Technology (NIST) the authority to oversee IoT cybersecurity risks for equipment bought by the federal government. Specifically, the text mandates NIST to issue guidelines dealing with security development, identity management, upgrade, and configuration management for IoT products. The bill also calls upon IoT device manufacturers to adopt coordinated vulnerability disclosure policies.

3.48 California legislature passed a new IoT security law[41] in 2018 that became effective on January 1, 2020. This is the first IoT-specific security law in the country. It defines new security requirements for IoT devices connected directly or indirectly to the Internet with an IP or Bluetooth address. It requires that these devices sold in California be fitted with "reasonable security features." The security features should protect the IoT device and its data. But California's IoT law is a significant first step as it targets IoT devices and basic cyber-attack methods that can leave consumers vulnerable to security and privacy risks. This act places liability on the IoT vendors if the device is connected to the Internet in California. Oregon also joined California with a similar text that went into effect on January 1 2020.

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[41] https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB327

Initiatives taken in India

3.49 TRAI in its recommendations on "Spectrum, Roaming and QoS related requirements in Machine-to-Machine Communications", released in September 2017, had also mentioned the following requirements which have been accepted by DoT:

   i. Device manufacturers should be mandated to implement "Security by design" principle in M2M devices manufacturing so that end to end encryption can be achieved.

   ii. A National Trust Center (NTC), under the aegis of TEC, should be created for the certification of M2M devices and applications (hardware and software).

3.50 As per "Framework of Nataional Trust Centre for M2M/IoT Devices and Applications (TEC 31188:2022) R1.0" released by TEC in March 2022, These recommendations were accepted by DoT and it was also decided that for certification of software products & applications related to M2M devices, STQC (Standardization Testing and Quality Certification) under MeitY (Ministry of Electronics and Information Technology) may be the agency to carry out such testing under single window of proposed National Trust Centre". Whereas, testing and Certification of IoT devices hardware is already covered in Essential Requirements (ERs) under MTCTE having testing specifications related to EMC, Safety, communication interfaces, IP, SAR and Security. Security specifications is being prepared in ITSAR (Indian telecom security assurance requirements).

3.51 IoT device hardware will be tested as per Mandatory Testing and Certification of Telecommunication Equipment (MTCTE) Essential requirement (ER) prepared by TEC, and the software by STQC. MTCTE is already in progress and being implemented in phased manner to cover the telecom equipment and the devices. TEC has also released guidelines "*Code of practice for securing Consumer IoT*" to help in creating the ecosystem of secured devices and reducing vulnerabilities. However, no such specific trust centre for IoT devices appears to be functional under TEC or STQC

and no specific IoT related security testing specifications have been published till date.

3.52 Another bigger issue is most of the sectors using digital technologies or integrating emerging technologies do not have a digital risk element defined by the sectoral regulators till date. For example, the automotive sector is relying on IoT for connected vehicles. The oil & gas market, nuclear, manufacturing and chemical industries are keen to leverage IoT to manage supply chains, improve efficiency and reduce costs. However, a key challenge faced by these sectors is securing the Internet of things. And, in this regard, no policy, standard or governance framework exists in India so far.

3.53 The Indian healthcare ecosystem is steadily moving towards smart medical devices, digital operation theatres and digital pharmacies, however, there is no call for standardisation from regulatory bodies such as NABH to safeguard Indian healthcare industry from cyber-attacks. Even though the new, advanced, medical equipment deployed in hospitals today are IoT enabled, and a majority of them are imported in India, apparently, there is no baseline criteria, labelling scheme available to test the security of these IoT-enabled medical devices.

3.54 IoT, today, has larger consequences for industry, and hence multiple government department and sectoral regulators need to work collaboratively on IoT Security. While many of the working groups under these ministries talk to each other through common committees such as BIS/ LITD, a common arrangement defining and allocating areas of responsibility and ownership is clearly missing. In view of this, the issue which needs to be deliberated by the stakeholders is:

Q.8. What additional measures are required to strengthen the National Trust Centre (NTC) framework for complete security testing and certification of IoT devices (hardware as well as software) under DoT / TEC. What modifications in roles and responsibilities are required to make NTC more effective? Kindly provide your comments with

justification in line with the global best practices

Q.9.   IoT security challenges and requirements vary significantly across different industry verticals. Is there a need to develop sector-specific IoT security and privacy guidelines?

Q.10.   If answer to Q.9 is yes, is there a need for a common framework and methodology for developing such sector-specific guidelines?

E.   Privacy

3.55   The rapid rise of the Internet of Things (IoT) raises pressing privacy concerns despite its possible benefits. IoT devices can collect vast quantities of granular data about individuals' daily habits and activities. The data that these devices can collect include consumption rate data, location data, and health-related data, among other things. IoT devices can be used by various entities to colonize and obtain access to people's homes and bodies while compromising their anonymity. This possible corporate colonization and surveillance may limit individuals' ability to determine what happens to their information and may decrease their ability to shield themselves, their emotions and their daily activities from various actors. The lack of a comprehensive privacy legislation may lead to regulatory gaps. There is a need to adopt comprehensive privacy and security legislation that provides baseline privacy rights to consumers by providing guidance on permissible and impermissible data practices and additional protections for sensitive data, such as biometric identifiers.

International Experience

3.56   The most recent regulatory frameworks impacting the IoT privacy are summarised in the following table:

Table 3.2: Regulatory Frameworks for IoT Privacy

Region	Consumer Data Privacy
EU	The General Data Protection Regulation (EU GDPR Directive 95/46/EC) effective May 25 2018, became law in the EU and the UK.

USA	No comprehensive federal law regulating the collection and use of personal information yet. Specific laws: • Healthcare: Health Insurance Portability and Accountability Act • Finance: Gramm-Leach-Bliley Act • Government agencies: US Privacy Act of 1974 Children's Online Privacy Protection Act
California	The California Consumer Privacy Act SB-1121 became effective on January 1 2020 The California Privacy Rights Act CPRA will be enforced on July 1, 2023

3.57 European Union's General Data Protection Regulation[42] (GDPR) is considered as the golden standard by many countries in privacy legislation. It is followed in all member countries of the EU and UK. The General Data Protection Regulation (GDPR) is the toughest privacy and security law in the world. Though it was drafted and passed by the European Union (EU), it imposes obligations onto organizations anywhere, so long as they target or collect data related to people in the EU. The regulation was put into effect on May 25, 2018. The GDPR levies harsh fines against those who violate its privacy and security standards, with penalties reaching into the tens of millions of euros. All entities processing data must obey the following seven protection and accountability principles:

i. Lawfulness, fairness, and transparency — Processing must be lawful, fair, and transparent to the data subject.

ii. Purpose limitation — Data must be processed for the legitimate purposes specified explicitly to the data subject when it is collected.

iii. Data minimization —Only as much data should be collected and processed as absolutely necessary for the purposes specified.

iv. Accuracy — Personal data must be kept accurate and up to date.

v. Storage limitation — Only personally identifying data may be stored for as long as necessary for the specified purpose.

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[42] https://gdpr.eu/what-is-gdpr/

vi. Integrity and confidentiality — Processing must be done in such a way as to ensure appropriate security, integrity, and confidentiality (e.g. by using encryption).

vii. Accountability — The data controller is responsible for being able to demonstrate GDPR compliance with all of these principles.

3.58 **US** has no "GDPR-like," comprehensive federal law regulating the collection and use of personal information. Instead, it has a combination of federal and state laws and regulations that can sometimes overlap or contradict one another. Also, some industry sectors and their related markets are restricted by specific US laws. For example, the healthcare technology industry has its requirements in the United States, as defined in the Health Insurance Portability and Accountability Act of 1996[43] (HIPAA) and the Federal Exchange Data Breach Notification Act of 2015.[44] HIPAA specifies national standards for the privacy and protection of healthcare information. This means that devices that may have access to that information, including the Internet of Medical Things, must protect their data and report if their security is breached. Another primary legislation from the 90s, the Gramm-Leach-Bliley Act (GLBA)[45], is a banking and financial law with crucial data privacy and security requirements.

3.59 The **California** Privacy Rights Act (CPRA)[46] toughens the privacy requirements and brings California more in line with the GDPR. It creates a new state agency—the California Privacy Protection Agency. Previously, the state's attorney general dealt with consumer privacy issues on top of all their other responsibilities. The dedicated agency with a $10 million basic budget, in addition to part of the fines and settlements it collects from companies that break the law. Enforcement of the CPRA begins in

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[43] https://www.hhs.gov/hipaa/for-professionals/privacy/laws-regulations/index.html
[44] https://govtrackinsider.com/data-security-and-breach-notification-act-would-create-the-first-ever-federal-standard-for-9842596a27ba
[45] https://www.ftc.gov/business-guidance/privacy-security/gramm-leach-bliley-act
[46] https://www.csoonline.com/article/3601123/cpra-explained-new-california-privacy-law-ramps-up-restrictions-on-data-use.html

July 2023. California earlier had a privacy law in place, the California Consumer Privacy Act (CCPA), adopted in 2018. It went into effect in January 2020, and enforcement officially began in July 2020.

Initiatives taken in India

3.60   As India moves towards a digitally empowered economy, there is a growing concern about data privacy and protection of personal information. The government, along with various stakeholders, is taking steps to address the challenges of data privacy in the digital age. Through the use of IoT and associated devices, large quantities of personal data and sensitive personal data in certain cases, are exchanged. In most of these cases, the storage of the data is done in clouds. Therefore, data stored in a cloud service and not protected adequately may result in unauthorized third-party access and information leaks, who may use and process it for unwarranted purposes. Hence, there is a need to ensure that the personal data of individuals is protected and respected in accordance with the constitutional values and international standards.

Government Initiatives

3.61   The Supreme Court of India recognized the Right to Privacy as a fundamental Right covered within the ambit of Right to life and personal liberty under Article 21.[47] The sharing or receiving of personal information in spoken, writing, or electronic form is not protected by a stand-alone legislation in India. Although there are safeguards, they are spread over a variety of Laws, regulations, and policies. IT Act, 2000 (Amendment in 2008), herein after called IT Act and IT Sensitive Personal Data or Information Rules of 2011, herein after called SPDI Rules, are the most significant legislations.

3.62   Section 43A of IT Act, states that : *"Where a body corporate, possessing, dealing or handling any sensitive personal data or information in a*

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[47] vbcvcbcvc

computer resource which it owns, controls or operates, is negligent in implementing and maintaining reasonable security practices and procedures and thereby causes wrongful loss or wrongful gain to any person, such body corporate shall be liable to pay damages by way of compensation, not exceeding five crore rupees, to the person so affected.."

3.63   As per Sec 72A of IT Act, the punishment for disclosure of information in breach of Lawful contract and any person may be punished with imprisonment for a term not exceeding three years, or with a fine not exceeding up to five lakh rupees, or with both, in case disclosure of the information is made in breach of Lawful contract." Punishment for it is stated in Sec 72. It says that: "any person who, in pursuance of any of the powers conferred under the IT Act Rules or Regulations made thereunder, has secured access to any electronic record, book, register, correspondence, information, document or other material without the consent of the person concerned, discloses such electronic record, book, register, correspondence, information, document or other material to any other person, shall be punishable with imprisonment for a term which may extend to two years, or with fine which may extend to one lakh rupees, or with both." Anyone who commits an offense or violation outside of India shall be held to the same standards as anyone who commits an offense or violation in India. This is stated in Section 75 of the Act.

3.64   The Indian government established a Committee of Experts, headed by Justice B.N. Srikrishna, to investigate Data Privacy problems in India. This report and draft Personal Data Protection Bill were given to Ministry of Electronics and Information Technology in July 2018 after the white paper's open consultation. Expert Committee suggestions and stakeholder input were used to draft Personal Data Protection Bill 2019. In August 2022, Ministry of Electronics and Information Technology (MeitY) had withdrawn Personal Data Protection Bill, 2019, owing to multiple recommendations received through public consultation. As revised version of its predecessor, the Government has formulated new Digital

Personal Data Protection Bill in November, 2022. The new bill called "Digital Personal Data Protection Bill, 2023", was passed by the parliament on 9th August 2023[48] and Digital Personal Data Protection Act, 2023 came into effect from 11th August 2023.

3.65   As per section 3 of this Act, *it shall*

   (a) *apply to the processing of digital personal data within the territory of India where the personal data is collected in digital form; or in non-digital form and digitised subsequently.*

   (b) *also apply to processing of digital personal data outside the territory of India, if such processing is in connection with any activity related to offering of goods or services to Data Principals within the territory of India;apply to such processing outside India, if it is for offering goods or services in India.*

3.66   Personal data may be processed only for a lawful purpose upon consent of an individual. Consent may not be required for specified legitimate uses such as voluntary sharing of data by the individual or processing by the State for permits, licenses, benefits, and services. Data fiduciaries will be obligated to maintain the accuracy of data, keep data secure, and delete data once its purpose has been met or consent has been withdrawn by the individual.

3.67   The Act grants certain rights to individuals including the right to obtain information, seek correction and erasure, and grievance redressal. The central government may exempt government agencies from the application of provisions of the Bill in the interest of specified grounds such as security of the state, public order, and prevention of offences. The central government will establish the Data Protection Board of India to adjudicate on non-compliance with the provisions of the Act.

TRAI's Recommendation on "Privacy, Security and Ownership of Data in the Telecom Sector"

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[48] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1947264

3.68   In the backdrop of possible threats to the data privacy of the telecommunication consumers, the Authority released its recommendations[49] dated 16th July, 2018 on "Privacy, Security and Ownership of Data in the Telecom Sector". The Recommendations proposed consent mechanisms with varying levels of granularity in choices to be provided to the users by the service providers. Such choices are to be explicitly presented to the user before any data is collected. It is also recommended that the users be provided with appropriate notices detailing the practises regarding personal information being collected. Examples of such practises include purpose of collection and its intended use, and whether the personal data which is collected will be shared with a third party. Individual consent may be obtained only after providing the notice.

3.69   In this recommendation, it was emphasized that Notice, Choice, and Consent are the most important rights that should be given to the data consumers. Such notices should include disclosures on what personal information is being collected; purpose for collection and its use; whether it will be disclosed to third parties; notification in case of data breach, etc. Similarly, Choice and Consent implies that a data controller shall give individuals choices (opt-in/opt-out) with regard to providing their personal information and take individual consent only after providing notice of its information practices. Consent may be considered to be a powerful means of protecting an individual's information. An individual is best placed to decide the sensitivity of his/her information rather than the Government or any other agency deciding it on his behalf.

3.70   Regarding issues related to consent management and Account Aggregators, the Authority recommended that

"(a) The Right to Choice, Notice, Consent, Data Portability, and Right to be

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[49]https://www.trai.gov.in/sites/default/files/RecommendationDataPrivacy16072018_0.pdf

Forgotten should be conferred upon the telecommunication consumers.

(b) In order to ensure sufficient choices to the users of digital services, granularities in the consent mechanism should be built-in by the service providers.

(c) For the benefit of telecommunication users', a framework, on the basis of the Electronic Consent Framework developed by MeitY and on lines of the master direction for data fiduciary (account aggregator) issued by Reserve Bank of India, should be notified for telecommunication sector also. It should have provisions for revoking the consent, at a later date, by users."

3.71 The issue of Account Aggregator and Electronic Consent Framework was also deliberated in the recommendations as follows:

"Subsequent to the development of the Electronic Consent Framework by MeitY, RBI, on behalf of all the Financial Sector Regulators, has issued the master direction known as the "Non-Banking Financial Company - Account Aggregator (Reserve Bank) Directions, 2016" for all the Financial Sector participants. It has the concept of the data fiduciary (Account aggregator) that, after obtaining the consent of the customers electronically, collects the information from providers of information based on the standardized consent artifact and securely transmits the same to users of the information. This direction is for the benefit of financial sector consumers, as it empowers them to use their personal data, in the form of financial transactions history, for availing new services from any other competing service provider."

3.72 In view of the above discussions, the following issue arises for consultation with stakeholders :

Q.11. Please suggest regulatory and policy interventions required to ensure privacy of the massive amount of sensitive user data generated by IoT applications specifically in light of the Digital Personal Data Protection Act, 2023. Kindly provide justifications along with the global best practices.

F.   Startup ecosystem and Research & Development

3.73   Agricultural startups in India have been gaining immense popularity in recent years as they aim to modernize and improve the traditional agricultural sector in the country. The majority of the farmers in India are small and marginal, and the agricultural sector faces challenges such as low productivity, inadequate infrastructure, and limited access to technology and financing. The startups are using innovative technologies, financial services, and improved supply chain systems to improve the efficiency and profitability of Indian agriculture. With their continued growth and expansion, the agricultural sector in India has the potential to become one of the leading agricultural producers in the world, providing numerous economic and social benefits to the country and its people.

3.74   The Centre of Excellence (CoE) for IoT[50] (MeitY, NASSCOM, ERNET initiative) was announced by Hon'ble in July 2015 as a part of Digital India Initiative to help the IoT start up ecosystem. The program has done well since its inception and has created strong start-ups ecosystem. The major achievements of program are - 80 Start-ups enrolled in house, connected with 1075 start-ups pan India, 100 IoT research centres incubated, 66 Prototypes showcased, 23 Papers presented in global conferences, IP's applied (post incubation start) -19, Received- 5, 34 societal projects executed, Funds raised by startups - Rs. 118 Cr.

3.75   The Ministry of Electronics and Information Technology (MEITY) and innovation ecosystem THub is financially supporting startups in the hardware and internet of things (IoT) sectors for Digital India's Scale Up programme. MeitY in partnership with NASSCOM had initiated a program to setup Centre of Excellences in IoT throughout the country. The objective of these CoEs in IoT is to promote the development and adoption of innovative solutions in the field of IoT. These are being setup in PPP model with contribution from MeitY, State Governments and rest from Industry.

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[50] https://ernet.in/projects/iot.html

3.76 The Authority in its recommendations on "Auction of Spectrum in frequency bands identified for IMT/5G" dated 11th April 2022 took cognisance of involving the startups in the development of use cases of digital technologies like 5G, IoT, M2M, AI etc. It recommended that:

a. *A 5G-dedicated Inter-Ministerial Working Group (IMWG), under the chairmanship of Member (Technology), DoT should be formed comprising Ministry of Electronics and Information Technology, Department for Promotion of Industry and Internal Trade, Ministry of Information and Broadcasting, Department of Space, Ministry of Finance, Ministry of Education, Department of Science & Technology, Ministry of Micro, Small and Medium Enterprises (MSME) and Niti Ayog as members, which should be represented by JS Level officers.*

b. *The IMWG may co-opt officers from other concerned Ministry(ies) / Department(s) as per requirement.*

c. *The concerned Ministries/Departments shall establish a special dedicated Digital Cell, headed by the JS Level officer nominated as member in IMWG, with dedicated technical manpower to formulate the use of digital technologies like 5G, IoT, M2M, AI etc. and development of relevant and affordable use cases involving start-up companies, entrepreneurs, application providers etc. The scope of the Digital Cell shall include, but*

not limited to, involving the relevant stakeholders in discussions, framing and monitoring short-term (annual), medium-term (5-year), and long-term (10-year) plans with quantitative targets in respect of sector specific 5G use cases, providing platform and promoting 5G use cases. The Digital Cell

may also need to focus on issues relating to digital literacy, connectivity and affordable user devices for their sector.

d. *The Ministries/Departments should take up short-term (annual), medium-term (5-year), and long-term (10-year) plans with quantitative targets in respect of sector specific 5G use cases and the same can be considered by*

IMWG for consistent and coordinated development of use cases and start-up ecosystems to align issues such as connectivity, privacy, data security etc. in the country.

e. *The participating members of IMWG should be responsible for outlining strategies, defining targets, and budgetary provisions for achieving defined targets for their respective Ministries / Departments.*

f. *The IMWG should conduct periodic meetings and discussions, at least once in 3 months, in which progress achieved will be reviewed and outline path for achieving planned objectives will be framed.*

g. *The IMWG should present consolidated status/proposals to the Department of Telecommunications (DoT) being nodal Ministry,on a regular basis.*

h. *The progress of digital transformation and implementation of 5G use cases in various verticals should also be monitored and documented by IMWG and be submitted to DoT for perusal and appropriate decision.*

3.77   Recently, a team of officers from TRAI visited one such NASSCOM Centre of Excellence – IoT & AI at Bengaluru, a joint initiative of Ministry of Electronics and Information Technology (MeitY), Govt. of India and Govt. of Karnataka, Haryana, Gujarat, A.P and NASSCOM. The CoE has provided extensive workstation spaces to Start-ups within its facility. Apart from that it also provides them with required lab facilities, tools, bandwidth etc. It helps them raise funds from investors, connects them with mentors, experts and enterprises for their development and growth. Some of the innovative projects being undertaken by startups here include

i) Medical training simulator named as Fertilator, for assisted IVF procedures, which is also useful for skill-upgradation of Infertologists, Gynaecologists & Embryologists.

ii) Quantum computing projects, next generation superconductivity based products such as motors, high temperature qubits, material discovery using Quantum and AI based discovery engine.

iii)End-to-end testing in a manufacturing facility using AI.

iv) App based Electric Vehicle Charging stations to be installed in Malls, Apartment complexes.

v) Automated machines to provide batter for food industry with right mix of ingredients, temperature and other controls.

vi) use cases built around Drones.

3.78 During this visit it was found that the startups are facing certain challenges. One of the main challenges is importing the equipment for R&D purposes and it was felt that an institutional framework is required to provide assistance in procurement of such equipment. They are also facing the issue of warehousing requirements. Several test equipments are required by them, which are quite costly and require regular Opex for their calibration and maintenance. The Start-ups need regular interface with experts, mentors and other enterpises to develop and improve upon their projects. While CoE has partnered with several industry organisations, this needs to be further strengthened. Some Start-ups may require access to large computing power which may not be readily available within CoE. They need to tap this computing power through Cloud based solutions or other organisations providing compute power on demand. Another significant challenge being faced by them is the access to high and reliable bandwidth. They also need market access with the help of industry to help them scale their work for commercial deployment. These startups are also not well aware about patent and other IPR laws and filing procedures.

3.79 In view of above discussions, the question arises is:

Q.12. What additional policy and regulatory measures are required to encourage research and development of IoT use cases in various sectors? Is there a need to incentivize startups for research and development of IoT enabled use cases in various industry verticals? If yes, kindly suggest measures for the same.

Q.13. What measures should be taken to encourage centres of excellence to handhold startups working in the development of use cases and

applications in 5G and beyond technologies? How can the domestic and foreign investors be encouraged to invest for funding the startups for these kinds of development activities?

G.   Legal Framework

3.80   IoT has many potential benefits for various sectors such as agriculture, healthcare, education, transportation and more. However, IoT also poses significant challenges and risks. One of the major challenges is the liability for damages caused by IoT devices or applications. For example, who should be held responsible if a smart car causes an accident, or if a medical device malfunctions and harms a patient, or if a smart home device leaks personal data to unauthorized parties? Whether the current legal framework in India provides clear and consistent answers to these questions, and able to account for the specific features and implications of IoT.

3.81   There is a need for a clear allocation of roles and responsibilities among the various stakeholders involved in IoT, such as manufacturers, service providers, consumers, regulators and third parties. Creating liability regimes in the world of IoT is another challenging task considering the number of actors from internet providers, device manufacturers to app service providers. Compromising of any one of these devices or networks would create havoc. Finding ways to impute liability in a confusing world of diverse actors will have to be explored. A specific and effective mechanism for redressal and compensation for damages caused by IoT devices or applications may also be required. However, conceiving new laws or evolving existing ones is a daunting task. Therefore, the stakeholders' response is solicited on the following question:

Q.14.   Whether there is a need to make changes in relevant laws to handle various issues, including liability regime and effective mechanism for redressal and compensation in case of accidents, damages, or
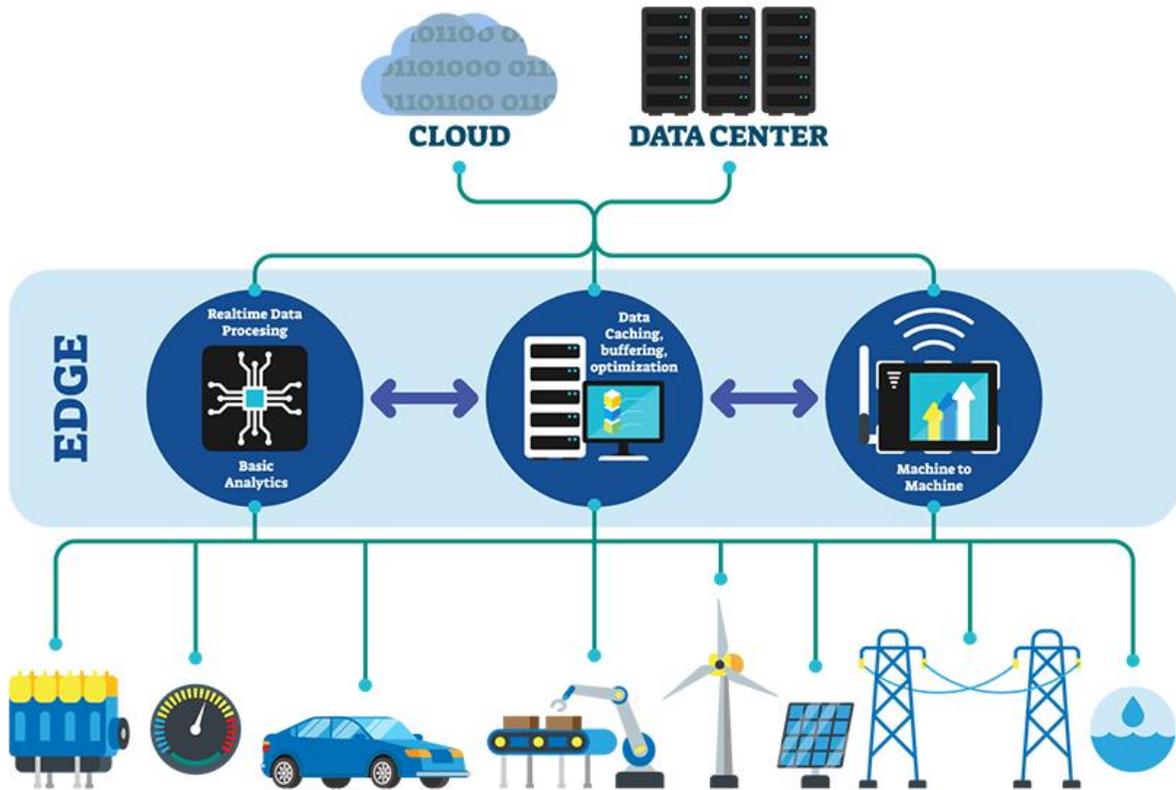
malfunctions involving IoT, drones, or robotic systems. If yes, give detailed suggestions.

IV. Edge Computing for 5G enabled IoT Applications

3.82   Edge computing creates opportunities to enhance digital experiences, improve performance and security in 5G ecosystem. Edge computing brings computation and data storage closer to the source of data generation. For example, in the context of the Internet of Things (IoT), the sources of data generation are usually things with sensors or embedded devices. Edge computing allows storing, processing, and analyzing data locally instead of just sending it to a centralized server. (See Figure 3.1) From there, the processed data can be delivered to its destination sooner. Edge computing reduces the cascade of potential bandwidth bottlenecks and processes the data that matters, keeping it close to the source. The major benefit of this is reduced network traffic and latency along with improved efficiency. Another advantage is the better compliance to law of the land, wherein the data protection regulation may require to process and store certain data locally.

3.83   Enterprises, cloud service providers, and telecom companies are investing heavily in digital edge data center to boost the speed of applications like streaming video, telemedicine, factory automation, etc. In addition, these data center types enable new technologies like augmented and virtual reality (AR/VR) and autonomous vehicles. Gartner estimates that by 2025, 75 percent of data will be processed outside the traditional data center or cloud.[51]

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[51]https://www.gartner.com/smarterwithgartner/what-edge-computing-means-for-infrastructure-and-operations-leaders/

Figure 3.2 : Edge Computing in IoT Use Cases

Source : IEEE innovation at work

Edge Computing Use Cases

3.84 Prime use cases, which take full advantage of edge technology, include:

i. Autonomous Vehicles: The decision to stop for a pedestrian crossing in front of an autonomous vehicle (AV) must be made immediately. Relying on a remote server to handle this decision is not reasonable. Additionally, vehicles that utilize edge technology can interact more efficiently because they can communicate with each other first as opposed to sending data on accidents, weather conditions, traffic, or detours to a remote server first. Edge computing can help.

ii. Healthcare Devices: Health monitors and other wearable healthcare devices can keep an eye on chronic conditions for patients. It can save lives by instantly alerting caregivers when help is required. Additionally, robots assisting in surgery must be able to quickly analyze data in order

to assist safely, quickly, and accurately. If these devices rely on transmitting data to the cloud before making decisions, the results could be fatal.

iii. Security Solutions: Because it's necessary to respond to threats within seconds, security surveillance systems can also benefit from edge computing technology. Security systems can identify potential threats and alert users to unusual activity in real-time.

iv. Retail Advertising: Targeted ads and information for retail organizations are based on key parameters, such as demographic information, set on field devices. In this use case, edge computing can help protect user privacy. It can encrypt the data and keep the source rather than sending unprotected information to the cloud.

v. Smart Speakers: Smart speakers can gain the ability to interpret voice instructions locally in order to run basic commands. Turning lights on or off, or adjusting thermostat settings, even if internet connectivity fails would be possible.

vi. Video Conferencing: Poor video quality, voice delays, frozen screens— a slow link to the cloud can cause many video conferencing frustrations. By placing the server-side of video conferencing software closer to participants, quality problems can be reduced.

A. MEC Security

3.85 When it comes to the security of MEC, it may appear at first sight that it is more secure because data is not travelling over the network. However, the flip side of it is that it is less secure because the edge devices in themselves can be more vulnerable. Edge applications relating to IoT pose special security risks because IoT devices are designed for low cost, low power usage and deployment to areas often not suitable for complex technology because of conditions in the environment where they're deployed, such as temperature and humidity, dust or vibration. These risks include the use of specialized IoT protocols, which normally lack sophisticated security features such as encryption; wireless interfaces

such as Wi-Fi, which could be subject to hacking or hijacking because of easy access to the area where the Wi-Fi hubs are installed; and IoT gateways not being upgraded with proper security software.

3.86   Edge computing exposes data to more potential threats and vulnerabilities, as data is stored and processed on devices that may have lower security standards or capabilities than centralized cloud servers. Data controllers and processors need to implement appropriate technical and organizational measures to protect the data at the edge from unauthorized or accidental disclosure, alteration, or loss. To address these regulatory challenges, edge computing stakeholders need to adopt a risk-based approach that considers the nature, scope, context, and purpose of the data processing at the edge. They also need to collaborate with regulators and policymakers to develop clear and consistent frameworks and guidelines that balance the benefits and risks of edge computing for data protection, privacy, and security.

3.87   In view of the above discussions, the inputs of stakeholders are solicited on the following issue:

Q.15.   Is there a need to have a separate security mechanism for Multi-access Edge Computing (MEC)? If yes, please give your inputs and suggestions with regard to policies, rules, regulations and guidelines.

B. MEC Environmental Concerns

3.88   The importance of data centres has risen substantially over the last decade as people are getting more and more inclined towards digital lives. They are the backbone of the Internet. The nature of data centre demand appears likely to evolve over the coming decade. 5G, the Internet of things and the metaverse are likely to increase demand for low-latency computing i.e. edge computing. According to a market research[52], the edge computing market size is expected to grow from USD 44.7 billion in 2022 to USD

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[52]https://www.researchandmarkets.com/reports/5668996/edge-computing-market-by-component-hardware

101.3 billion by 2027, at a Compound Annual Growth Rate (CAGR) of 17.8% during the forecast period (See fig. 3.3).

Figure 3.3: Global Edge computing Market
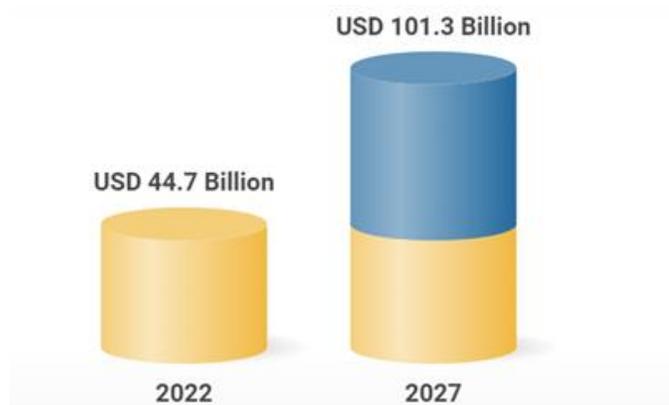
<div align="right">Source : ResearchAndMarkets</div>

3.89   Data centres are one of the most energy-intensive buildings having a significant impact on the environment and their sustainability has become an important topic in recent years. Global data centre electricity use in 2021 was 220-320 TWh[53], or around 0.9-1.3% of global final electricity demand. This figure is only going to increase as the demand for cloud computing (including edge) grows. In some countries, data centres will account for an estimated 5-10% of energy consumption by 2030.[54] Similarly, the data centres and data transmission networks that underpin digitalisation accounted for around 300 Mt CO_2-eq in 2020[55] (including embodied emissions), equivalent to 0.9% of energy-related GHG emissions (or 0.6% of total GHG emissions).

3.90   Major digital operators are implementing a significant push to reduce the energy consumption of all data centre components to mitigate their growing environmental impact. Huge efforts have already been made by a number of industry players to reduce the environmental impact of data centres. For example, the Climate Neutral Data Centre Pact[56] is a

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[53] https://www.iea.org/reports/data-centres-and-data-transmission-networks#reference-2
[54] https://stlpartners.com/articles/sustainability/edge-computing-sustainability/
[55] https://www.itu.int/rec/T-REC-L.1470-202001-I/en
[56] https://www.climateneutraldatacentre.net/

movement that sets forth a vision for climate neutrality of data centres in Europe by 2030 by addressing 5 efficiency metrics including 100% carbon free energy and water conservation. Some data centre providers seeking to minimise their footprint have already made significant headway, particularly with respect to reducing non-renewable energy consumption.

International Experience

3.91   The **European Union** relies on the following instruments to ensure the energy-efficiency, climate-neutrality and overall sustainability of data centres.[57]

   i.   EU Code of Conduct for Data Centres was launched in 2008 with the aim of improving the energy efficiency in data centre. The Code of Conduct is a voluntary initiative, which sets ambitious voluntary standards for companies willing to participate. The Code of Conduct identifies and focuses on key issues and agreed solutions, and best practices.

   ii.   Servers and data storage products sold in the EU for data centres and server rooms of companies, are subject to rules laid out in the Regulation on eco-design requirements for servers and data storage products EU 2019/424[58]. The objective of the regulation is to limit the environmental impact of these products with a set of rules on energy efficiency, such as minimum efficiency of the power supply units and minimum server efficiency in active state, maximum consumption in idle state and information on the product operating temperature.

   iii. EU Green Public Procurement (GPP) Criteria is aimed at helping public authorities to ensure that data centres' equipment and services are procured in such a way that they deliver environmental improvements. Three priority areas of focus are identified as the basis for criteria: 1) ICT System Performance, 2) Mechanical and electrical system performance, 3) Reduction of greenhouse gas (GHG) Emissions.

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[57] https://digital-strategy.ec.europa.eu/en/policies/green-cloud
[58]https://eur-lex.europa.eu/legalcontent/EN/TXT/?qid=1553786820621&uri=CELEX%3A32019R0424

The European Commission is currently conducting a study to address the lack of commonly accepted definitions and methods to assess the energy-efficiency, climate-neutrality and overall sustainability of data centres: 'Greening cloud computing and electronic communications services and networks: towards climate neutrality by 2050'.[59]

3.92   IMDA **Singapore** has developed Green DC standard "SS 564", which helps organisations establish systems and processes necessary to improve the energy efficiency of their DCs. It provides them with a recognised framework as well as a logical and consistent methodology to achieve continuous improvement in their DC facilities. This standard is based on the "ISO 50001" standard on energy management but is specifically tailored to meet the needs of DCs in Singapore. In addition, the Green DC Standard defines a set of performance metrics for DCs to measure their energy efficiency. These metrics provide a common benchmark to help DCs track their performance and improvements. It also includes a comprehensive set of recommended industry best practices covering various aspects of DC operations and design.

3.93   **Malaysia** has developed a technical code[60], which provides the minimum requirements for green data centres. It helps in establishing policies, systems and processes to improve the energy efficiency of data centres and at the same time reducing the carbon footprint of the industry. This Technical Code also outlines the best practices that data centres should adopt in achieving a sustainable industry. This Technical Code covers all private and public data centres operating in Malaysia. Within a data centre, the following areas are covered namely environmental conditions, energy management, air management, cooling management, IT equipment

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[59]https://digital-strategy.ec.europa.eu/en/library/study-greening-cloud-computing-and-electronic-communications-services-and-networks-towards-climate

[60]https://www.mcmc.gov.my/skmmgovmy/media/General/pdf/MCMC-Green_Data_Centres.pdf

and lighting, power chain management, space management, information management, governance and guidelines.

3.94   **Japanese** Government has planned to set a target for the country to hit carbon neutrality by 2050 in line with EU. Japan's New Energy and Industrial Technology Development Organization (NEDO), through its $17 billion Green Innovation Fund[61], aims to support the development of 'next-generation green data center technology' that will create energy savings of 40 percent or more compared to current data centers. It will fund projects for greener and more efficient data centers including optoelectronics technology, power-saving CPUs, and cheaper silicon carbide semiconductors. The Japanese government has announced that it will subsidise 50% of the building costs towards new zero carbon-emissions data centres, and upgrades of existing facilities as part of a new $7.3bn initiative to innovate the industry and cut carbon emissions.[62] To reduce carbon-emissions and the amount of energy used in cooling of data centres, Japan is planning to build new facilities in its colder regions.

3.95   In the **United States,** green building rating system "Leadership in Energy and Environmental Design (LEED)" is used to certify the DCs as green DCs. This rating system has been developed by the U.S. Green Building Council and is available in several categories like silver, gold or platinum certification. The platinum certification is given to data centers with the highest level of environmentally responsible construction and efficient use of resources.[63] There is another certification programme for DCs called "National Data Centre Energy Efficiency Information Program" by Energy Star, part of an initiative by the U.S. Environmental Protection Agency and the U.S. Department of Energy. The program certifies buildings and consumer products for energy efficiency.

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[61]https://www.datacenterdynamics.com/en/news/japans-nedo-to-fund-new-green-data-center-research-projects/
[62] https://datacentremagazine.com/data-centres/japans-data-centres-go-green
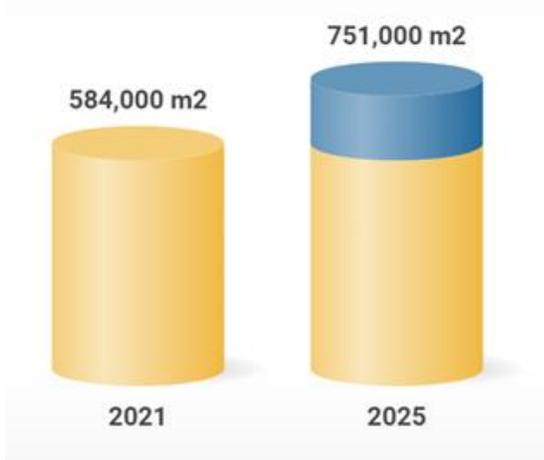[63]https://lifelinedatacenters.com/colocation/leed-certification-data-centers/

3.96   Several vendors have released products and software that support green data centre initiatives. For example, complete end to end solution for data centres with green hydrogen generated by renewable energy, AI based solution to predict the data centre's power consumption and adapt to green hydrogen, underwater data centres minimising or even eliminating the need of cooling system.

Initiatives taken in India

3.97   India's natural resources, connectivity to global markets and strategic location at the junction of multiple submarine cables offers private players good incentives to invest in data centres. One of the market research reveals that potential Indian data centre investment can grow by almost USD $8 Billion from the beginning of 2021 to the beginning of 2025.[64] Recognising this, the Government of India released a draft 'National Data Centre Policy' in 2020. Several major states have also notified their respective data centre policies and others have signed MoUs with private players to develop data centres. Due to these efforts, the installed data centre capacity of India in terms of floor space is expected to grow at a CAGR of 6.5% from 584,000 m^2 in 2021 to 751,000 m^2 by 2025.

Figure 3.3: Indian Data Centre Market

Source : ResearchAndMarkets

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[64]https://www.researchandmarkets.com/reports/5312315/india-data-centre-landscape-2021-to-2025

3.98   These policies, however, ignore a very pertinent issue with data centres, which is their environmental impact. Data centres affect the environment in two major ways electricity consumption and water usage. They are online 24/7 and require power back-up and a captive power source, as well as a substantial volume of water to stay cool. They often have a deleterious impact on nearby watersheds along with emissions issues arising from the disposal of cooling water and heat dissipation.

3.99   Most countries don't require reporting of data centre-specific energy or environmental impact studies. The figures for India are also not available. But, the issue of the source of electricity is well known. At present, 59.1% of India's electricity comes from fossil fuels, with 51% of that from coal. In states with the largest number of data centre projects, namely Maharashtra and Delhi NCR, some 78%[65] and 85-90%[66] of the total electricity generated is from fossil fuel sources, and mostly coal. It seems unlikely that this expansion can be achieved without serious reliance on coal and fossil fuel-powered electricity.

3.100   National Data Centre Policy 2020, which is still in draft stage, encourages the use of "solar or wind" energy for data centres and for reduction of carbon footprint, but it does not mandate the use of green energy or a minimum threshold for use of green energy. So any measures to reduce the carbon footprint of data centres is at the initiative of the industry alone. The IGBC (Indian Green Building Council), a division of the Confederation of Indian Industry (CII), provides a green data centre accreditation consisting of various criteria and standards to assess efficiency and functioning of green data centres. The IGBC green data center rating system[67] addresses priorities like reduction in energy demand and related infrastructure, saving water, use of renewable energy

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[65]https://npp.gov.in/public-reports/cea/monthly/installcap/2021/DEC/capacity2-Western-2021-12.pdf

[66]   https://npp.gov.in/public-reports/cea/monthly/installcap/2021/DEC/capacity2-Northern-2021-12.pdf

[67] https://igbc.in/igbc/redirectHtml.htm?redVal=showgreendataenrenosign

resources, waste segregation and proper disposal, aiming to create new benchmarks amid national standards and codes.

3.101 In continuation of several initiatives to promote clean and green energy by Government of India, the Ministry of Power has notified the Green Open Access Rules, 2022 in which it has reduced the open access transactions limit from 1 MW to 100 kW for green energy to enable small consumers to purchase renewable power through open access.[68] As per these rules, any consumer with a connected load of 100 kW or above can get Renewable Energy through open access from any Renewable Energy generating plant set up by himself or by any developer. The application for open access can be made on a portal, which will allow consumers to access green power easily through transparent, simplified, uniform and streamlined procedure. Approval for Green Energy Open Access will be granted to a Consumer in a time bound manner within 15 days.

3.102 The Authority in its Recommendations[69] dated 18th November 2022 on "Regulatory Framework for Promoting Data Economy Through Establishment of Data Centres, Content Delivery Networks, and Interconnect Exchanges in India" has addressed this issue and has envisioned that "*the Indian Green Building Council (IGBC) along with Telecommunication Engineering Center (TEC) should be entrusted with task of framing certification standards of green DCs in India*". In the same recommendations it has also been recommended that *"Government should launch a scheme to incentivize (in the form of Government subsidy) implementation of innovative solutions and green initiatives by the DCs. For the same, it may invite Requests for Proposal (RFP) on an experimental basis for new technology/methods/processes that can be adopted for promoting green DCs."*

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[68] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1875269

[69] https://trai.gov.in/sites/default/files/Recommendations_18112022.pdf

3.103   The Authority has also recommended that *"For overall development of green data centers in India, energy-banking provisions for Data Centers and Data Center Parks producing renewable green energy should be facilitated by the Ministry of Power on yearly basis."* In the same recommendations it has been mentioned that states can also examine options of extending capital and interest subsidy to data centers or data parks that are ab-initio endeavouring and obtaining green data centre certifications. Availability of surplus power in Indian states and robust yet extensive fiberization is still insufficient to match global players. Thus, catching up on alternatives of renewable energy resources is a prerequisite. The Authority has further suggested that the rating system needs to be India-specific, pushing the requirement of national standards and codes to certify data centres operating under prevalent conditions, for instance, codes and standards applied by the NBC (National Building Code), ECBC (Energy Conservation Building Code), guidelines issued by the Central Pollution Control Board (CPCB) and the Ministry of Environment, Forest and Climate Change (MoEFCC).

3.104   Another grave issue, which needs to be addressed is the use of water by data centres. They use water for cooling purposes. The data of data centres' use of water is quite sparse. There is no law requiring the disclosure of water consumption by data centres, in the US or in India. Instead, examples of profligate water use only come to light due to disputes with local residents. For example, a major Google data centre in South Carolina, a water-deficit region, used up to 2.4 billion litres[70] of water every year. The Ministry of Water Resources in India has estimated that a total of 17 trillion litres[71] of water was used in all the industrial areas in India.

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[70]https://www.datacenterdynamics.com/en/analysis/data-center-water-usage-remains-hidden/
[71]https://science.thewire.in/environment/hidden-environmental-costs-india-data-centre-push/

3.105   According to World Bank, India has 18% of the world's population, but only 4% of its water resources.[72] The country has been facing water scarcity in nearly 21 major cities; the data hubs of Mumbai, Bengaluru, Delhi and Chennai are all likely to face major water crises, as per one NITI Aayog report. However, neither the draft National Data Centre Policy nor any of the extant state policies address the issue of water requirements of data centres. The absence of knowledge about the true cost of data centres in terms of water consumption means states continue to incentivise investments without asking for any data about water consumption – or the impact of such use on the water table and local residents. No laws mandate the use of sustainable water and conservation practices either.

3.106   The Authority in its Recommendations dated 18th November 2022 on "Regulatory Framework for Promoting Data Economy Through Establishment of Data Centres, Content Delivery Networks, and Interconnect Exchanges in India" has addressed this issue and has recommended mandatory rainwater harvesting and recycling arrangements to be included in Data Centre buildings and parks.

3.107   As India's own experience has shown, it is possible to conserve water and foster sustainable water use practices at scale. For electricity, it's important to actualise the shift to renewable energy. These issues can be addressed with incentivising schemes to support the development of 'next-generation green data center technology', the reporting norms, independent audits and proper planning. In the information economy of the 21st century, data centres present an incredible economic and strategic opportunity. However, it is important that we take the true costs of data centres into account and ensure that India's dreams of data sovereignty do not come at the cost of its people and its environment.

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[72]https://www.worldbank.org/en/country/india/brief/world-water-day-2022-how-india-is-addressing-its-water-needs

Chapter – 4

METAVERSE : OPPORTUNITIES AND CHALLENGES

I. Introduction

4.1 The metaverse is the key to the next wave of digital transformation. It creates an immersive space for interactions that are enabled by a range of technologies—including, but not limited to augmented reality (AR), virtual reality (VR), extended reality (XR), artificial intelligence (AI), internet of things, and digital twins. It has the potential of creating a simulated real-life environment where people can talk, work, and play using specialized glasses, headsets, controllers, and related resources. The Metaverse is currently all the rage in the digital world because of its seemingly endless potential and objectives. Industry players and investors are overwhelmingly looking for new use cases and monetisation opportunities from metaverse. It is an environment where the physical and digital worlds can coexist and significantly impact fundamental areas of daily life. It is a universe of limitless, interconnected virtual communities where people can socialize, collaborate, and have fun using virtual reality headsets, augmented reality glasses, smartphone apps, and other technologies.

4.2 The metaverse is a term that refers to a shared virtual reality where people can interact with each other and with digital content across different platforms and devices. The metaverse has been envisioned as a potential future of the internet, where immersive and social experiences are enhanced by technologies such as augmented reality, virtual reality, blockchain, artificial intelligence, and cloud computing. However, the metaverse also poses significant challenges for regulation, as it involves complex and novel issues such as data privacy, content moderation, intellectual property rights, digital identity, cybersecurity, taxation, competition, and governance. These issues require careful consideration and coordination among various stakeholders, such as governments,

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businesses, civil society, and users.

4.3   Web3 and Metaverse allow users to own and control their digital assets. These assets are stored in decentralized wallets and stay under the total control of the users. Both Web 3.0 and Metaverse provide immersive experiences to their users. Web3 and Metaverse are community-driven systems. Web3 relies on the active participation of developers, users, and other stakeholders to build and maintain the decentralized web. Similarly, Metaverse relies on its community to create virtual experiences and applications, govern the platform and make decisions about its future direction. In fact, Web3 is used to access the Metaverse immersive experiences. This consultation paper deals with the issues related to Metaverse in detail, because ultimately this is going to be the user interface in Web3.

4.4   Web3 and Metaverse will play an important role in building the next version of the Internet and leading the next wave of digital adoption for Indian industries. According to a recent report[73] released by Arthur D. Little, Web3 and Metaverse market opportunity in India is expected to grow at an annual growth rate of nearly 40%, with the potential to become a US $200 billion industry by 2035. This report has also projected Metaverse to become a US $13 trillion opportunity globally by 2030. It is estimated that about 8% of the $160 trillion global GDP by 2030 will come from Web3 and Metaverse. India's e-commerce penetration and its leadership in digital payments adoption presents an opportunity for Web3 and Metaverse technologies to enhance the retail and finance sectors. Investors, corporates, start-ups, government and regulators need to work together to help India realize the US $ 200 Bn potential in Web3 and Metaverse.

4.5   TRAI has organised various seminars and workshops on Metaverse to understand the subject and discuss the regulatory challenges involved in

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[73] Web3 and Metaverse could be US $ 200 Bn opportunity for India according to a new report released by Arthur D. Little - Technuter

detail. First such workshop was organised on 12th September 2022, in which various industry experts and legal experts were invited as speakers to express their opinions and views. Subsequently, TRAI Centre of Studies and Research (TCSR) in collaboration with FICCI organized another Seminar on "Metaverse – understanding & regulatory framework" on 5th Dec 2022. The industry experts from various think-tank organizations and subject-matter experts were invited for discussion & brainstorming on the topic. Another workshop on "Metaverse Introduction, Applications, and Upcoming challenges" was organised on 17th May 2023 in TRAI. With this background, the Authority has come out with certain policy and regulatory issues for consultation with the stakeholders to facilitate an orderly growth of Metaverse.

II. Building Blocks of Metaverse

Figure 4.1: Metaverse Stack
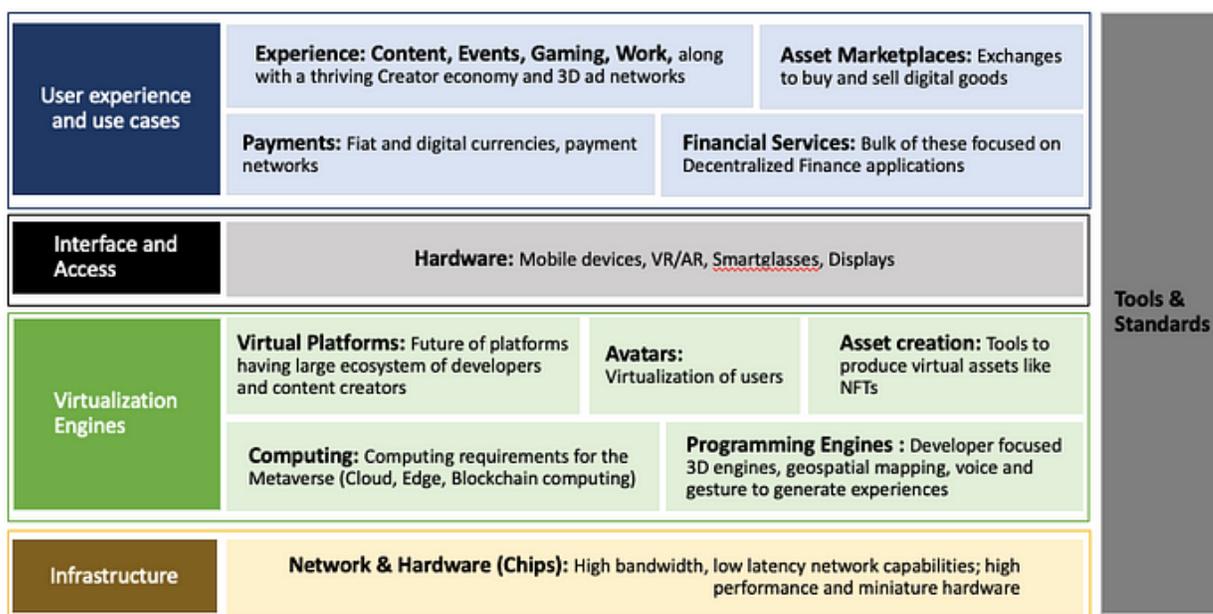
Source : Level Up Coding

4.6 The Metaverse stack (See Figure 4.1) is broadly consists of 4 layers, each of which along with their subcategories are critical building blocks. This layered architecture of the Metaverse give an idea about how the various technological building blocks will fit together in the stack, and also about

its flow. However, this stack is just a reference for the time being and is evolving and dynamic due to various developments taking place rapidly in the metaverse landscape.

4.7   Layer 1 i.e., the infrastructure layer includes the technology that enables our devices, connects them to the network, and delivers content. It consists of network and hardware. A major component of this layer is a reliable, high bandwidth and low latency network connectivity. 5G networks have the capability to fulfil these requirements of bandwidth and latency. 6G will improve these capabilities by yet another order of magnitude. Another major component of this layer is hardware inside the end user devices like smartphones to VR/AR devices to haptic devices and display technologies. These devices will require increasingly powerful and miniaturized processors, tiny sensors and long-lasting batteries.

4.8   Layer 2 i.e., the virtualization engine layer provides the computational and programming platform for the metaverse. The Metaverse will have the greatest ongoing computational requirements in human history. The ever-expanding need for computing power and its scarcity will need to be addressed by a combination of Cloud computing, Local computing, Edge computing and Blockchain computing. This layer also consists of virtual platforms on top of which the content creators and developers will built the immersive digital contents. Another major component at this layer would be Avatars. Avatars are the embodiment of Metaverse users. They are a person's identity in the Metaverse, allowing them to go on different adventures in different experiences.

4.9   Layer 3 i.e., Interface and Access layer helps users in accessing the Metaverse. It ranges from evolving smartphones to VR/AR headsets to future technologies like haptic devices and smart glasses. Smartphones are evolving towards absorbing more immersive applications and experiences from metaverse with further miniaturization, embedded AI technology and powerful sensors and low latency access to edge computing systems. Other Metaverse compatible devices include AR

glasses, VR headsets, haptic gloves, wrist bands, 3D-printed wearables, hologram displays, etc.

4.10 Layer 4 i.e., user experience and use cases layer is responsible for the creation, sale, trading, storage, payment and financial management of digital assets like content, games, shopping malls, movies, etc. This layer contains all business and services, which is built specifically for the Metaverse, independent of virtual platforms. Users can buy and sell goods with the help of non-fungible tokens (NFTs). It supports digital payment processes and platforms, including cryptocurrencies like bitcoin and ether and other blockchain technologies.

III. Critical Technological Components of Metaverse

4.11 Based on above discussions, we can say that the metaverse is technically complex since it is built from many technological components. The technologies that are needed for an effective metaverse deployment are discussed in the following sections.

A. Extended Reality

4.12 Extended reality is an umbrella term for all digital and physical reality combinations. This includes augmented reality (AR), virtual reality (VR) and mixed reality (MR).

4.13 Augmented Reality (AR) is a form of extended reality that essentially overlays the metaverse onto the physical world. AR superimposes virtual content onto the real world allowing users to interact with virtual content while continuing to see the "real" environment around them. The use of AR can allow for additional information such as directions, video, internet pages and more to be available to users through the use of an app on their smartphone (or other AR technologies such as glasses) in the real world. Augmented Reality can be used in multiple environments. AR use may help students become more engaged in the concept/topic at hand. Rather than just looking at the textbook, or watching a video, students can see the topic come to life in a 3D model through the use of the digital device.

By offering 3D visual representation and/or additional information, AR offers educators and students an opportunity to experience an engaging and hands on learning experience.

4.14   Virtual Reality provides users with the experience of engaging with the metaverse in an immersive fashion. VR technology, when paired with a headset, allows users to enter the virtual world. Fully immersive VR incorporates multiple senses to immerse users in the experience of a new reality fully. This includes sight, sound, and possibly even tactile feedback. Appropriate gear is used to stimulate each sense. This includes headsets, gloves, and goggles. A person is still present in the physical world when using VR, but interacting entirely with digital content. Surgeons have benefitted from the ability to practice their profession in a virtual environment. VR can provide visual and spatial simulation experiences by allowing the student to feel as though they are physically placed within the environment they are learning about.

Figure 4.2 : Reality Spectrum
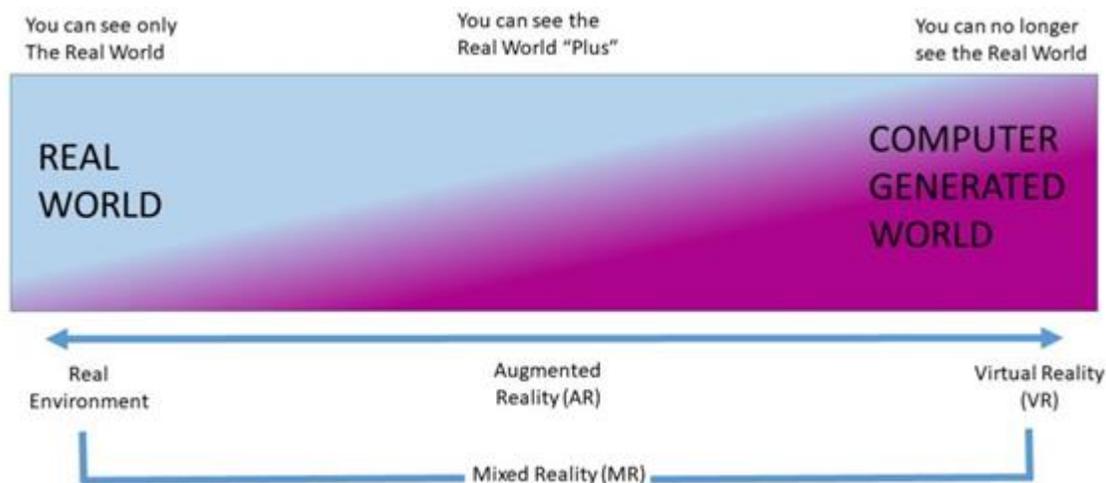
4.15   Mixed Reality (MR) is a blend of real world with virtual reality. In MR, users can interact and manipulate both physical and virtual objects using next generation sensing and imaging technologies. The experiences that can transition between augmented and virtual realities form mixed reality, where a user can place a digital object, such as a hologram, in the physical

world as if it were physically present. Or, the user may be personally and digitally present in the physical world, in the form of an avatar, to asynchronously collaborate with others at different points in time.

B. Blockchain

4.16   Blockchain is a public digital ledger system that can be used for executing transactions, smart contracts, and other agreements. Its power relies upon its decentralized nature as every transaction is stored on a distributed database in different locations. It records transactions chronologically and transparently protecting privacy and ensuring the fidelity of the data. It was first introduced in crypto currency market to store the transactions. These transactions or records being stored as blocks, are linked together using hashing mechanisms. It ensures the ledgers 'immutability'. In the context of the metaverse, blockchain paves the way for secure and decentralized transactions between users in the metaverse. The ability to create and own digital assets that can be traded and sold in the metaverse is another benefit of this technology. The metaverse eco-system relies on blockchain for accounting their content and transactions to ensure user integrity, privacy, and reputation.

C. AI and Machine Learning

4.17   Machine learning (ML) and other forms of artificial intelligence are rapidly gaining ground as critical tools for the development of intelligent and adaptive metaverse virtual environments. They can be utilized to make intelligent "characters" that interact with users, delivering a greater sense of life and personality to virtual environments.

D. Cloud / Edge Computing

4.18   Cloud computing is just as vital as AI and ML for constructing the metaverse. Both the processing power and data storage for massive metaverses can be available in the cloud. In addition, consumers can use

the metaverse from any device, because of cloud connectivity.

E.   5G Ecosystem: A necessity for Metaverse

4.19   Metaverse is envisioned as a seamless integration of the physical and digital worlds, where users can move between different platforms and devices without losing their identity or data. To realize this vision, a high-speed, low-latency, and reliable network infrastructure is essential. 5G will be the first generation of networks to successfully support the Metaverse and make it feasible for digital words to operate because of its high reliability, low latency, fast speed, and higher capacity. 5G is a necessity for the metaverse because it can provide the network performance, scalability, and flexibility that are required for a rich and realistic virtual world.

4.20   5G can enable immersive and interactive experiences in the metaverse, such as high-definition video streaming, cloud gaming, augmented reality, and virtual reality. 5G can also support massive connectivity of devices and sensors, enabling the creation of smart environments and digital twins that mirror the physical world. 5G can also enhance the experience of users in the metaverse, by providing a dedicated end-to-end network resource using network slicing. 5G can unlock the full potential of the metaverse and enable new possibilities for innovation, collaboration, and entertainment.

F.   Non-fungible Tokens (NFTs)

4.21   Non-fungible tokens (NFTs) are unique and verifiable digital assets that can be stored on a blockchain, a distributed ledger that ensures security and transparency. NFTs have a significant role to play in the metaverse. NFTs allow users to own and trade their digital creations and collections in the metaverse. NFTs encourage artists and creators to produce original and diverse content for the metaverse, as they can monetize their work and reach a global audience. NFTs also facilitate social and economic exchange, as users can join communities, participate in events, and

access platforms and services related to NFTs. NFTs are therefore essential for the development and growth of the metaverse, as they provide a way to create, own, and enjoy digital assets in a decentralized and secure way.

IV. Evolution of Metaverse

4.22 In the 1970s, MIT created the Aspen Movie Map, which enabled users to take a computer-generated tour of the town of Aspen, Colorado. This was the first time VR was used to transport users to another place. Metaverse made its first appearance only in 1992 when Neil Stevenson highlighted the concept of virtual reality through the characters of his novel 'Snow Crash.' Further in the early 90s, a firm called Sega launched VR gaming solutions such as SEGA VR-1 to offer immersive gaming experience to players in arcades. All these inventions can be seen as the starting push for the thriving Metaverse industry we are seeing today.[74]

4.23 In 2014, Sony and Samsung both announced they were creating their own VR headsets, and Google released its first Cardboard device and Google Glass AR glasses. Google's Cardboard device is a low-cost cardboard VR viewer for smartphones. Microsoft's HoloLens headsets hit the market in 2016, which provided mixed reality (AR and VR) experience for the first time. With HoloLens, we can create a holographic image in front of us, then put it into the real world and manipulate it using augmented reality. Also in 2016, the Pokémon GO augmented reality game gained immense popularity.

4.24 Swedish furniture giant IKEA joined the metaverse mix in 2017 with their innovative Place app, which allows its consumers to select a piece of furniture and view how it looks like in their home or office. In 2020, Apple added Lidar (Light Detection and Ranging) to iPhones and iPads, creating better depth scanning for better photos and AR, and also paving the way for mixed-reality headsets in the future. Metaverse was growing slowly and steadily, but the technology became the buzzword, when Facebook

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[74] Forbes: A short history of Metaverse

changed its name to 'Meta' in 2021 in a bid to show its newly developed focus in the sector.

4.25 The scope of Metaverse is expanding quickly. Where earlier it was limited to gaming projects, today the technology has become an inevitable part of multi-billion-dollar worth industrial realms. Its application is widely appreciated in the sports sector, entertainment world, business field, etc. Global music brands and producers are shifting to Metaverse for hosting concerts and interacting with fans. Popular sports clubs like Manchester City are building virtual stadiums for sports lovers to enjoy their favourite matches from the comfort of their homes.

4.26 Metaverse offers opportunities for brands and celebrities to launch their official merchandise for fans to purchase. A metaverse-based shopping mall has been opened by Middle East lifestyle and leisure conglomerate Majid al Futtaim.[75] The Mall of the Metaverse is based in the Decentraland platform and will offer "increased digital experiences across retail, entertainment and leisure offerings".

V. Metaverse Use Cases

4.27 Various industry verticals across the world have already deployed the metaverse use cases and are getting benefitted out of that. Even more promising use cases will be seen in time to come. Some current and potential use cases of metaverse technology are discussed below.

A. Healthcare

4.28 Metaverse has enormous potential for the healthcare industry. The growing use of VR in medical education, the application of AR in surgery, the use of gamification to link hospital personnel and patients, and other metaverse components are now playing a significant role in healthcare. In August 2022, the BBC reported that a group of international surgeons had been practising in virtual reality for months prior to successfully

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[75]   https://www.weforum.org/agenda/2023/03/metaverse-competition-regulation-and-other-stories-you-need-to-read-this-week/

separating two conjoined-headed twin children who were three years old.[76] After sharing important veins in their brains at birth, the two identical twins had to undergo seven surgeries. Surgeons from all around the world collaborated in virtual environments to plan and carry out the ground-breaking treatment with the aid of VR applications.

4.29   The global market for metaverse in healthcare is projected to grow at a CAGR of 35.28% and is expected to reach a valuation of $54.47 billion by 2030[77] (See Figure 4.x).

Figure 4.3 : Global Metaverse Healthcare Market Revenue
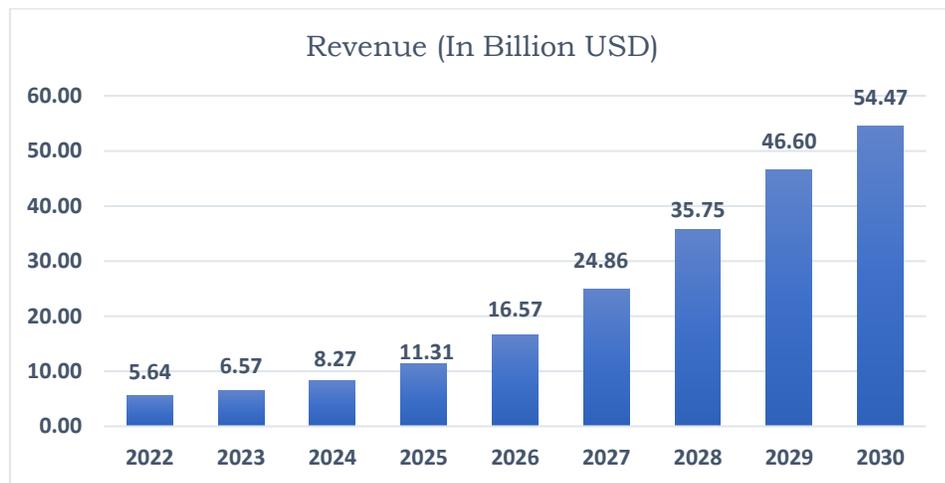
The Metaverse technologies are being used in several diagnostic and therapeutic applications, as well as in medical training. Some example use cases are discussed in following sections.

4.30   *Training, education, and skill building* - The metaverse's immersive capabilities like 3D visuals, 360 videos, haptics etc. allow cost-effective, fascinating, engaging and personalized learning experience. It enables medical staff onboarding, training, and upskilling with higher efficiencies on a larger scale at anytime and anywhere. Medical training is otherwise expensive and dependent on availability and cost of cadavers, equipment, and medical professionals. No risk simulations and gamifications are

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[76]   https://timesofindia.indiatimes.com/blogs/voices/future-of-metaverse-in-the-healthcare-sector/

[77]https://www.statista.com/outlook/amo/metaverse/metaverse-health-and-fitness/worldwide

powerful utilities that engage the user's sense of sight, hearing, and touch to create real-life experiences. It allows to train healthcare professionals on types of equipment and therapeutics. Metaverse also enables healthcare professionals to simulate the impact of a suggested treatment on the patient's body before it is applied. Pharma companies can simulate the experiences caused by various conditions and study their drug's performance. Some leading medical universities train surgeons in a virtual operating room with a table, instruments, and a virtual patient.

4.31   Patients with phobias like acrophobia are currently being treated by doctors by putting them in virtual environments to confront their concerns. VR is already used by psychologists and psychiatrists in aversion therapy, where patients can interact with situations that cause them anxiety, in safe environments where every aspect of the interaction can be closely monitored and controlled. Today, medical images—during radiology diagnosis—are visualized slice by slice on 2D screens. The metaverse technology enables advanced visualization of medical imaging and the patient's anatomy, improves error rates, speed, and outcomes. Metaverse technologies has the potential to enhance the value for disease analysis and surgical planning. The immersive and visualization capability of the metaverse can deliver more interactive and realistic medical experiences. Many healthcare providers are using AR to assist in medical procedures, including surgical preparation and execution in spine surgeries and catheter placement.

4.32   In India also the impact of the metaverse on clinical care is enormous. Surgeons are already using immersive technologies and robotics to perform minimally invasive surgeries. By getting a 3D image of a patient's body, surgeons can plan their surgical protocols ahead of time and using AR can get ideas on what obstacles lie ahead during the intervention. Now, India is set to get its first clinic in the metaverse. In August 2022, Hyderabad-based Yashoda Hospitals Group has acquired space on Decentraland (a metaverse platform where users can buy and sell property

and engage in shared digital experience) in order to set up a virtual clinic.[78] In February 2022, The Apollo Group of Hospitals announced a tie-up with California-based 8chili Hint VR platform. 8chili Hint VR is an end-to-end platform to manage metaverse strategy helping in original 3D content creation, metaverse customisation and delivery of this content across various metaverse real estate. The focus of VR in patient care would be for pre-post operative counselling, increasing patient outcomes by bringing in relaxing narratives that induce control over one's psychological responses. The VR will also help in a personalised approach to every patient.

4.33   Machenn Innovations, a virtual reality-based training startup in India, offers a cloud-based platform that provides access to more than 1000 medical equipment virtual training programs. The virtual training platform helps medical equipment professionals, engineers, and healthcare professionals access training related services. There are about 5.2 million medical errors registered annually that result in 83,000 deaths and 1.7 million injuries associated with inappropriate medical device usage.[79] These errors are committed by low skilled employees who are less trained in handling sophisticated medical equipment aided with advanced digital technology. There is also a dearth of skilled trainers and the medical equipment industry is also manpower- and financially-intensive. There is also a fear of equipment damage during classroom-based hands-on training programs. VR-based training overcomes all these limitations.

B.   Metaverse in Manufacturing

4.34   Metaverse has the potential to be used in variety of ways in manufacturing. There are several potential Metaverse use-cases in manufacturing such as virtual prototyping, virtual training, virtual

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78https://www.firstpost.com/india/explained-into-the-metaverse-hyderabads-yashoda-hospitals-becomes-first-indian-healthcare-group-on-platform-10828881.html

79   https://www.linkedin.com/pulse/daw-metaverse-indias-digital-healthcare-anusha-ashwin

assembly and virtual collaboration. One potential application of metaverse in manufacturing is as a platform for collaboration and communication among distributed teams. For example, team members could meet in a virtual factory floor to discuss and work on projects in real-time, regardless of their physical location.

4.35   Digital twin of the factories can be built to simulate and evaluate realtime data from plant operations to suggest changes. This data can then be utilized to create new workflows and streamline a business's processes. Several car manufacturing companies have begun to use the metaverse to improve their industrial processes. Hyundai Motor Company and Unity, a platform for developing real-time 3D content, announced a collaboration plan to design a Meta-Factory for the 2022 Consumer Electronics Show (CES). The concept involves creating a digital twin of a physical factory, which is supported by a metaverse platform, with the purpose of optimizing operations and resolving issues in a virtual area.

4.36   Several manufacturing companies have begun training staff on how to use and maintain equipment using VR headsets rather than real equipment that can be unsafe or difficult to use in a training scenario. Furthermore, rather than having employees sit in a classroom all day, immersive learning, which blends the sensation and presence of VR with learning theory, data science, and architectural design, enhances the learning experience for employees, particularly younger ones. For example, because training JetBlue mechanics with real planes is expensive and time consuming, the company implemented a VR solution in collaboration with software developer Strivr.[80] The tool allows technicians to simulate touching a jet in the most realistic way possible, but without the time, money, and risk of the physical environment.

4.37   Field service people and technicians, like new frontline workers, can benefit from AR, VR, and MR technologies for equipment maintenance and

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[80] https://rejolut.com/blog/metaverse-in-manufacturing-industry/

support. Support teams don't need to travel all the way and are able to provide remote help using VR/AR technologies. Another significant area is in product design for manufacturers. With virtual reality, design engineers from all around the world can cooperate remotely to build a virtual design. Automotive firms develop automobiles by starting with clay models that anybody can create visually. They are then designed in CAD software and using mixed reality - AR and VR - taken in 3D and others are invited to input on the car design.

C. Remote virtual office

4.38 Remote working has become a trend in the last few years, and the pandemic has only accelerated this trend. One of the biggest challenges of remote work is staying connected with team and maintaining productivity. In such a scenario, Metaverse can be used for various purposes, including virtual collaboration, team-building exercises, and much more. Nowadays, work meetings are usually held online via Microsoft Teams or Zoom. However, metaverse technology can help create a virtual office space for the team, so that everyone can meet and work together in real-time, regardless of location. It can help to improve communication and collaboration among the team members.

4.39 As metaverse provides the 3D environment, it also could add some fun and excitement to employees' workday. With customisable digital avatars, employees could visit a virtual meeting room, walk up to a virtual help desk, have a chat, or relax with colleagues in a networking lounge. For example, Vice Media Group has teamed up with Bjarke Ingels Group to create "Viceverse"[81], a digital headquarters in the metaverse. This virtual office allows for meetings, briefings, presentations and demonstrations of metaworld experiments, as well as experimenting with NFTs and Web 3.0.

D. Interactive and Immersive learning

4.40 In the education sector, metaverse can be used for interactive and

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[81]https://www.campaignlive.co.uk/article/viceverse-opens-its-virtual-doors-inside-the-culture-future/1747945

immersive educational experiences. Regarding professional training, metaverse can create an immersive learning environment to help learners absorb information more effectively. In addition, the pace of metaverse-based learning can be adjusted according to learners as they can explore virtual worlds at their own pace and revisit concepts as needed. When it comes to remote learning, metaverse has created new learning opportunities by giving the fundamental subject content in an improved and coordinated manner. The students can interact with variety of objects related to concepts to get a better understanding and enhancement of learning opportunities. As per Statista, the number of users in the metaverse education market is anticipated to reach 14.84 million by 2030.[82]

4.41   One of the benefits of using VR and metaverse for virtual training is that learners can be exposed to realistic scenarios. For example, in a healthcare simulation, learners can practise treating patients in a safe and controlled environment. Such exposure can help professionals become more comfortable with procedures and protocols before facing them in the real world.

4.42   Another benefit of using virtual space for learning is that learners can receive real-time feedback. This feedback can help learners improve their skills and make the most of their training time. Virtual learning can also help establish effective communication by eliminating the language barrier. It could help people from different countries to study in a single digital space without social or linguistic complications. Here are some real-world examples of Metaverse enabled learning experiences.

4.43   Here are some of the leading examples from academic world on the adaptation of Metaverse and its related technologies. The "Virtual Harvard"[83] project is a project by Harvard University to create a virtual campus accessible by everyone through Metaverse. Stanford University

[82] https://www.analyticsinsight.net/how-metaverse-is-impacting-home-schooling-in-india/
[83] https://www.thecrimson.com/article/2021/10/21/virtual-harvard-project/

has conducted "Virtual People"[84] class for over 200 students in the Metaverse. Many universities such as the University of Western Australia, the University of South Florida are using "Second Life"[85] for creating VR content. At the Western Michigan University, Virtual Reality Lab offers the students the opportunity to learn in the virtual world. University College London is involved in providing medical surgical training to its staff and students through immersive VR training sessions. These are some of the examples, however, many universities around the world have piloted various initiatives that use AR/VR and Metaverse to support the learning and teaching activities.

4.44   In India, the National Education Policy (NEP) intends to assimilate Artificial Intelligence into the Indian Education system. From this we can conclude that the Metaverse, with its inclusivity and new approach, can bring exciting changes in this sector for both the teachers and the students. In addition, efforts are also being made by education sector for learning metaverse, because skill development in this innovative technology is a prerequisite for development and deployment of country-specific use cases. In June 2022, IIT-Jodhpur launched a part-time online M.Tech programme for working professionals in AR and VR for the semester commencing 2022-23. And more recently, IT major Tech Mahindra is collaborating with Mahindra University to set up a Makers Lab to promote research and development in quantum computing, XAI (explainable AI) and metaverse.

E.   Metaverse in Travel and Tourism

4.45   Metaverse is the next defining moment for the Tourism industry. It can provide people, who might not be able to travel physically, a way to explore the world. Some organisations are already providing virtual 3D versions of real-life spaces and locations. For example, it is now possible to explore

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[84]   https://news.stanford.edu/2021/11/05/new-class-among-first-taught-entirely-virtual-reality/

[85] https://secondlife.com/

the Louvre Museum, Paris, in VR. Virtual visitors can view exhibitions, enjoy concerts, or even meet friends for a virtual stroll around the museum. However, the benefits of metaverse tourism should not cause panic in the tourism and hospitality sector. Virtual travel experiences in the metaverse would not affect bookings for physical vacations. As a matter of fact, the metaverse would offer a new instrument for the tourism and travel industry to connect with consumers.

4.46   Virtual tourism provide new and better travel inspiration sources to the prospective travellers for an upcoming trip. Travellers who take a VR tour of a location or use VR to try out an experience are more likely to book the real thing. One example would be Thomas Cook's VR excursions of Manhattan, which offered visitors to their stores a five-minute *"taster"* of the city. The company saw a 190 per cent increase in related bookings.[86] Metaverse travel could also make the booking experience more pleasant and engaging, something which an online booking app or website just can't provide. It will be possible to let travellers inspect hotel rooms and other spaces before they book. For example, a traveller can use virtual tours of two different hotels in the metaverse to find the better choice for vacation.

4.47   Metaverse travel is also providing new ways to conduct trade shows and expos. In 2022, students from Assumption University's tourism programme designed and realised a three-in-one expo in the metaverse, featuring career, travel and tourism expos. Event Management students developed virtual exhibition booths to showcase travel brands like Hyatt, Hilton and Marriott-Starwood, focusing on career opportunities. The benefits of metaverse tourism can also introduce promising improvements in marketing opportunities for tourism and hospitality organizations. Businesses can offer immersive experiences in their marketing strategies

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[86] https://www.revfine.com/metaverse-travel/

with a more immersive demonstration of their products and services.

VI. Need for an orderly growth of Metaverse

4.48   Some estimates suggest that the metaverse market could be worth up to US$13 trillion by 2030[87]. The size of the metaverse will make it hard to ignore and denotes its influence over the way people will live, work and play. Many things that people do today on the internet, may soon be done in the metaverse instead. Regulators and policy makers around the world have started noticing that. The shift to a more virtualized and interactive environment will require regulators to update their existing regulation in a wide range of spheres.

4.49   As application scenarios mature, the Metaverse will develop into an exceptionally large-scale, extremely open, and dynamically optimized system. When any market receives investment in millions of dollars of hard-earned money, legal and regulatory frameworks become a necessity to ensure a degree of ethics, trust, and diligence. To create a system that can support various virtual reality application scenarios, creators from different fields will work together. One of the main challenges in regulating the metaverse is the fact that it is decentralized. No single organization owns the metaverse. The infrastructure is not subject to any one country's rules or regulations. It can't easily be blocked or manipulated. The technologies, the infrastructure and the data are at nobody's mercy. The other challenge with decentralization is that it is driven by consumers. Which means Governments need to think carefully about how they will insert themselves into the conversation. Ultimately, people want regulation to protect them, but understanding where that line is now drawn is becoming increasingly challenging.

4.50   Governments could also play a more proactive role in helping solve the need for identification and authentication in the metaverse. Greater virtualization requires participants to have greater levels of trust. People

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[87]   https://www.precedenceresearch.com/metaverse-market

will want to know they are transacting with legitimate sources, that they are receiving services from certified professionals and that they will be recognized as themselves when they need to be.

4.51 Another major challenge that attracts the attention of policy makers and regulators is the safety, privacy and well-being of billions of users at stake. Ensuring trust and transparency in metaverse is essential to instil confidence among the consumers for its adoption. If we do not start a movement of forging trust and safety for the digital spaces where we live, work and play, the next generations may inherit a digital world polluted by predators, hate speech and mistrust. Hence, it is important that regulators across the world get on board sooner and put in place necessary guidance or frameworks fit for metaverse. Then only its benefits will be visible across the economies and societies.

4.52 The characteristics of the metaverse are likely to also create several new questions and challenges that regulators will need to grapple with. How will intellectual property created in the metaverse be protected? How will virtual property sales be taxed? How will antisocial behaviour (such as bullying or indoctrination) be monitored and controlled? How will identities be established, or certifications authenticated? How will healthcare and personal data be handled in virtual settings? Many more such questions and challenges for regulators will arise in time to come. The reality is that the metaverse is big, it's inevitable and it is going to require a lot of regulatory guidance.

International Experience

4.53 In April 2023, the **European Commission** launched a public consultation[88] to "develop a vision for emerging virtual worlds (e.g. metaverses), based on respect for digital rights and EU laws and values". The objective of this consultation is to ensure that open, interoperable, and innovative virtual worlds can be used safely and with confidence by

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[88] [Regulating the Metaverse in Europe | Global Policy Watch](#)

the public and businesses. The European Parliament is also working on its own-initiative report on opportunities, risk and policy implications for the metaverse. In response, the European institutions are gearing up to facilitate (and most likely regulate) the development of the metaverse in Europe. This includes the development of digital infrastructure, education of citizens and companies, and highlighting the potential to improve the lives of citizens and the daily operations of industry.

4.54   In September 2022, **South Korea**'s Ministry of Science and ICT (MSIT) announced that it would develop new Metaverse regulations to encourage widespread adoption of the Metaverse.[89] This means that MSIT, South Korea is not going to regulate this new service with existing law. Over the last few years, South Korea is also making efforts to promote the use of Metaverse in the country. One such initiative is the recent $200 million investment to establish a national Metaverse. MSIT is of the opinion that that applying old laws to a new industry like the Metaverse will stifle its long-term growth and innovation.

4.55   In July 2022, **Japan**ese Ministry of Economy, Trade and Industry (METI) has established an office named the "Web 3.0 Policy Office" under the Minister's Secretariat. The office has the mandate of strengthening the framework for developing the business environment in relation to Web 3.0. It will serve as a Cross-Departmental Internal Organization, bringing together departments responsible for industrial finance, taxation, and corporate system, media and content, sports, fashion, and the other related industries. Web 3.0 is a term used to describe the third iteration of the internet that is powered by blockchain-related technologies like non-fungible tokens (NFTs) and digital assets for creating value and managing data. Japan has realised that due to the younger generation's interest in Web 3.0, the digital assets and spaces become more important

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[89] South Korea's MSIT Reveals Plans To Enact Special Metaverse Laws - Forbes India

to its economy.

4.56   The **US** Congress is more likely to take a 'wait and watch' approach to metaverse regulation. The CHIPS and Science Act was passed in 2022, which will see billions of dollars in emerging technologies research funding. The initial focus of US Congress will be ensuring US companies' competitiveness in the field and exploring the enabling technologies of the metaverse, such as blockchain, VR and AR.[90]

4.57   In **China**, a metaverse industry group, the Metaverse Industry Committee, was formed under the state-supervised China Mobile Communications Association, in December 2021. The committee has the stated objectives of strengthening innovation and integration among metaverse builders, organizing the training of professionals, and promoting new thinking. In addition, cryptocurrencies have been banned in China since September 2021, with concerns over their potential impact on China's financial markets and currency stability.

4.58   In May 2022, the **World Economic Forum** (WEF) launched the "Defining and Building the Metaverse" initiative.[91] The goal of the initiative is to build consensus among major metaverse stakeholders and contribute to a future metaverse that is economically viable, interoperable, safe, equitable and inclusive. This initiative has brought together a global, multisector working group of more than 100 experts in academia, civil society, government, technology and business. All insights, frameworks and guidance published in the frame of this initiative are being co-designed and guided by this working group via two tracks: *governance* and *economic and social value creation*. The value creation track looks at the opportunities in consumer, industrial and enterprise metaverses. Meanwhile, the governance track focuses on governance frameworks that may empower stakeholders to lead responsibly within the metaverse while

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[90] GSMA | The Year Ahead in Digital Policy: Regulating the Metaverse | Public Policy

[91] https://initiatives.weforum.org/defining-and-building-the-metaverse/home

mitigating potential socioeconomic harms.

4.59 Ultimately, industry collaboration will be crucial to ensure open standards. In June 2022, technology companies and standards organisations have jointly launched the Metaverse Standards Forum[92] to develop industry guidelines that ensure immersive VR worlds are compatible. The group will explore coordination and interoperability standards via consistent terminology, deployment guidelines, testing and adoption of standards to deliver an open and inclusive metaverse. XR Association[93] is another such multistakeholder initiative leading the way for the responsible development and adoption of XR. The XR Association represents the broad ecosystem of the XR industry including headset manufacturers, technology platforms, component and peripheral companies, internet infrastructure companies, enterprise solution providers, and corporate end-users.

Initiatives taken in India

4.60 Since 2015, India has risen almost 41 places in the Global Innovation Index[94], now ranking 40th in the world and first among the lower middle income group countries. India also has a thriving culture of entrepreneurship, which has recently experienced significant growth. In 2021, a record 44 unicorns were created in India with a total valuation of $ 93.00 Bn.[95] The use of digital payment mechanisms has grown rapidly. Furthermore, consumption of video streaming and gaming in India has also been increasing at a scorching rate. India is the world's largest mobile gaming market in terms of App downloads. The sector is expected to grow by 20% by FY25 to reach INR 231 Bn.[96]

4.61 These developments in the country have been taking place within the broader context of the Government of India trying to foster a digital

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[92] https://metaverse-standards.org/
[93] https://xra.org/
[94] Source: Global Innovation Index Database, WIPO, 2022.
[95] https://www.investindia.gov.in/indian-unicorn-landscape
[96] https://www.investindia.gov.in/sector/media/gaming

economy worth up to \$1 trillion by 2025.[97] It has developed incentives and policies for technologies and industries that could be viewed as forming the building blocks of the metaverse. Its National Blockchain Strategy was released in December 2021.[98] Reserve Bank of India has launched pilots of Central Bank Digital Currency (CBDC) in both Wholesale (for interbank transactions) and Retail (for the public) segments. In December 2022, Government of India has launched the new draft policy for the Animation, Visual Effects, Gaming, and Comics and Extended Reality (AVGC-XR) sector, at the national and state level with an objective to boost India's domestic capacity and develop opportunities in the industry.

VII. Policy Challenges and issues for consultation

A. Creating Awareness

4.62 The metaverse is not a distant or hypothetical concept. India has a unique opportunity to shape and benefit from this emerging phenomenon. However, this requires creating awareness about the metaverse among its diverse and dynamic population. By doing so, India can not only join but also lead the global movement towards a more connected, creative, and collaborative future. Therefore, it is important to create awareness about the metaverse among the citizens of India. Creating awareness about the metaverse can help India leverage its strengths in information technology, innovation, and creativity to become a leader in the development and adoption of the metaverse. It can enable India to address some of its pressing issues, such as access to quality education, health care, and employment opportunities, by using the metaverse as a platform for delivering inclusive and affordable solutions. It can foster a culture of digital citizenship and literacy among Indians, who can learn to use the metaverse responsibly and respectfully, while also protecting their rights

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[97] https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=1565669
[98] NATIONAL STRATEGY ON BLOCKCHAIN (psa.gov.in)

and interests. In view of this, the opinion of stakeholders is solicited on:

Q.16. **What are the policy measures required to create awareness and promote use of Metaverse, so that the citizens including those residing in rural and remote areas may benefit from the Metaverse use cases and services to create new economic activities and increase employment opportunities and thereby promote economic growth of the country?**

B. Privacy, Safety and Security

4.63 Over the last two decades, technology companies have made a science of tracking and characterizing users on their platforms, as it enables the targeted advertising. Such targeting has been a boon for advertisers and a windfall for media platforms, resulting in some of the most valuable corporations in history. Unfortunately, such targeting has exploited consumers, reduced personal privacy, and has made social media a polarizing force by allowing third-parties to deploy customize messaging that is skilfully aimed at very specific demographic groups. This tactic has had the widespread effect of amplifying existing biases and preconceptions in populations, radicalizing political views and spreading misinformation.

4.64 In the metaverse, these problems are likely to get significantly worse. Because the technology will not just track where users click, but where they go, who they are with, what they do, what they look at, even how long their gaze lingers. Immersive platforms will also track facial expressions, vocal inflections, and vital signs, while intelligent algorithms use such data to predict each person's real-time emotional state . Tracking will also include real-time monitoring of user gait and posture, assessing when users slow down to browse products or services. Metaverse platforms will even monitor manual reach, assessing when users grab for objects (both real and virtual) and tracking how long they hold the objects to investigate. This will be especially invasive in the augmented metaverse in which user gaze, gait, and reach will be monitored in the real world, for example while

shopping in augmented physical stores.

4.65 Hence, metaverse raises critical issues like privacy, safety and security which require greater deliberation. All the challenges that we currently have in online applications, such as snooping, data breaches, harassment, and hate speech are likely to be amplified in coming times with increased digitisation and online activities. As in the case of any other technology, data lies at the centre of the development of the metaverse. The rise in virtual interactions and the unique features of the metaverse means greater sharing of data. This may lead to a surge in threats of data breaches and concerns around how technology companies collect and process the personal data of people. These concerns are all the more prominent for countries like India that still do not have a dedicated data protection legislation.

4.66 In addition to data theft concerns, the increase in virtual interactions and the growth of concepts like digital avatars will make the tracking of cybercriminals and interception of illegal content more pernicious. The questions of legislations and jurisdictions that will be applicable in this boundless digital world is also a prominent concern requiring consideration by lawmakers. In view of this, the issue on which the stakeholders need to deliberate is:

Q.17. Whether there is a need to develop a regulatory framework for the responsible development and use of Metaverse? If yes, kindly suggest how this framework will address the following issues:

i. **How can users control their personal information and identity in the metaverse?**

ii. **How can users protect themselves from cyberattacks, harassment and manipulation in the metaverse?**

iii. **How can users trust the content and services they access in the metaverse?**

iv. **How can data privacy and security be ensured in the metaverse,**

especially when users may have multiple digital identities and avatars across different platforms and jurisdictions?

C. Experimental Campuses

4.67 While the technical, demographic and policy foundations for the metaverse appear to be present in India, there remains the operational challenge of building the metaverse. For an orderly growth of an innovative technology like Metaverse, there is a need to provide a conducive environment for testing and validating new technologies and applications that can enable the creation and integration of virtual worlds with the physical world. Such technologies may include immersive interfaces, spatial computing, blockchain, artificial intelligence, and 5G/6G networks.

4.68 It is also required to foster cross-disciplinary and cross-sectoral collaboration among various stakeholders who can contribute to the development and adoption of the Metaverse. These stakeholders may include academia, industry, government, civil society, and end-users. By working together, they can share knowledge, resources, and feedback, as well as identify and address the opportunities and challenges of the Metaverse. In order to attract more investment and support for its further development and expansion, the outcomes and impacts of the Metaverse projects need to be showcased and disseminated to the wider public and potential partners. Experimental campuses in India can foster the development of metaverse use cases. In view of this the question arises is:

Q.18. Whether there is a need to establish experimental campuses where startups, innovators, and researchers can collaborate and develop or demonstrate technological capabilities, innovative use cases, and operational models for Metaverse? How can the present CoEs be strengthened for this purpose? Justify your response with rationale and suitable best practices, if any.

D. Interoperability

4.69 Building the metaverse environment requires interconnection and

interoperability among many devices and platforms across the digital ecosystem. Major tech companies are rapidly shaping the metaverse environment building blocks and will likely take a lead in defining technical standards and protocols, which may be their proprietary solutions. This will provide these companies with unparalleled opportunities to monopolise digital markets. To prevent such undue advantage to these selected market players, efforts are required for the development of open Metaverse standards. Such protocols and standards may be essential for fostering innovation, collaboration and inclusion in the metaverse ecosystem. Open interoperability protocols and standards will enable different metaverse platforms and applications to communicate and interact with each other seamlessly. It will also help in building an affordable device ecosystem for the users.

4.70 The metaverse consists of many spaces, and new spaces might be included over time. Users might expect that their avatar and properties bought in one digital space, can be used in another digital space. For example, a buyer can bring its digital wallet into a virtual world hosted by another provider.This requires standardization and interoperability among the spaces making up the metaverse. With open interoperability standards in place, the users may bring and use assets from one space into other spaces By choosing either a trusted third-party intermediary or self-management with decentralized data stores, a user can create a single interoperable token that provides authentication into multiple different independent services, devices, platforms and systems. It will allow users and stakeholders to benefit from frictionless development and experience.

4.71 The **ITU-T Focus Group on metaverse (FG-MV)**[99] was established in December 2022 to lay the groundwork for technical standards to help everyone benefit from metaverse services. At present, FG-MV comprises

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[99] https://www.itu.int/hub/2023/04/metaverse-focus-group-calls-for-contributions/

eight working groups as mentioned in the following table:

Table 4.1 : ITU Metaverse Focus Group – Working Groups

	FG-MV Working Groups	Mandate of the Working Group
1	**General**	Build clarity around key metaverse concepts, service models, and enabling technologies for metaverse platforms and services.
2	**Applications and Services**	Document envisaged use cases of metaverse applications and their technical requirements.
3	**Architecture and Infrastructure**	Network architectures and networking and computing infrastructure.
4	**Virtual/Real world Integration**	structured data models and application and service integration between virtual and real worlds
5	**Interoperability**	technical requirements for interoperability across metaverse platforms, applications, and services.
6	**Security, Data & PII [personally identifiable information] Protection**	necessary building blocks with respect to data and digital asset ownership and their security dimensions.
7	**Economic, Regulatory & Competition aspects**	Analyse metaverse value chains and identify questions for the consideration of regulatory authorities.
8	**Sustainability, Accessibility & Inclusion**	explore social and environmental dimensions of metaverse sustainability, promoting diversity and inclusion and specific consideration of the needs of persons with disabilities.

In view of the above, the opinion of stakeholders are solicited on the following issue:

Q.19. How can India play a leading role in metaverse standardization work being done by ITU? What mechanism should be evolved in India for making an effective and significant contribution in Metaverse standardisation? Kindly provide elaborate justifications in support of your response.

E. Governance & Oversight

4.72   The metaverse is still in the research phase, and regulatory policies need to be developed for the society to benefit from the opportunities offered by the metaverse. It is essential to secure networks, build confidence in the metaverse through open standards and interoperability, and focus on personal privacy, security, data protection, and child rights. As the metaverse grows and evolves, it will pose new challenges for various stakeholders, such as users, developers, platforms, regulators, and society at large. Therefore, there is a need for collaborative approach for regulation of the metaverse to ensure its positive impact and value creation for society.

4.73   Governance is needed for operating the metaverse to ensure consistency, transparency, accountability, and safety. As discussed earlier, metaverse encounters governance challenges due to its decentralized nature. **Mirror governance** is a concept that refers to the alignment of the interests and incentives of different stakeholders in a decentralized system. It is a concept that explains how a decentralized organization can align its governance structure with the governance structure of the blockchain platform that supports it. By doing so, the organization can achieve more consistency, transparency, and accountability in its decision-making processes, as well as benefit from the security and scalability features of the blockchain technology. Mirror Governance can be implemented using smart contracts, DAOs (decentralized autonomous organizations) etc., to create self-governing entities that operate according to predefined governance rules and logic, without human intervention or intermediaries.

4.74   To take advantage of the benefits of the metaverse, there is a need to create a governance environment that fosters interoperability and security. Global regulatory discussions should take place to ensure that the metaverse is accessible to all and that its governance has community input. Efforts should also be made to bridge the digital divide and create opportunities for education using the metaverse. As the metaverse has the

potential to generate significant economic value, Governments and industry must work together to train the skilled workforce necessary to create and develop the metaverse. Additionally, governments and stakeholders must balance needs of public and private sector stakeholders to ensure that the metaverse benefits all. Hence, the opinion of stakeholders is solicited on the following issue:

Q.20. **(i) What should be the appropriate governance mechanism for the metaverse for balancing innovation, competition, diversity, and public interest? Kindly give your response with reasons along with global best practices.**

(ii) Whether there is a need of a national level mechanism to coordinate development of Metaverse standards and guidelines? Kindly give your response with reasons along with global best practices.

F. Content Moderation

4.75 The immersive and interactive nature of the metaverse has the potential to transform user experiences and to allow brands to build more meaningful relationships with consumers. In doing so, metaverse is enabling children and adults from every corner of the planet to learn and experience things that was unavailable to them till now. Web2 era has taught us that anonymity and online culture can bring out the worst in some people. The online disinhibition effect will be more profound in the immersive and virtual world with an increasing potential for invasive and damaging abuse.

4.76 The metaverse's safety problem is complex and opaque. Journalists have reported instances of abusive comments, scamming, sexual assaults, and even a kidnapping orchestrated through Meta's Oculus.[100] Metaverse is considered to be an evolution of social media, but due to its immersive

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[100]https://www.technologyreview.com/2023/04/28/1072393/undercover-content-moderator-polices-the-metaverse/

nature it requires a completely different moderation technique. The tools built to deal with the billions of potentially harmful words and images in the two-dimensional web would not work well in VR. Adults with predatory intentions trying to form trusted relationships with minors, is also a real challenge. When the content/application providers are not able to filter out and prevent this abuse proactively, users are tasked with reporting and catching the bad behaviour. Relying on users to report potentially traumatic things that have happened to them or potentially dangerous situations is not desirable. The onus should not be on the children to have to report that by the time any potential trauma or damage is done.

4.77   The metaverse is a new and emerging digital space that offers unprecedented opportunities for creativity, collaboration and social interaction. However, it also poses significant challenges for content moderation, as it involves diverse platforms, technologies and communities with different norms and expectations. There is a need to identify best practices, common standards and ethical principles for ensuring a safe and respectful environment for all users. To address these challenges, consultation with stakeholders is solicited on the following:

Q.21.   Whether there is a need to establish a regulatory framework for content moderation in the metaverse, given the diversity of cultural norms and values, as well as the potential for harmful or illegal content such as hate speech, misinformation, cyberbullying, and child exploitation?

Q.22.   If answer to Q.21 is yes, please elaborate on the following:

   i.   **What are the current policies and practices for content moderation on Metaverse platforms?**

  ii.   **What are the main challenges and gaps in content moderation in the Metaverse?**

 iii.   **What are the best practices and examples of effective content moderation in the Metaverse or other similar spaces?**

iv. **What are the key principles and values that should guide content moderation in the Metaverse?**

v. **How can stakeholders collaborate and coordinate on content moderation in the Metaverse?**

G. **Intellectual Property Rights (IPR)**

4.78 The protection of intellectual property and ownership is a very important legal issue that is likely to emerge in Metaverse. One of the main issues is the lack of clear ownership and attribution of digital assets and creations in the metaverse. If creations are built by Artificial Intelligence, then it is difficult to accord it IPR protection since currently only a work emerging from a human being is considered copyrightable. Protecting the IPR of content creators will also be a challenge considering the difficulty in tracking copyright infringements in the virtual space.

4.79 Another issue is the jurisdictional complexity and uncertainty of the metaverse. The metaverse is not bound by physical borders or national laws, but rather by the rules and policies of different platforms and service providers. This creates a potential for conflicts and inconsistencies among different legal systems and regimes. These IPR issues need to be addressed and resolved in order to foster innovation, creativity, and trust in the metaverse. The stakeholders involved in the development and governance of the metaverse should collaborate and cooperate to establish clear and fair rules and standards for IPR protection and enforcement in the metaverse. The users should also be aware of their rights and responsibilities as creators and consumers of digital content in the metaverse.

4.80 The existing legal framework may not be adequate to address the IPR issues in the metaverse, such as infringement, ownership, licensing, and enforcement. Therefore, some modifications are required in the legal framework to address these issues. In view of this, the inputs of

stakeholders are invited on the following issue related to IPR:

Q.23. Please suggest the modifications required in the existing legal framework with regard to:

   i.   **Establishing mechanisms for identifying and registering IPRs in the metaverse.**

   ii.   **Creating a harmonized and balanced approach for protecting and enforcing IPRs in the metaverse, taking into account the interests of both creators and users of virtual goods and services.**

  iii.   **Ensuring interoperability and compatibility of IPRs across different virtual environments. Kindly give your response with reasons along with global best practices.**

Chapter – 5

## DIGITISATION, MONETIZATION & SHARING OF DATA

I. Introduction

5.1 5G is set to become a connectivity fabric that connects people, devices, machines and ecosystems. Promising use-cases like smart farming, remote healthcare, industry 4.0, immersive and interactive learning using AR/VR, etc. could go a long way in enabling the success of India. With emerging technologies like massive IoT, AR/ VR, AI, robotics, etc. 5G in India will be an enabler for this digital transformation. With increasing digitization enabled by 5G, the volume of data will increase exponentially, providing opportunities for better governance and service delivery. India's ambitions of becoming a $5 trillion-dollar digital economy depends on its ability to harness the value of data. The process of extracting economic value out of data and information is referred to as Data Monetization.

5.2 Data monetization has become a critical aspect of the digital transformation journey for organisations. With the emergence of the data economy, the volume, velocity, and variety of data available are overwhelming. IDC has estimated that 95% of organizations will consume some form of outside data KPIs digitally by 2023. However, gaining access to the right data is challenging. In a recent study conducted across 34 countries, it was found that only 1 in 12 firms is fully monetizing their data.[101] This can be attributed to the fact that most organisations do not have the infrastructure to collect and store data, let alone use it to generate insights. Additionally, many organisations do not have the resources or expertise to analyze the data they collect and turn it into

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[101] From insights to revenue: Growing importance of data monetizationDATAQUEST (dqindia.com)

actionable business decisions. With the exponential growth of data, the potential for data monetization is immense.

5.3   Companies with a strong data-driven culture focus on internal data monetization, use data to improve business processes, streamline decision-making, cut operational costs, elevate User Experience, generate new revenue streams, and boost employee productivity. Data-driven companies such as Amazon, Meta, and Apple focus on data-driven business models to develop new products and services, improve customer experience, and generate additional revenue streams. The global data monetization market is expected to grow from $2.63 billion in 2021 to $12.22 billion in 2030, a CAGR of 19.6%.[102] This will be driven by the increasing magnitude of generated data, awareness of data monetization, and emerging tech opportunities such as Business Intelligence and Analytics (BI&A), cloud computing, blockchain, IoT, social networks, and post-Covid-19 pandemic business approaches and strategies.

Figure 5.1 : Global Data Monetization Market Size
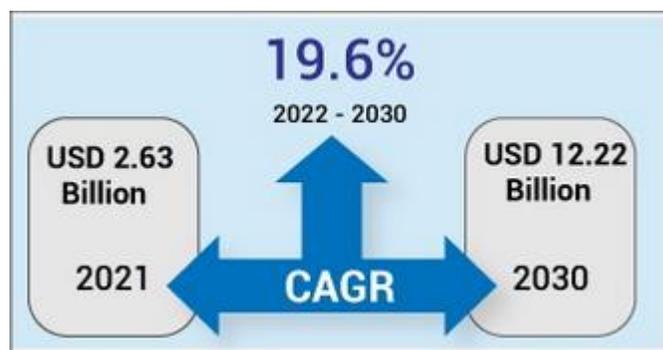
Source : Polaris Market Research

5.4   The Indian data monetization market is expected to grow at a CAGR of 7.02% over the forecast period of 2019-2024.[103] Rapid growth of industries on account of increasing support from the government, presence of a good number of MSMEs and large enterprises and increasing digitization of

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[102] https://www.polarismarketresearch.com/industry-analysis/data-monetization-market
[103]   https://www.researchandmarkets.com/reports/4767070/india-data-monetization-market-forecasts-from

business processes is increasing the volume of data generated every day. Some of the key drivers for this growth are:

i. The increasing adoption of data analytics and business intelligence tools across various sectors, such as banking, insurance, telecom, retail, healthcare, and manufacturing.

ii. The growing availability and accessibility of data from various sources, such as social media, IoT applications, public domain, and government initiatives like Aadhaar and Digital India.

iii. The rising demand for personalized services, which require insights into customer behavior, preferences, and needs.

5.5 However, organisations face multiple challenges while doing data monetization. There is a lack of a clear data strategy and governance framework that defines the objectives, roles, responsibilities, policies, and standards for data collection, storage, processing, sharing, and usage. Another major challenge is the scarcity of skilled talent and expertise in data science, analytics, and engineering that can extract value from data and generate actionable insights. Organisations are also facing difficulties due to the complexity and diversity of data sources and formats that require integration, harmonization, and quality assurance. The ethical and legal issues related to data privacy, security, ownership, etc. is also a significant challenge.

II. International Experience

5.6 Open Government Data (OGD) platforms have recently become the channel of choice for Governments to provide transparency and accountability. OGD is based on a simple idea that Government data be a shared resource. The purpose is to enable citizens, the research community and the private sector to reuse public data for knowledge creation and innovation. The Organisation for Economic Co-operation and Development (OECD) defines OGD as *"a philosophy- and increasingly a set*

of policies - that promotes transparency, accountability and value creation by making government data available to all".

5.7   The Public Sector Information (PSI) Directive in Europe of 2003 and the open data initiative in the United States (US) in 2008 were the first steps in the direction of making government data publicly accessible. OGD as a term arose in international debates in the early 2010s. In 2013, the G8 open data charter (ODC) set five international principles: "Open by Default", "Timely and Comprehensive", "Accessible and Usable", "Comparable and Interoperable", "For Improved Governance and Citizen Engagement", "For Inclusive Development and Innovation". The Open Government Partnership (OGP)[104] was also set up by OECD to help countries open their data through these principles. Since then, countries developed their own sets of principles and definitions. Today, open data platforms and initiatives are multiplying; the OGP has 76 country members that commit to biannual plans to improve their open data ecosystems.

III.   Initiatives taken in India

A.   Government Initiatives

5.8   India is currently experiencing a digital boom, with widespread access to cheap mobile internet and deeper penetration of internet access. Simultaneously, the Indian government has embraced the use of information technology and has launched numerous e-Governance schemes in the last two decades. These projects create Government-owned personal data based on anonymised interactions with Indian citizens. They also create purely non-personal data like weather, traffic, military, scientific, commercial and economic research data processed by the government in a digital medium. Data processed by the Government thus presents enormous economic potential. Data monetization can benefit

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[104] https://www.opengovpartnership.org

various stakeholders, such as data providers, data collectors, data processors, data users, and data consumers. However, data monetization also poses significant challenges and risks, such as privacy breaches, data misuse, data quality issues, data security threats, etc. Therefore, a balanced and effective regulatory framework is needed to foster data monetization while protecting the rights and interests of all parties involved. In India, several regulatory initiatives have been taken to encourage data monetization while ensuring data protection and governance. Some of these initiatives are discussed here.

5.9　The *National Data Sharing and Accessibility Policy* (NDSAP)[105] published in March 2012, widely regarded as the genesis of open government data in India. NDSAP aims to provide an enabling provision and platform for providing proactive and open access to the data available with various departments / organizations of Government of India. It facilitates the access to Government of India owned shareable data and information in both human readable and machine-readable formats. The NDSAP enabled ministries to frame pricing policies for their respective data sets. The implementation guidelines for NDSAP laid out the following principles for sharing data: "Openness, Flexibility, Transparency, Quality, Security and Machine readability."

5.10　Critically, NDSAP set up India's Open Government Data platform *"data.gov.in"*. The platform was formally launched in 2012 and is managed by the National Informatics Centre (NIC) under the Ministry of Electronics and Information Technology (MeitY) of the Government of India. Following the launch of data.gov.in, the Ministry of Housing and Urban Affairs (MoHUA) created *"smartCities.data.gov.in"*, a portal for use by the 100 cities selected as part of the Smart Cities Mission, which provides city-level data published by the Urban Local Bodies. The India Urban Data Exchange provides a platform to facilitate sharing of data by cities to

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[105] https://dst.gov.in/national-data-sharing-and-accessibility-policy-0

collaborate with industry, citizens and academia. Another initiative, *"Cityfinance"*[106] is a portal created by MoHUA and supported by many civil society organisations to provide transparency about municipal finance in India. Each of these initiatives has seen varying degrees of success in the publication and reuse of data.

5.11   This framework for digitizing government data is not sufficient for the development of an innovative ecosystem of AI, data science and analytics. Therefore, a draft policy, titled India Data Accessibility and Use Policy (IDAUP) was released in February, 2022 for public consultation. It provided for the sale and licensing of public data by the government to the private sector. As per the IDAUP, it was proposed that since certain datasets would be undergoing transformation and value-addition by the government, it would be reasonable for the same to be monetized; by providing the private sector access to readily available and transformed data sets for their commercial purposes. However, the Draft Data Policy was not well received by the stakeholders, as it allowed the government to monetize public data in the absence of a valid data protection legislation, which could threaten data privacy of individuals in the long run. To harness the full potential of data, a proper framework was required for data governance, which would aid data-based innovation and significantly improve the delivery of government services to its citizens, especially in important areas like education, law and justice, and health; amongst others. The government thus decided to lay out a new draft Policy to address some of the issues in this framework.

5.12   The Ministry of Electronics and Information Technology (MeitY) released the draft National Data Governance Framework Policy (NDGFP) on 26th May 2022, inviting the public to provide feedback and comments on the same. The Policy will be applicable to all such data which is collected and managed by government departments and entities; thus, bringing all

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[106] https://cityfinance.in/

government departments under its ambit. Even state governments are encouraged to adopt the provisions of this Policy, as may be applicable. The Policy will also be applicable to non-personal datasets as it proposes to launch an 'India Datasets Program' which is based on non-personal data. The Policy provides certain rules and methods which would ensure that any anonymized data and non-personal data from both the private or government entities can be accessed by the 'research and innovation ecosystem', in a safe and accessible manner. The NDGFP envisages a detailed institutional framework, centered around an "India Data Management Office" (IDMO) that shall be set up under the Digital India Corporation under MEITY.

5.13   While the updated draft policy is an improvement, certain concerns from the older draft versions still exist, especially in terms of effective implementation. Issues of capacity building and incentives that have been a major challenge in earlier efforts to open government data still needs to be addressed. While India has adopted many policies in the past to make government data more accessible (from the RTI Act to the National Data Sharing and Accessibility Policy (NDSAP), challenges in effective implementation are required to be addressed.

B.   TRAI Recommendations

5.14   In order to take the full advantage of the unprecedented acceleration in digital transformation enabled by 5G ecosystem, it has become necessary to harness the full potential of data. It has also become necessary to promote AI based research and innovation for the growth and development of the country, to facilitate technological advancements by allowing researchers, innovators, private entities and startups to gain access to non-personal datasets. With this objective in mind, the Authority has issued several recommendations to promote data digitisation, monetisation and sharing.

5.15 The Authority in its Recommendations dated 18th November 2022 on "Regulatory Framework for Promoting Data Economy Through Establishment of Data Centres, Content Delivery Networks, and Interconnect Exchanges in India" has recommended the following:

i. *For steering the data digitization drive, the Authority recommends that a statutory body, Data Digitization and Monetization Council (DDMC), be established at the Centre by enactment of new law or by amendment of the present law. The proposed body should have suitable representation from DoT and MeitY, in addition to representatives from Central and State governments. The proposed body should be entrusted with the responsibility to review and prioritize the avenues which would require more concentrated efforts of data digitization and fix timeframes accordingly. DDMC should also assess the data digitization requirements and define the process framework for use of AI and related technology in data processing, data sharing and data monetization while ensuring the privacy and security of the data owner. The proposed body should also be entrusted with framing policies and incentivization schemes for data digitalization, data sharing, and data monetization. DDMC should be the apex body to oversee all issues related to data digitization, data sharing, and data monetization in the country.*

ii. *The Government should put in place a data sharing and consent management framework on lines of Data Empowerment and Protection Architecture (DEPA) framework to provide telecom subscribers consent based option to share their KYC data with recipient TSP when they port their numbers.*

iii. *This framework can later be merged with Financial Stability and Development Council (FSDC) Account Aggregator (AA) system facilitating onboarding of entities from other sectors and in process allowing telecom subscribers to access, control, and consent-based sharing of their other data with any onboarded entity.*

iv. *Formation of Data Digitization and Monetization Council (DDMC), an apex body to oversee all issues related to data digitization, data sharing, and data monetization in country. The Authority further recommends that DDMC should also be entrusted with responsibility of putting in place an overarching framework for ethical use of data both by the Government as well as by the corporates in India. The framework should address the generic as well as vertical sector specific requirements. DDMC should also study the possible impact of upcoming technologies on data ethics and come out with relevant rules/guidelines on the subject.*

5.16 Subsequently, the Authority in its Recommendations dated 20th July 2023 on "Leveraging Artificial Intelligence and Big Data in Telecommunication Sector." has reiterated the above recommendations and has further stated that

(a) *DDMC should now be renamed as "Artificial Intelligence and Data Authority of India" (AIDAI). The Authority recommends that formation of too many statutory authorities/ bodies creates confusion for the sector and therefore, in order to derive synergy, organically the work of AIDAI should be entrusted to TRAI with suitable modifications in the TRAI Act.*

(b) *The functions of the DDMC (now proposed AIDAI) has been reiterated and are summarised below -*

i. Assess the data digitization requirement in the country; review and prioritize the avenues requiring concentrated efforts for data digitization and fix timeframes accordingly.

ii. Be the apex body to oversee all issues related to data digitization, data sharing and data monetization in the country including framing policies and incentivization schemes for data digitalization, data sharing and data monetization.

iii. Define the process framework for use of AI and related technology in data processing, data sharing and data monetization while ensuring the privacy and security of the data owner.

iv. Putting in place an overarching framework for ethical use of data both by the Government as well as by the corporates in India. The framework should address the generic as well as vertical sector specific requirements.
v. Study the possible impact of upcoming technologies on data ethics and come out with relevant rules/guidelines on the subject.

Q.24. **Please comment on any other related issue in promotion of the development, deployment and adoption of 5G use cases, 5G enabled IoT use cases and Metaverse use cases in India. Please support your answer with suitable examples and best practices in India and abroad in this regard.**

Chapter- 6

ISSUES FOR CONSULTATION

Q.1. **Is there a need for additional measures to further strengthen the cross-sector collaboration for development and adoption of 5G use cases in India? If answer is yes, please submit your suggestions with reasons and justifications. Please also provide the best practices and lessons learnt from other countries and India to support your comments.**

Q.2. **Do you anticipate any barriers in development of ecosystem for 5G use cases, which need to be addressed? If yes, please identify those barriers and suggest the possible policy and regulatory interventions including incentives to overcome such barriers. Please also provide the details of the measures taken by other countries to remove such barriers.**

[2.63]

Q.3. **What are the policy measures required to create awareness and promote use of 5G technology and its infrastructure so that the citizens including those residing in rural and remote areas may benefit from the 5G use cases and services to create new economic activities and increase employment opportunities and thereby promote economic growth of the country?**

[2.64]

Q.4. **What are the policy measures required to promote use of IoT technology and its infrastructure so that the citizens including those residing in rural and remote areas may benefit from these 5G enabled IoT smart applications and services to create new economic activities and increase employment opportunities and thereby promote**

economic growth of the country?

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[3.26]

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Q.5. **What initiatives are required to be taken by the Government to spread awareness among the citizens about IoT enabled smart applications? Should the private companies / startups developing these applications need to be engaged in this exercise through some incentivization schemes?**

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[3.27]

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Q.6. **Industry 4.0 encompasses Artificial intelligence, Robotics, Big data, and the Internet of things and set to change the nature of jobs.**

  (a) **What measures would you suggest for upskilling the top management and owners of industries?**

  (b) **What measures would you suggest for upskilling the workforce of industries?**

  (c) **What kind of public private partnership models can be adopted for this upskilling task?**

  Please reply with proper justification and reasons and also by referring to the global best practices in this regard.

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[3.29]

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Q.7. **What are the policy, regulatory and other challenges faced by MSMEs in India in adoption of Industry 4.0. Kindly suggest measures to address these challenges. Provide detailed justification with reasons along with the best practices in other countries.**

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[3.41]

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Q.8. **What additional measures are required to strengthen the National Trust Centre (NTC) framework for complete security testing and certification of IoT devices (hardware as well as software) under DoT / TEC. What modifications in roles and responsibilities are required to make NTC more effective? Kindly provide your comments with**

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justification in line with the global best practices

Q.9. **IoT security challenges and requirements vary significantly across different industry verticals. Is there a need to develop sector-specific IoT security and privacy guidelines?**

Q.10. **If answer to Q.9 is yes, is there a need for a common framework and methodology for developing such sector-specific guidelines.**

[3.54]

Q.11. **Please suggest regulatory and policy interventions required to ensure privacy of the massive amount of sensitive user data generated by IoT applications specifically in light of the Digital Personal Data Protection Act, 2023. Kindly provide justifications along with the global best practices.**

[3.72]

Q.12. **What additional policy and regulatory measures are required to encourage research and development of IoT use cases in various sectors? Is there a need to incentivize startups for research and development of IoT enabled use cases in various industry verticals? If yes, kindly suggest measures for the same.**

Q.13. **What measures should be taken to encourage centres of excellence to handhold startups working in the development of use cases and applications in 5G and beyond technologies? How can the domestic and foreign investors be encouraged to invest for funding the startups for these kinds of development activities?**

[3.79]

Q.14. **Whether there is a need to make changes in relevant laws to handle various issues, including liability regime and effective mechanism for redressal and compensation in case of accidents, damages, or malfunctions involving IoT, drones, or robotic systems. If yes, give detailed suggestions.**

Q.15. **Is there a need to have a separate security mechanism for Multi-access Edge Computing (MEC)? If yes, please give your inputs and suggestions with regard to policies, rules, regulations and guidelines.**

Q.16. **What are the policy measures required to create awareness and promote use of Metaverse, so that the citizens including those residing in rural and remote areas may benefit from the Metaverse use cases and services to create new economic activities and increase employment opportunities and thereby promote economic growth of the country?**

Q.17. **Whether there is a need to develop a regulatory framework for the responsible development and use of Metaverse? If yes, kindly suggest how this framework will address the following issues:**

   i.   **How can users control their personal information and identity in the metaverse?**

   ii.   **How can users protect themselves from cyberattacks, harassment and manipulation in the metaverse?**

   iii.   **How can users trust the content and services they access in the metaverse?**

   iv.   **How can data privacy and security be ensured in the metaverse, especially when users may have multiple digital identities and avatars across different platforms and jurisdictions?**

Q.18. **Whether there is a need to establish experimental campuses where startups, innovators, and researchers can collaborate and develop or demonstrate technological capabilities, innovative use cases, and operational models for Metaverse? How can the present CoEs be**

strengthened for this purpose? Justify your response with rationale and suitable best practices, if any.

[4.68]

Q.19. How can India play a leading role in metaverse standardization work being done by ITU? What mechanism should be evolved in India for making effective and significant contribution in Metaverse standardisation? Kindly provide elaborate justifications in support of your response.

[4.71]

Q.20. (i) What should be the appropriate governance mechanism for the metaverse for balancing innovation, competition, diversity, and public interest? Kindly give your response with reasons along with global best practices.

(ii) Whether there is a need of a national level mechanism to coordinate development of Metaverse standards and guidelines? Kindly give your response with reasons along with global best practices.

[4.74]

Q.21. Whether there is a need to establish a regulatory framework for content moderation in the metaverse, given the diversity of cultural norms and values, as well as the potential for harmful or illegal content such as hate speech, misinformation, cyberbullying, and child exploitation?

Q.22. If answer to Q.21 is yes, please elaborate on the following:

i. What are the current policies and practices for content moderation on Metaverse platforms?

ii. What are the main challenges and gaps in content moderation in the Metaverse?

iii.   **What are the best practices and examples of effective content moderation in the Metaverse or other similar spaces?**

iv.   **What are the key principles and values that should guide content moderation in the Metaverse?**

v.   **How can stakeholders collaborate and coordinate on content moderation in the Metaverse?**

[4.77]

Q.23.   **Please suggest the modifications required in the existing legal framework with regard to:**

i.   **Establishing mechanisms for identifying and registering IPRs in the metaverse.**

ii.   **Creating a harmonized and balanced approach for protecting and enforcing IPRs in the metaverse, taking into account the interests of both creators and users of virtual goods and services.**

iii.   **Ensuring interoperability and compatibility of IPRs across different virtual environments. Kindly give your response with reasons along with global best practices.**

[4.80]

Q.24.   **Please comment on any other related issue in promotion of the development, deployment and adoption of 5G use cases, 5G enabled IoT use cases and Metaverse use cases in India. Please support your answer with suitable examples and best practices in India and abroad in this regard.**

List of Acronyms

S.No.	Acronym	Description
1.	3GPP	Third Generation Partnership Project
2.	5GC	5G Core
3.	ABFPI	Agro Based & Food Processing Industry
4.	ADAS	Advanced Driver Assistance Systems
5.	AI	Artificial Intelligence
6.	AICTE	All India Council for Technical Education
7.	API	Application Programming Interface
8.	AR	Augmented Reality
9.	ARPU	Average Revenue Per User
10.	AV	Autonomous Vehicle
11.	AVGC-XR	Animation, Visual Effects, Gaming, and Comics and Extended Reality
12.	BIS	Bureau of Indian Standards
13.	CAD	Computer-Aided Design
14.	CAGR	Compound Annual Growth Rate
15.	CBDC	Central Bank Digital Currency
16.	CCPA	California Consumer Privacy Act
17.	CERC	Central Electricity Regulatory Commission
18.	CHAMPIONS	Creation and Harmonious Application of Modern Processes for Increasing the Output and National Strength
19.	CII	Confederation of Indian Industry
20.	CoDCI	Council of Digital Connectivity Infrastructure
21.	CoE	Centre of Excellence
22.	CPCB	Central Pollution Control Board
23.	CPRA	California Privacy Rights Act
24.	CRA	Cyber Resilience Act
25.	CSDC	Construction Skill Development Council
26.	CT	Computed Tomography
27.	C-V2X	Cellular Vehicle-To-Everything

28.	DAO	Decentralized Autonomous Organization
29.	DCI	Digital Connectivity Infrastructure
30.	DISCOM	Distribution Company
31.	DoT	Department of Telecommunication
32.	E2E	End To End
33.	ECBC	Energy Conservation Building Code
34.	EcR	Economic Research
35.	EDGE	Enhanced Data For Global Evolution
36.	eMBB	Enhanced Mobile Broadband
37.	EMC	Electromagnetic Compatibility
38.	ENISA	European Union Agency for Network and Information Security
39.	ER	Essential Requirement
40.	ERNET	Education and Research Network
41.	EV	Electric Vehicle
42.	FG-MV	Focus Group on Metaverse
43.	FOIR	Forum of India Regulators
44.	FOR	Forum of Regulators
45.	FWA	Fixed Wireless Access
46.	G2B	Government to Business Services
47.	G2C	Governance, Risk, and Compliance
48.	GCI	Global Cybersecurity Index
49.	GDP	Gross Domestic Product
50.	GDPR	General Data Protection Regulation
51.	GHG	Greenhouse Gases
52.	GLBA	Gramm-Leach-Bliley Act
53.	GPP	Green Public Procurement
54.	GPRS	General Packet Radio Service
55.	GPS	Global Positioning System
56.	GSMA	Global System for Mobile Communications
57.	GVA	Gross Value Added
58.	HIPAA	Health Insurance Portability and Accountability Act
59.	HPLPI	Hand Made Paper, Leather & Plastic Industry
60.	HSPA	High Speed Packet Access

61.	I4.0	Industry 4.0
62.	ICT	Computers and Information Technology
63.	IDAUP	India Data Accessibility and Use Policy
64.	IDMO	India Data Management Office
65.	IEEE	Institute of Electrical and Electronics Engineers
66.	IGBC	Indian Green Building Council
67.	IMDA	Infocomm Media Development Authority
68.	IMT	International Mobile Telecommunication
69.	IMWG	Inter-Ministerial Working Group
70.	IoMT	Internet of Medical Things
71.	IoT	Internet of Things
72.	IP	Internet Protocol
73.	IPR	Intellectual Property Rights
74.	IT	Information Technology
75.	ITSAR	Indian Telecom Security Assurance Requirements
76.	ITU	International Telecommunication Union
77.	JCOR	Joint Committee of Regulators
78.	KPI	Key Performance Indicator
79.	KVIC	Khadi & Village Industry Commission
80.	LEED	Leadership in Energy and Environmental Design
81.	LIDAR CES	Light Detection and Ranging Consumer Electronics Show
82.	LTE	Long Term Evolution
83.	M2M	Machine-to-Machine
84.	MBI	Mineral Based Industry
85.	MEC	Multi-access Edge Computing
86.	MeitY	Ministry of Electronics and Information Technology
87.	METI	Ministry of Economy, Trade and Industry
88.	MIT	Massachusetts Institute of Technology
89.	ML	Machine Learning
90.	mMTC	Massive Machine-Type Communications
91.	MNOs	Mobile Network Operators
92.	MoCA	Ministry of Consumer Affairs
93.	MoEFCC	Ministry of Environment, Forest and Climate Change

94.	MoHUA	Ministry of Housing and Urban Affairs
95.	MOU	Memorandum of Understanding
96.	MPN	Mobile Private Network
97.	MR	Mixed Reality
98.	MSIT	Ministry of Science & ICT
99.	MSME	Micro, Small & Medium Enterprises
100.	MTCTE	Mandatory Testing and Certification of Telecom Equipment
101.	NABH	National Accreditation Board for Hospitals & Healthcare Providers
102.	NBC	National Building Code
103.	NBTC	National Broadcasting and Telecommunication Commission
104.	NDGFP	National Data Governance Framework Policy
105.	NDSAP	National Data Sharing and Accessibility Policy
106.	NEDO	New Energy and Industrial Technology Development Organization
107.	NEF	Network Exposure Function
108.	NEP	National Education Policy
109.	NER	North-eastern Region
110.	NF	Network Function
111.	NFI	Network Function Instance
112.	NFT	Non-Fungible Token
113.	NFV	Network Function Virtualization
114.	NIC	National Information Centre
115.	NI-MSME	National Institutes for MSME
116.	NIS	Network and Information Security
117.	NIST	National Institute of Standards and Technology
118.	NR	New Radio
119.	NSA	Non-standalone
120.	NSDC	National Skill Development Council
121.	NSI	Network Slice Instance
122.	NSIC	National Small Industries Corporation Ltd.
123.	NTC	National Trust Centre

124.	ODC	Open Data Charter
125.	OECD	Organisation for Economic Co-operation and Development
126.	OEM	Original Equipment Manufacturer
127.	OGD	Open Government Data
128.	OTT	Over-the-top
129.	PAAS	Platform As A Service
130.	PE	Private Equity
131.	PPP	Public-Private Partnership
132.	PSI	Public Sector Information
133.	QoS	Quality of Service
134.	RBI	Reserve Bank of India
135.	RENTI	Rural Engineering & New Technology Industry
136.	RFID	Radio-Frequency Identification
137.	RFP	Request for Proposal
138.	RoW	Right of Way
139.	RTI	Right to Information
140.	SA	Standalone
141.	SB	Senate Bill
142.	SBA	Service-Based Architecture
143.	SBI	Service Based Interface
144.	SDN	Software-Defined Networking
145.	SEBI	Securities & Exchanges Board of India
146.	SERCs	State Electricity Regulatory Commission
147.	SPDI	Sensitive Personal Data or Information
148.	SRI	Self-Reliant India
149.	STQC	Standardization Testing and Quality Certification
150.	TC	Technology Centres
151.	TCU	Telematics Control Unit
152.	TEC	Telecommunication Engineering Centre
153.	TIG	Technology Innovation Group
154.	TRAI	Telecom Regulatory Authority of India
155.	TRL	Transport Research Laboratory
156.	TSP	Telecommunications Service Provider

157.	TSSC	Telecom Sector Skill Council
158.	TTDF	Telecom Technology Development Fund
159.	TWh	Terawatt Hour
160.	UAVs	Unmanned Aerial Vehicles
161.	UE	User Equipment
162.	UMTS	Universal Mobile Telecommunications System
163.	UPI	Unified Payments Interface
164.	URLLC	Ultra-Reliable Low-Latency Communication
165.	USOF	Universal Service Obligation Fund
166.	V2I	Vehicle-To-Infrastructure
167.	V2V	Vehicle-To-Vehicle
168.	VC	Venture Capital
169.	VEPP	Vertical Engagement and Partnership Program
170.	VR	Virtual Reality
171.	WCI	Wellness & Cosmetics Industry
172.	WEF	World Economic Forum
173.	WIFI	Wireless Fidelity
174.	XAI	Explainable Artificial Intelligence