metamorphoses

ALKING TECHNOLOGY

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1 INTRODUCTION

We are living in an age of technological change which is unprecedented in scale and rapidity. It has been a driver of material progress, improved the access of millions to knowledge, and spurred innovations and creativity. And yet the gap between technology and human understanding of its ever more intricate working has never been as wide as it is today. We all use the Internet, smart-phones and digital devices and marvel at their almost magical attributes. But our communities and societies and the human mind itself have been unable to comprehend, much less manage, their impacts on the way we think, live and relate to the world around us. We are becoming familiar with terms like algorithms, artificial intelligence, big data and machine learning, but the ordinary individual and the larger community have little understanding of their meaning, how they work, and how they impact individual psyche and social attitudes. There are benefits which we take for granted but there are negative consequences, too, which we witness with growing concern. These include the viral spread of disinformation, the instigation of ugly prejudice and manipulation of popular perceptions for narrow political and ideological purposes. The challenge lies in finding a balance which enables us to reap the benefits of technological advancement, but also be aware of and deal with the negative psychological and social consequences thereof. Bridging the gap between technology and human understanding is a critical issue of our times, and the series, 'Metamorphoses: Talking Technology', was launched at the India International Centre (IIC) to serve this purpose. It was supported by NITI Aayog and the Centre for Policy Research.

Metamorphoses was launched in 2018 and was designed to create awareness and understanding, in a general audience, of the various aspects of digital technologies, through enabling conversations between leaders in the field with members of civil society. These interactions and free-flowing

panel discussions on a range of topics have been edited and presented here as summaries of each session highlighting the critical issues debated.

It was our privilege that Prof. Yochai Benkler of Harvard University accepted our invitation to deliver the Keynote Address. Unfortunately, his presentation could not be included here, but he set the ball rolling with his belief that 'we have to think about technology and its relationship to politics, to institutions, to values, and how these elements work together'. For unforeseen reasons, two 'special lectures' have also not been included in this volume. The first was by Prof. Soumitra Dutta on 'Leading Digital Transformation and Innovation'; and the second by Prof. Langdon Winner on 'Beyond Techno-Narcissism: Self and Other in the Digital Realm'. The valedictory address was delivered by Prof Arogyaswami Paulraj of Stanford University. His presentation on Artificial Intelligence was a master class on this most complex but fascinating of subjects.

'The Vocabulary of the Digital' is an attempt to demystify new and arcane vocabulary associated with digital technologies and put complex ideas into more simple and easily understood terms. The 'Future of Governance' examines the important concern of state regulation and even more importantly, the issue of data privacy, which is at the heart of the challenge of governance associated with technology today. Another critical concern in India is the lives of the most marginalised sections who form the bottom rung of societal hierarchy. Has the Internet empowered them? Has new technology done anything to make us a better democracy? These are some of the questions dealt with in 'Technology, Social Divides and Diversity'. Print and TV journalists address the issue of 'Unpacking Media—Digital and Traditional', highlighting how this field has changed with the advent of digital media, social media, Twitter and Facebook.

One of the sessions addressed the very real fear of the potentially adverse impact these technologies may have on employment. This is summarised under the heading, 'Automation, AI and the Future of Jobs', and the consensus is that new technology has the potential to create more jobs than may be lost as the result of adopting new technologies.

One of the most debated issues, in India and globally, is discussed under 'Cyber Security'. It is clear that cyberspace is here to stay and is already an integral part of our lives. Yet, it is still a very anarchic space, and we need to be mindful of the vulnerabilities it has spawned. As this is a borderless medium, there has to be an ecosystem of international cooperation because a national policy alone is not sufficient. We urgently need to establish international norms and systems needed for a safe cyberspace.

Interestingly, new pathologies have entered our lexicon along with new technologies—Internet addiction disorder, attention deficit disorder and the compulsive use of social media. We are aware of the negative impacts of over-indulgence in the use of social media on relationships and life in general. Being digitally active round the clock can create a host of mental as well as psychological problems. On the other hand, social media, discussion groups and chat rooms may actually help people find kindred company. This may be a way of overcoming social isolation, or reconnecting with long lost friends, or communicating with family members who may be scattered across the world. The value of digital technology was amply demonstrated during the pandemic when the virtual medium enabled people to overcome social isolation and communicate with one another. The challenge really lies in finding the right balance. The paper on 'Solutions to Technology Pessimism'

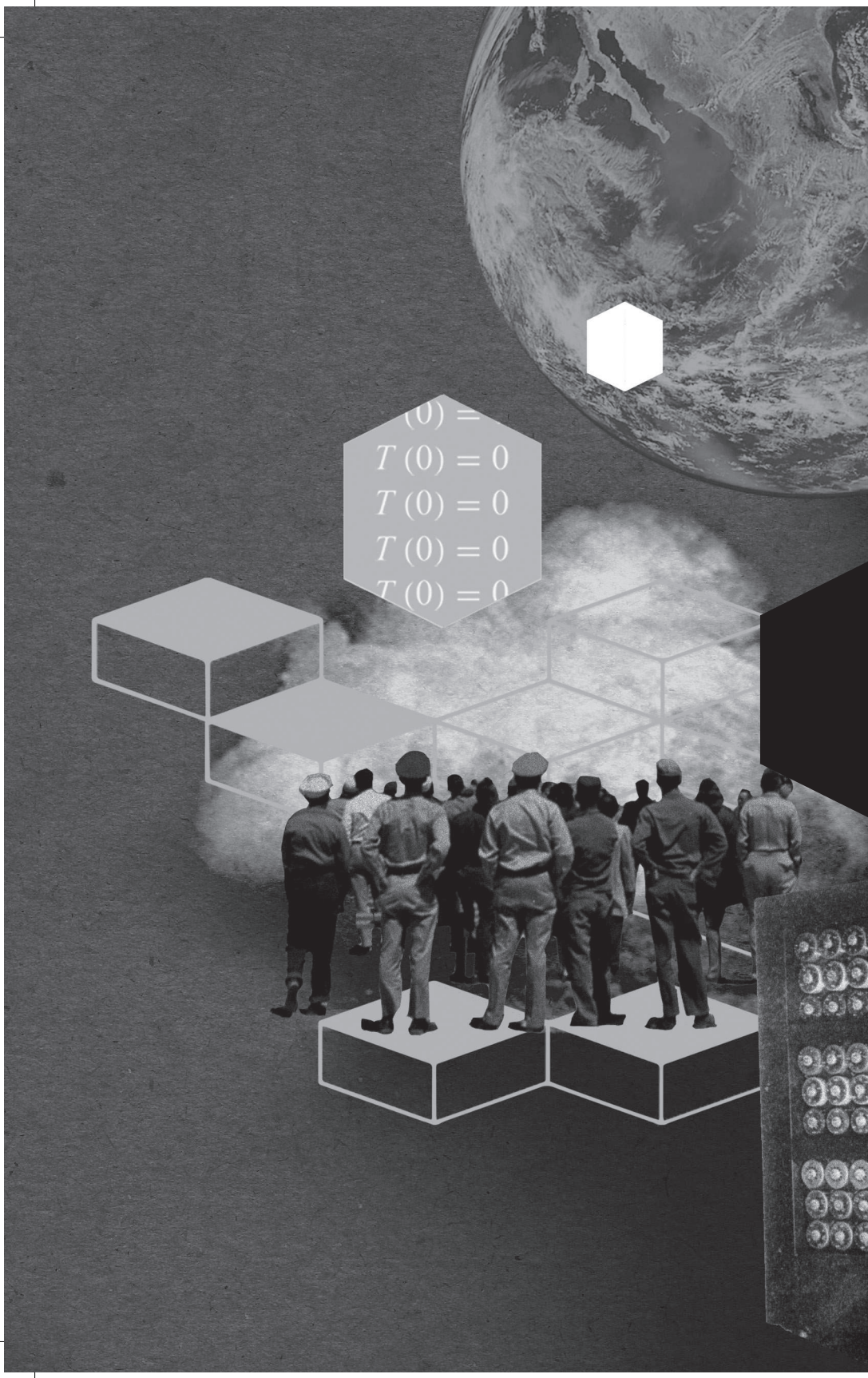
brings out a critical policy issue: pessimism creates fertile ground for various actors, including the state, to introduce censorship and burdensome regulation.

We believe that we must bridge the digital divide if we are to leave no citizen behind in the march to becoming the digital economy being envisioned as a positive and productive future for India and the world.

This imaginative initiative germinated within a group of young people from the Centre for Policy Research (CPR), the India International Centre (IIC) and Niti Aayog. I'd like to specially mention Richa Bansal, Dhruv Arora, Dhruv Bhasin and Priyanka Shah from CPR; Portia Conrad from IIC; Akshay Alaksharan and Puneet Shukla from Niti Aayog; Imran Khan, Oroon Das and Apar Gupta for designing the series and organising filming and image creation. I would also like to pay tribute to the late Premola Ghose and to Teteii from the IIC's Programme Division who helped us put all this together. The distinguished members of the Board of Trustees of the IIC, its officers and staff members; Ms Yamini Aiyar, President of CPR, and her extremely able and enthusiastic team worked closely together to ensure the success of the series. This would not have been possible but for their teamwork.

My special thanks are due to Shri Amitabh Kant, the erstwhile CEO of Niti Aayog and currently India's Sherpa for the G-20, for his kind support and encouragement to Metamorphoses, without which this initiative would not have seen the light of day.

Shyam Saran
PRESIDENT, IIC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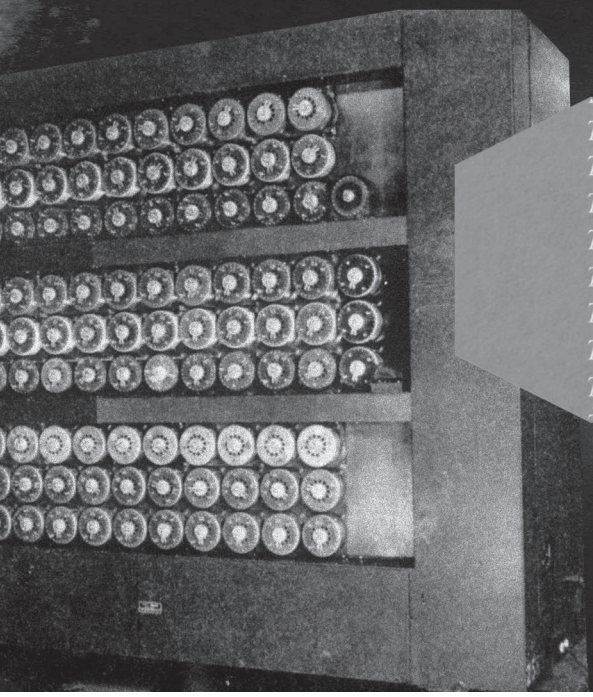
2 VOCABULARY OF THE DIGITAL



With the expansion of the digital space, new jargon, usually only understood by the expert and the initiated, has entered our daily lexicon. For instance, what is 3D Printing or Blockchain technology? What are algorithms, and what is artificial intelligence (AI)? The reason it is important to understand digital vocabulary is that language occasionally becomes a means of creating esoteric groups that keep people out. The inability to master jargon effectively leads to marginalisation. Consequently, part of the challenge is to bridge that gap. More important, what are the implications of these technologies, both in terms of expanding the enormous opportunities that they bring to us, and the issues involved with respect to the consequences. The very rapidity of these changes has consequences in terms of how we interact with one another in society and how individuals interact with one another.

ADVENT OF ARTIFICIAL INTELLIGENCE

The principal challenge today is not merely the advent of technologies, but the fear that new technology and machines will be equipped with the same capabilities in every manner as humans, and, therefore, could potentially take over the planet. Some of those familiar with technology believe this to be a tangible problem, while a significant number are dismissive. The question is: Is this issue indeed meaningful and something to be worried about?

How did the vocabulary of the digital come about? The answer lies in our vocabulary in the broader context of all life on Earth, and it must be remembered that all life on this planet is linked to all other life forms. At this wall of T=0, there was the evolution of, at first approximation, single cellular organisms. These organisms had a certain chemistry, a language, a vocabulary; they had to survive, they had to propagate, and they had to communicate.

Those organisms were the only lifeforms that occupied the planet at the time. But with the passage of time, through accident upon accident over hundreds of millions of years of evolution, complex organisms evolved. Humans are one example of an extremely complex multicellular organism, with a language, a vocabulary and communication skills. All life on this planet is linked together by shared chemistry through the thread of DNA. Therefore, the study and knowledge of any one organism on this planet lead to the effective study and understanding of any other organism which currently exists or which has existed in the past.

One of the peculiarities of humans as organisms is that they have rapidly moved away from this chemistry. Although not rapid initially, this move came about by a series of accidents during evolution. One hypothesis is that unlike other large primates, the human's ability to use the opposing thumb and forefinger, the capacity to use fire to cook, thereby compressing nutrition into very small packets of highly nutritive food that provided energy to the human brain, permitted the brain's expansion disproportionate to the body. This allowed the brain to expand its ability to speak, to make tools, resulting in something truly extraordinary which Richard Dawkins calls the extended phenotype.

While humans are no longer a consequence of biology, there is an expression of that biology in complex social systems, which has an effect on ecology, and more recently, on the planet as a whole. There is much debate on when this extended phenotype started to impact the planet, leading it into an age known as the Anthropocene. Some believe that this started when humans began to practise agriculture, while others see its beginnings in New Mexico when the atomic bomb was first exploded. But whatever the date, the Anthropocene is upon us. An important aspect of this age is the creation of new technology.

How did that happen? The chemistry that nerve cells use to communicate with each other has been replicated in engineering today in all the devices with which we communicate. But the difference is that communication in the human body is not digital but chemical. This chemistry, with some minor differences, drives communication in the tiny worm as well as in the enormous elephant. Accordingly, both small and large circuits use the same chemistry to function. The circuits which humans use, which allow humans to be sentient and use language and abstraction, are composed of the very same nuts and bolts and rivets found in the worm's circuit, which it uses to locate odours.

How, then, despite the chemistry being identical, does this large human brain behave in a manner more complex than other brains? Clearly, it is not merely a matter of size because there are other large circuits. How have human consciousness, the ability to speak and engage with abstraction come about? The two components are: (i) biological; and (ii) engineering. From the biological point of view, there are two perspectives. One, that the emergence of consciousness is a profound problem, i.e., it involves new principles. Some neuro-philosophers doubt our ability to address this profound problem. Others hold that it is merely a software issue—which is completely understandable with all the information available currently. The ability to see one other, to engage in abstractions, and so on, are emergent properties of neural circuits. As complex computers perform extraordinary feats of computation based on software, it would be incorrect to search for intrinsic properties in their hardware for an explanation. Similarly, it would be wrong to search for seats of consciousness or some intrinsic property in the brain, as these are all computational outcomes.

Therefore, if the emergence of consciousness can be explained, then, in principle, should we not be able to construct a machine

with all the properties of consciousness? That challenge was first posed in a concise manner by Alan Turing, who posited three major ways to look at this critical problem. First, the emergence of pattern in biology. Second, as regards computing numbers, with sufficient memory and an algorithm, almost anything could be computed. He invented the Turing machine, a theoretical machine which could do this. John von Neumann, another famous computer scientist, observed that if the Turing machine was replicated, and if during replication the machine made errors, it would produce mutations and, thereby, a diversity of machines. Therefore, essentially, the Neumann computer was able to replicate the Turing machine, but in doing so also mimicked real life where the replication of life forms takes place with mutation, resulting in diversity.

The third contribution from Turing was with regard to AI. What was the test to ascertain whether one was human or a machine? How could one interrogate a person to determine if the brain was full of wires, not neurons?

There are two major challenges related to AI and the Turing computer. One is with regard to decision making: Can we rely on machines to take decisions for us? The second aspect relates to consciousness: Are we going to create machines, which in fact take autonomous decisions that are more complex, in a manner which we as humans would otherwise be taking? For instance, would a machine say that a given war, or a given decision, or a given relationship with the World Bank, is wise?

There are two views on both these matters. Both are relatively uninformed, in terms of data and analyses. One view is that thus far technology has never overtaken human decision making to an extent such that we are unable to just pull the plug and stop the process, should we so wish. The solution provided by one group of philosophers is to simply turn off

the power to a machine in case it is controlling humans. The other, dissenting, view is that it is an infinitely complex runaway system which cannot be stopped. Nevertheless, we are entering a complex state of affairs today in which these kinds of machines can do extraordinary things not feasible earlier.

ARTIFICIAL INTELLIGENCE IN DAILY LIVES

With the advent of electronic health records, information can be maintained on patients. The more complete the records, the easier it becomes to follow the history of patients and to manage them. Along with that development came other technologies, and indeed much of medicine is now about technology.

Digital technology has also changed the way humans communicate with each other and has allowed one and all to actually communicate their points of view. It has inverted that pyramid somewhat. If one looks at information dissemination, previously one could think of it as a pyramid in which information came from limited sources, it was disseminated, with all and sundry consuming the same thing at all times. But today we are all able to express ourselves and are all able to consume various sources of information, previously not available.

However, with such ease of communication one can very rapidly move into an echo chamber, where the only views available are those which one likes, as has occurred with Facebook. Algorithms, in a sense, are essentially formulae that decide the content viewed. An algorithm looks at the information that people have been engaging with and tries to show more of the same with the intention of increasing the engagement. While this might appear interesting initially, it is an opportunity for Facebook to show far more content with which one agrees, and not enough content that one may disagree with—which is the problem. An excellent example of this occurred during the

United States elections recently.

Along with healthcare and social or personal communication, AI has also made an appearance in the manner in which we handle our finances. Take for instance, Blockchain, which is probably the richest technology domain at the moment. In February 2017, the global capital infusion in this space was 19 billion USD. By February 2018, that number had spiked to almost 475 billion USD. The simplest way to understand Blockchain technology is that it eliminates the middleman. It does that by fundamentally facilitating a transaction with the use of a code and automates that transaction. The reason it is so successful is because it is a trust-less system by the very nature of the structural characteristics of the technology. For example, if Amazon is selling something, one has to trust Amazon. But in the case of Blockchain that trust is eliminated from the system; one does not have to trust the system anymore—it is correct by itself. Immutability is one of the characteristics that makes it a trust-less system.

Second, Blockchain is auditable, and anybody can audit that system as it is distributed. To shut down a Blockchain, one has to either shut down the Internet, or shut down all the nodes. Currency is one of the biggest applications that has been explored so far. Blockchain is a technology that powers it. The Government of India is also exploring Blockchain technology in the assessment of land records to ensure traceability of ownership.

EVOLVING USE OF ARTIFICIAL INTELLIGENCE

Clearly, digital technology has penetrated almost all aspects of our regular life. It must also be emphasised that such usage is constantly evolving. In healthcare, if the different sources of information can be integrated, one can make not just a

diagnosis, but also a prediction about somebody who is well today, but might fall ill in three or five years in the future. Thus, the power of new technologies allows for both better measurement and better integration of information.

To return to the algorithms: if, on social media, in a certain place, issues to do with a disease or water-borne problems start to trend, it can provide an early indication of a problem that might be starting, or even on the conclusion of a situation. There could perhaps have been a public health issue which can in fact be assessed by going back into the data to check if there were any tweets that could have indicated early warning signs.

Social media's impact is not limited to the manner in which individuals communicate with each other, but also how relations are conducted between nations. Earlier, PR exercises were used as communication between governments, today geopolitics can shift at 3:00 a.m. with a simple click.

FUTURISTIC PROBLEMS RELATED TO ARTIFICIAL INTELLIGENCE

In the age of social media and Twitter, a key question today concerns fake news and online safety. It is essential to create safe spaces for conversation in online spaces, especially for youth in a Post-Truth world.

First, a framework has to be created for AI to operate, and especially for people who are inventing AI-based technologies. As regards the types of innovation that are taking place at the moment, we are headed towards a situation where there will be much investment in capital and resources. Therefore, the sooner we begin to think as governance bodies in order to establish a framework to regulate the integral nature of the technology, even as these innovations are taking place,

the better, rather than retro-installing this framework after development has already taken place.

There is definitely the need to create safer spaces online, which is taking place. Companies such as WhatsApp and Twitter have taken initiatives to flag mass forwards or violent content.

The questions that platforms can pose to themselves are in three buckets. One, what are our policies? Are they evolving with changed circumstances? The second is with regard to product features. Platforms need to be able to give the user many tools in terms of how they want to experience any space or any public space or any conversation. The third is the larger question of what it reveals about us as a society. Being online can bring to the surface many issues that are already in existence, and yet it can also give a strong voice to voices previously unheard.

As regards Blockchain, usually middlemen or platforms not only facilitate, but also take responsibility for failure. Who will assume responsibility and compensate the user if the transaction is not honoured? If we eliminate the governments who actually execute the block, who will take responsibility, and who will execute the Blockchain technology?

To deal with such challenges, a better understanding of technology is required. Further, India is a country where the majority of the population are digital illiterates. If education is itself at the bottom of the ladder, how can digital literacy be ensured for these technologies to benefit the populace? Besides, is this digital world giving those who own the digital technology, the corporates who are actually fuelling and funding it, the power to control things? In a democracy, is it justifiable that people have become, or are becoming, slaves to digital corporates?

The answer to this question lies in the nature of the Internet, which in itself is inherently distributed and open. While there might be certain platforms with their own networks within the Internet, the Internet itself cannot be monopolised. We must also be mindful of the fact that in this age digital literacy is the first thing that people acquire. The penetration of mobile phone technologies, particularly with smartphones, and people's ability to use them to their advantage, has not been recognised sufficiently. Whether in the field of health or in any other area, this is a source of information that people are using at every level of society—and this is only going to increase.

Lastly, in a modern war, does not AI take over human decision making? For example, one may presume that a missile shield will decide to hit back and not leave it to humans to decide. Again, the evolved ability over hundreds of millions years of time to take what in statistics would be called Bayesian statistics decisions is probably unique to humans. Therefore, machines will take their decisions based on huge amounts of data. But the ability to take a decision on little or no data is peculiarly human. Machines, after all, do not have instincts.

PANELLISTS

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3

FUTURE OF GOVERNANCE

The rapid advance of digital technologies is outpacing our awareness of the legal and ethical issues that confront us. The issue of state regulation, and perhaps even more significantly, that of data privacy—which in more ways than one has been at the forefront of the debates that have unfolded in India, and many aspects of which still need to be understood and debated—is of critical importance.

DIGITALISATION AND THE INTERNET IN GOVERNANCE OF THE NATION

Dr. J. Satyanarayana recalls how, in 1989, a Banjara woman travelled 70 km to register her grievance regarding her pension. Today, in Andhra Pradesh, through the intervention of digital technology, 4.3 million people get their pension at their doorstep, 2.5 million students get scholarships deposited into their accounts or with their institutions, and 13 million families receive rations, all through Aadhar identification. These programmes are all monitored online. This transformation is testimony to the accomplishments of technology and the positive, empathetic manner in which it impacts the populace.

Keeping pace with the dramatic evolution of technology, governance too has evolved. Starting with e-government, which focused on efficiency, there has been a shift to e-governance, m-governance and, more recently, real-time governance. The goal is to achieve 'one government', wherein the citizen does not have to deal with 30 departments, or 100 agencies, but one entity. The goal is of an invisible government, and invisible governance at a future date.

The Organisation for Economic Co-operation and Development (OECD) has recently published a report on embracing innovation in governance and related global trends. In this endeavour, the three key enablers are: (i) identity, i.e., digital

identity; (ii) systems approach, which looks at the system/ governance as a whole; and (iii) inclusiveness.

As regards identity, the Aadhar is meant to provide a unique identity to each individual and enable authentication anytime, anywhere—the mandate of UIDAI, which involves enrollment, authentication and updation. Currently, 1.21 billion Aadhar have been issued and EKYC (Electronic Know Your Customer) is constantly authenticated and updated every time it is used. Undoubtedly an enormous project by any standards, in this context it is necessary to regulate security measures as well, which are taken right from the design phase and secured by its very design.

The second aspect is the system's approach. Government, which is usually viewed in terms of departments and agencies, is piecemeal. A vision needs to be created for the whole of governance, such as the system established in Andhra Pradesh known as an e-Pragati ecosystem, in which a core connects various government departments. It is a life event-driven system and is citizen-centric and citizen-driven, and marked by its convenience vis a vis the citizen. The purpose of real-time governance is to engage citizens in a positive manner by addressing their grievances using a unified method till the matter is satisfactorily concluded.

This gives rise to several questions: How does one close the loop by improving the system? How does one manage disasters and major incidents on a real-time basis? Technologies can be used in a positive and beneficial manner that impacts as well as empathises with the needs of the country. Finally, a holistic approach to development and welfare is required. Citizen-centric and citizen-driven services, citizen engagement in real time, and security and privacy need to be enhanced.

THE NEED FOR DATA PROTECTION

With the rise of information technology (IT), the capacity to store, aggregate and process data has also greatly increased. The situation in India is such that, on the one hand, there is data collection in the form of family-owned small businesses using manual entries in registers. On the other is a government database like Aadhar that spans multiple services, and Facebook that not only collects data that is entered by a user but also intangible data based on user preferences. This aggregate amount of data tells a story that previously could not be assessed easily without putting all of the data together. Data protection is not only increasing in importance with the amount of data that can be stored, but also with the new ways in which it can be used. Facebook, in particular, uses algorithms that are now able to process data in ways which humans cannot predict. This leads to increased challenges in terms of the problems that people might suffer as a result, making data controversial.

Broadly, there are two sets of harms. Traditionally, there were privacy problems. However, today, problems go much beyond that. One is the shift from Web 2.0 to 3.0. Machines are capable of doing much more with data than individuals ever could, thereby raising the set of issues that come with re-identification, and so on. The standard set of responses was, if there was personal data involved, then that data was depersonalised from the data set. Today, machines have created a situation where it is much easier to re-identify individuals by the combination of two or three data sets, which yields far greater data insight into individuals, and is of importance in sectors such as finance, healthcare, and so on.

The second, and equally important, set of issues concerns algorithmic decision making, in which the possibility of bias creeps in. Here again, one needs to make a distinction between

the use of algorithms for public decision making vis-à-vis private decision making. Hence, Facebook's use of data, while clearly problematic in certain situations, is much less of a problem than, say, bias in the government's use of multiple data sets to decide on policy insights for education.

The third set of harms, which is particularly important for India, is that with Web 2.0 we were largely consumers of all these services. With Web 3.0, on the other hand, there is huge potential for India to innovate for which large amounts of data are required for start-ups to function. There is a huge possibility of innovation harms occurring simply because there are data silos being created today, causing danger to society, and of data being strewn around with little or no control. Over time, data from the key sectors of education, mobility, healthcare, agriculture, among others, is being siloed with certain companies, thereby raising the fear of monopoly over this data.

Data risk must be reduced, which can be done in different ways. A Data Protection Law is an obvious requirement, which will define rights and responsibilities. Answers must be sought to the complex questions of ownership and custodianship of data, and an adjudication mechanism, such as a regulator, must be set up. An accountability framework can be set up for the regulator that will interact with the entire system. However, laws alone cannot solve technology problems, because technology will always be three steps ahead of the law.

One solution is to permit the law to maintain flexible principles that will allow any regulator to catch up with technology. In addition, with consumer education and increased consumer awareness, companies will offer consumers some sort of graded privacy protection. After Cambridge Analytica, consumers have begun to question access to their data, and their rights, thus driving the idea of privacy by design.

Studies show that when companies use the term 'privacy policy', consumers are far more trusting. Thus, a multipronged approach for engaging with these regulators, composed of the law and consumer awareness, would be effective. In the Indian context, many of these issues are likely to be resolved in court: for instance, Facebook's takeover of WhatsApp or Aadhar-related issues. While there has not been much work on the legislative or executive front, the Indian judiciary has taken on a proactive role.

DATA AS PROPERTY

Web 2.0 is driven by the consent model with standard form contracts. There are problems with that model, like consent fatigue, etc. However, consent plays an important role, perhaps less in terms of expression of human autonomy, but more in terms of an educational function.

The question then is: Can one work around the property assignment model to bring in restrictions on what users would still assign, or what companies can still take, despite the fact that there is consent and users have agreed to everything vis à vis privacy in their contract with the data company? Property does give a hook to slicing up everything that one could possibly do with the data. One possible solution is that when it comes to core sectors like mobility, healthcare, and so on, nobody should really own this data, except for that particular limited point of doing one's business. However, when it comes to sharing this data in a data pool, which could be government managed or even data escrow, one needs to consider how to create markets, or even to create the third parties who will essentially hold this data and deal with start-ups which can then innovate using that data—'data sandbox', as Telecom Regulatory Authority of India (TRAI) calls it.

A critical question is the role or relevance of consent in the structure of a data privacy law. The consent model is also the reason that thinking of data as property is dangerous. Yochai Benkler points to a simple concept called externalities. He observes that if we think of privacy in terms of data that one can choose to part with—and that is empowerment—then we are ignoring the fact that many citizens who make this choice do so without exhaustive information about its consequences. Innovations might result from the collection of data from common people, but the same innovation could also result in profiling citizens and disenfranchising them.

Thus, consent is associated with a series of problems. There are situations in which for either government or private delivery of services, users' consent is requested. Users usually have little choice in the matter if they are to access a particular welfare service or a community network—the consent is mandatory and a precondition for services. The second problem is that users might feel they understand what they are consenting to. For instance, they might feel that it does not make a difference sharing, say, where they live. However, where they live signals their economic status in society, and once flagged, could affect the ways in which a particular service is delivered.

To deal with consent as a precondition for services, the focus ought to be on two different facets. One is an overall public safety perspective, like seatbelts, which if one does not consent to wear, one cannot drive. However, this is a very different public safety issue from, say, not possessing an Aadhar card, the lack of which denies a citizen its benefits, such as PDS services or mobile services. Thus, a citizen is faced with two choices: either to live like a hermit, or give consent as a precondition for use of welfare services.

TRUST IN THE DIGITAL ECOSYSTEM

While the process of data gathering has become a veritable juggernaut, and cannot be stalled, the responsible collection of that data can, and must, be ensured. Several applications which collect data involving children need to be upgraded in terms of the risk involved with processing, and liability in the event of any harm occurring.

Furthermore, two methods have been advocated to deal with data breaches. One, the regulator should be informed of data breaches, and decide how, and whether, to manage it. The other is to inform the public of a data breach as, often, it is their data that has been shared. Ideally, a hybrid model ought to be adopted, where, as far as possible, citizens ought to be informed of the data breach and given the opportunity to enforce their rights. While data may be outsourced to subcontractors, users should not be precluded from being able to sue the original data collector such that, depending on their sharing and contractual arrangements, they themselves are able to assess liability, inter se.

DATA SILOS: PROS AND CONS

Data aggregation or data silos are fraught with their own set of problems. Therfore, is important to establish a method of aggregation which will not give rise to predictive analyses of behaviour. The data remaining in silos has some advantages, as it is not all vested with one particular entity. However, the question is whether it is better, or worse, aggregated in five different silos, rather than in one silo. The reason Facebook has acquired 200 companies is because that composite view holds huge potential for innovation.

The solution lies in a co-regulation model in which these companies work with the Data Protection Authority in terms of data sharing within their organisations and their subsidiaries. The Data Protection Authority will then assess whether the data aggregation possibilities are harmful, or potentially harmful. Thus, the only type of response required by this scenario is anticipatory governance.

Since the aggregation of data is almost impossible to stop—indeed is escalating, thanks to technology innovation—how can we ensure that it does not lead to the profiling of citizens once data silos are created? As regards privacy in the case of big data, the law needs to deal with this in two ways. The familiar ways are the substantive norms, something we are quite capable of creating. Most Supreme Court case law ensures privacy with substantive norms, and wherever the right to privacy exists, it must be upheld in those contexts. The area in which improvements in the law are necessary is procedural law.

The third fact, which is completely unfamiliar, is this terrain within which technology is changing rapidly—it is a juggernaut. However, this opportunity to build a more empathetic society comes with a flip side—we could also build an authoritarian society. Hence, the law can enforce what is being currently referred to as digital due process—it is not necessary to accept the form in which the silos were created, and we need not permit profiling without prior knowledge. Technology ought to be designed in a way that is more democratic, such that accountability can be built into its very architecture as it develops.

SURVEILLANCE AND GOVERNANCE

Real-time governance and surveillance both require the personal data of citizens. Although intelligence and tax authorities need a citizen's personal information, it is termed governance. Where do we draw the line between surveillance and governance, especially when states like Andhra Pradesh are collecting data on location, medical information and religious beliefs to build 360-degree profiles of citizens in the name of real-time governance? There are often cases of this kind of data being made public, although the authorities claim foolproof security.

As all laws are designed to serve the interests of the citizen, inverting the process to assert that the citizen exists for the state is undesirable. In order to serve citizens better, it is necessary to ensure they are safe, free from disease and educated, among other requirements to be better citizens. One reason why surveillance becomes necessary is to ensure that the negative elements in society are monitored, an activity that is a legitimate interest of the state for the benefit of citizens—the state does not profit from it. Purpose limitation—in which data is taken specifically for, say, purposes of income tax—is desirable, as is the concept of deletion of data on conclusion of that purpose.

Likewise, while informed consent is essential, it is not sufficient as a basis of any data protection framework. A more practical solution would be some sort of a consent, along with the framework. In addition, the law needs to be strengthened in terms of transparency, accountability, data breach notification or privacy by design. Thus, the other elements of the law will become as important as consent, whereas, traditionally, consent was seen as the answer to everything. The manner in which consent is received throws open several interesting

discussions. Informed consent involves a situation which must be understood before the citizen consents, in a language that the user understands. Therefore, creative ways to educate customers and induce informed consent must be explored.

In terms of the emphasis on data sovereignty, the Supreme Court has spoken most decisively in the Puttaswamy case—at its core, privacy is a fundamental right. Even if a citizen decides to part with his right, certain kinds of fundamental rights may not be contracted out, as it is not permitted under the Constitution. This principle lies at the core of data sovereignty, which has two dimensions: (i) who has the ultimate right on the data, who is sovereign as far as the data are concerned; and (ii) from the point of view of any nation, does its sovereignty extend to the data generated in the country? The answers to such questions must allow for the free-flowing nature of the Internet or else it will have no meaning, and no value at all. At present, the value of the Internet is because it knows no borders.

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4 TECHNOLOGY, SOCIAL DIVIDES AND DIVERSITY

KNOWLEDGE PRODUCTION THROUGH TECHNOLOGY

The increasing use of technology has strengthened the belief that information is empowering. The lack of information and lack of access to information is disempowering because it is a question of one's rights and entitlements.

Today broadband and access to the Internet is the most basic infrastructure. This is true even for the poor as several essentials are dependent on connectivity, such as rations. But India is a paradox: on the one hand, it is the second largest user of Facebook in the world with 200 million users. However, given its population of 1.3 billion, not more than 30 per cent of the population is connected to the Internet.

Technology can also empower the most frugal, most impoverished community. Social experiments in remote areas have demonstrated that technology can make tangible differences to people's lives. But, the challenge in India also lies in the economic feasibility of making technology accessible to all.

Here, non-profit based innovations can intervene. Take, for instance, the free software movement which started about 35 years ago when computer scientists who were not motivated by profit and revenues decided to establish an alternative paradigm to what is still perhaps the dominant paradigm—proprietary software. They believed that one should have the right to study their software, to use software for any purpose, and that the software should be 'open' and not controlled by its manufacturer. Industry-led, non-profit interventions can also help poor countries build a cultural firewall. This is what happened when, in 2004, Bhutan, with the help of Microsoft and the United Nations (UN), was able to incorporate Dzongkha in Linux software. Such instances are also true for

India where a Santhali font was developed for their community.

Therefore, open technologies are key to protecting diversity. In the Little Rann of Kutch, for instance, there were no roads, no telecom, no Internet. A very basic technology called Spectrum was used to provide connectivity. With this, the culture of the tribal community became known to the outside world and vice versa. There is an increasing demand that every time the government auctions Spectrum, the revenues should not be used to balance a deficit budget, but rather be allocated specifically to protect the diversity of cultures, languages, etc. But this could also have a negative impact: there is the danger of creating an agglomeration of entitled communities who are proud of their culture or their language and this technology could become a means of walling people from one another.

In the free software movement, the first freedom was the freedom of use. When people put up content or software on the Internet under an open license, they are inviting people to use that content as they choose, remix it, etc., and to make very different types of works which may not have originally been expected. This should happen from a position of strength that is truly empowered sharing. Otherwise people are being forced to give up the richness of their own culture and to adopt a foreign one.

TECHNOLOGY FOR DEMOCRATIC EMPOWERMENT

There does appear to be a human interface to technology. There is a social and public policy interface which is very important in terms of ensuring that the benefits that we derive from that technology are not only available to as large a number of people as possible, but is also enabling and empowering. Without the right kind of public policy, there is the danger that it might veer off in a different and perhaps negative direction.

If each and every entitlement is written on paper/textual format, an illiterate person will not be able to access it. Even those who can, might find it difficult to go through pages and pages of text and still not know their entitlements or which form to fill! What technology does is to bring that paper into your telephone. Every government department today has an app to solve critical problems, and in a sense it is bringing the state closer to people. That could potentially be a true source of deep empowerment. However, what really matters is what kind of information is being provided. That is, how are we able to access it and the mechanisms by which that information can be used to exercise one's rights. One of the most critical challenges that technology faces today is precisely in the translation of what technology as a tool can do and how it can actually be used.

It needs to be emphasised that the mediation between the citizen and the state is done through people, and the state sees technology as a tool to solve its own failures. The assumption is that if mediators are removed, the complex art of statecraft and the complex art of engagement with citizens will be automated. However, the focus will then shift from the actual problem. Social activists have begun to use technology to highlight the failures of governance and this has been particularly beneficial to the poorest sections of society. They have also helped focus on the inefficiencies of technological design that makes it difficult for citizens to access information. Such technological solutions will truly bring about that empowerment.

ACCESSIBILITY AND ACCOUNTABILITY OF TECHNOLOGY

There are flaws in the design of e-governance systems in India, largely created by adherence to the Silicon Valley ideology that technology is the solution to all the world's problems, and the

erroneous view of the nation state as a firm. While this design in e-governance has created an automated system, interaction with the system is such that it has become an exploitation tool and not an ease-of-use tool for the poorest beneficiaries.

In India, there is an ambitious project called India Stack with the aim of creating a unified software platform to bring India's population into the digital age by making it paperless and cashless, and decrease the presence of the government. For the poor this means that if they are denied their legitimate rights, they will have no physical evidence to hold the government accountable. Thus, the design of e-governance systems tends to duck accountability, liability and culpability.

Nicholas Nassim Taleb's book, *Skin in the Game*, suggests that this is precisely what is happening. E-governance systems are being designed such that nobody has skin in the game except the poor, and this is the problem with systems that we design. Accountability needs to be fixed in the digital world as it is in the non-digital world. Further, technology, while protecting people's privacy, should help them form a collective that uses information to empower themselves and challenge the autocracy of technological designs as well as poor governance.

DIVERSITY AND TECHNOLOGY

The state has already put in place several key policies around openness, including two national policies on free and open source software. What is needed is policy implementation, especially for protecting the disappearing languages and cultures. However, we also require a budget because policies without budgets don't have teeth.

One more policy area intended to protect diversity is competition loan. Analysis shows that if there is competition because of a

multiplicity of firms in that particular domain or because the regulator has decided to fix competition in some way, there will be a diversity of content and of ideas. But this is not necessarily true. The best example in India is television. Some of these problems cannot be left to the market or even regulators to sort out. This needs actual government allocation of funds, i.e., as mentioned earlier, policy backed with budget allocations.

CENTRALISED NATURE OF TECHNOLOGY

One could argue that new technologies have shrunk the role of the state. Today, the Internet is highly centralised. There are a few global operations that control one's experience of the Internet in tremendously powerful ways. As a platform, it is allowing interaction far beyond the control of the state. One of the reasons why the state perhaps feels threatened is because such a lot is happening without the state's control or even knowledge of what is taking place in that space. However, the grip of the state on the Internet has never disappeared. There are several promising examples of joint ventures between state governments and private industry.

PRESENT AND FUTURE OF DIGITAL GOVERNANCE

In order to gaze into the future, one must know the present. Here are some institutional statistics which are quite pessimistic. There are 1.4 million schools in India, 7 million teachers and more than 200 something million children—not even 10 per cent of these schools have basic digital services. There are 250,000 panchayats with 3 million elected representatives, of whom 1 million are women. There are 156 million micro and nano enterprises in the country, most of which cannot sell digitally. There are 2 million anganwadis in the public health system, and yet it would be difficult to find even one that is digitally enabled to provide preventive health care.

India's governance at the lowest rung are panchayats which can deal with the school education system, nano and micro enterprises, but not, for instance, the stock market which is booming at the moment. So the larger economy of the country is left out of this system. Bharat Net is a scheme at the level of the panchayat for access to technology like broadband, etc. According to the latest data, it is claimed that 125,000 panchayats are service ready. However, a survey of 269 of these showed that 18.6 per cent had equipment installed, but only 11 per cent were found to be functional, and that too, with less than 100 MBPS speed. While we can talk about infrastructure connectivity with regard to companies like Ola and Uber and Google which work on AI, we have to acknowledge that India is struggling for connectivity for all.

We have highlighted several grave problems with technology, but there many empowering conveniences. From a public policy point of view, technology can improve the relationship between citizens and the state and provide access to basic information about how the state is functioning at the local level: the budget of one's panchayat or school; the kind of expenditure taking place, etc. Disaggregated data at that level can be a hugely empowering aspect of the democratic experience. It is precisely because that lens has not been applied one tends to think of technology as a solution to a problem, whereas technology highlights the extent to which state failure is experienced in our lives on a day-to-day basis.

NEW PROBLEMS, NEW SOLUTIONS

Although the Internet is open and free for public participation, some platforms are gaining monopoly. Are corporate gatekeepers a threat to the democratic nature of the Internet? And if so, how can this be combated? There is a service that Twitter has launched in India—Twitter Seva. For instance, if

one wants to lodge a complaint about the condition of railway compartments or make a police complaint, this facility will help. This is a backend MIS system through which the police or the railways can track the status of complaints. Is Twitter infantilising Indian e-governance, as some argue? Twitter is preventing the Indian government from producing proper e-governance systems. For instance, one cannot file an RTI request on Twitter. It is perhaps undermining the right to transparency. Twitter Seva is not a solution. What it is doing is highlighting the fact that our governance system is so broken that Twitter is the means by which citizens can access the government to tell them about problems that affect fundamental rights. And the government's first job is to ensure that the problem doesn't exist in the first place.

The other point to note is this: if one opens any newspaper, it is clear that ministries and departments are buying advertisement space and providing URLs for Facebook, Twitter, etc., with the taxpayer's money being used to provide free advertising for these giants. According to classic economic theory, as a new entrant comes into the market, there should be disruptive innovation whereby one entrant replaces the other. However, this kind of disruptive technology may not find space in India with the government helping to entrench monopoly.

Another question is, should access to the Internet be a basic right or should it be the government's responsibility? Yes, it should be a basic right. If not individually, certainly at the community level. Should it be part of the government's responsibility? Yes, because telecoms do not connect people unless it makes business sense. An ambitious project is BharatNet which is aimed at connecting gram panchayats through broadband, and to realise the vision of Digital India in partnership with states and the private sector. Unfortunately, its slow pace has been a setback. Therefore, a proposition was

made for the liberalisation of Internet access—be it an NGO or a single entrepreneur. There should be liberalisation of ISP licensing to any level so that entrepreneurship can be created and more and more access could be provided at any level.

Another related concern is the hurdle of illiteracy in meeting the goal of Digital India. Here too technology is both the problem and also part of the solution. The problem is that parents are abdicating their responsibility as parents and they are allowing their children to be raised by screens. The solution is emerging—Ed-Tech. The trouble, however, is that the same matrix that is used to develop digital payments solutions cannot apply in the Ed-Tech field. When it comes to digital payment solutions, the key is to eliminate friction. If the same approach is taken to the classroom, the absence of (all) friction is not pedagogically useful. Techno-solutionists need to consider this when moving to Ed-Tech.

In sum, there is no way to trace the origins of the technology–state relationship. However, what is important to realise is that the Indian state has less faith in its own ability to provide its citizens basic rights than citizens themselves. And because this culture is quite deeply ingrained in the state system, the government is always looking for ways to bypass itself and avoid fulfilling its roles and responsibilities. Thus, public–private partnerships in technology could potentially be a deeply empowering and sensible way forward, depending on what problem one is trying to solve.

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5

UNPACKING MEDIA: DIGITAL AND TRADITIONAL

DIGITAL MEDIA AND INFORMATION OVERLOAD

As digital technology penetrates more deeply into our lives, the manner in which we receive news has changed drastically too. Initially, news was created and delivered in a traditional manner with the assumption that the reader did not know. Today, as the reader has access to multiple sources of information as well, the objective is to inform him as to why he should care at all about the news.

In an era where the digital reader has very little time and patience, no loyalty, and access to multiple sources, there is an information overload. Another characteristic of the digital world is the surfeit of opinion. With almost everybody blogging, and, moreover, in a polarising manner, reader retention has become a challenge. One solution is to marry or bring together intelligent, informed, insightful analyses with a breezy clickable feel that is not overtly heavy or scholarly.

The same information overload also exists in TV media. Now redundant, the idea of 'breaking news' has shifted focus to 'enterprise stories'. An enterprise story could either be as big as a sting operation, with dramatic consequences, or just a source-based leak. It is information that only the news outlet or its reporter is exclusively privy to, and cannot be uploaded on either WhatsApp or any other social media before the reporter has broken the story.

MEDIA EVOLUTION IN THE RECENT PAST

In light of such information overload, traditional media has also tried to inculcate features of digital media. For instance, guests are brought in through digital platforms, or audiences may engage through comments on Facebook. Television channels

have also started putting out short videos on digital platforms, with hosts explaining matters, or text on video, etc. This trend represents the move toward shorter, quicker content as audiences do not have the attention span for anything longer. This model started to take off in India around 2016.

However, there are enough indications that audiences actually seek out longer 'quality content', rather than two-minute videos which tend to be fairly superficial. Documentary series on Netflix are an example, as are podcasts for an audience eager for longer, engrossing material.

ENTREPRENEURSHIP IN DIGITAL MEDIA

An entrepreneurial mindset in the age of digital media is essential. With breaking news becoming redundant, a media company or a journalist cannot be enslaved to platforms or a format, as they are temporary in nature. A good recent example is of Facebook forcing publishers to put out articles and stories on its platform first. When the issue of fake news first surfaced, Facebook denied any culpability on the grounds that it was not a media company, and thus not responsible for verifying content put out by media companies. However, while platforms might come and go, journalism is here to stay because of credibility and storytelling, particularly evidence-based storytelling.

There is much talk about next generation readers or millennials, and new careers in media. A certain mindset is required wherein media is viewed as a product, with stories as raw material. A new breed of talent is required to be in charge of the 'product', someone who will spend time at the intersection of stories, audiences, formats and the ever-changing world of platforms. Clearly, journalism and media need these talented product managers.

More important than the numbers who read are those who do. An anecdote on the value of time spent understanding audiences and building communities illustrates this. When FactorDaily.com first started writing about drones, they were new and fashionable. Following a series of articles, some readers expressed interest in learning to fly them, for which a workshop was organised. Some weeks later, readers requested FactorDaily.com to organise a drone-racing competition. Around that time, the Tata Group's chief technology officer reached out with a request for drone pilots for a new product, which FactorDaily.com facilitated by connecting the Tatas to that cohort.

Another problem is the inordinate emphasis on the right and the left in media, leading to massive polarisation. With some of the brightest minds consumed in fighting these polarisation battles, little attention is being paid to the use of new tools, or resources dedicated to setting up journalism labs, or finding answers to such questions as how to engage with a community or practise journalism in the age of Netflix.

INTERACTIVE JOURNALISM IN THE DIGITAL AGE

Today, there is an element of inter-activeness in new media, with constant interaction between reporters and audiences through digital news stories. Reporters, or even those with large followings on social media, have themselves become broadcasters. The kinds of audience they bring with them, and their roles as influencers, are critical when journalists are hired today. If readers are too familiar with a journalist's social media profile, his leanings and thoughts on a particular issue, there is then little curiosity about his report. The right balance is needed.

But the elephant in the room is 'traffic'. Some 10 or 15 years ago, the dirty word in Indian journalism was TRP—the dirty word today is traffic. These two concepts have changed the course of journalism, content and conversations, and their influence on politics in India. In the early 2000s, TRPs followed a 'Peepli Live' style of coverage—live coverage for three days of a boy who had fallen into a hole, and the like. With today's blind chase for traffic, Google algorithms are dictating the kind of journalism in practice. Since the importance of traffic is built into the matrix of annual appraisal, journalists start tailoring their stories accordingly. This is creating and encouraging echo chambers—if one wants to hear certain stories, Google will continue to suggest similar stories.

Traffic and TRPs are the only measures for revenue from the content put out. It is a global problem for new media, but not so much for TV. Today, certain mediums have become obsolete for certain age groups. For instance, millennials are not watching TV. Amidst the surge of fake videos, audiences are reverting to traditional media because of the trust factor. There is an inbuilt element of trust with so-called Legacy Media, which spends considerable sums on fact checkers to ensure that credible news is put out.

If one looks at the barometer of traffic, the biggest, digital properties in India— timesofindia.com, HT.com, Indianexpress.com, News18.com—are all legacy media. However, they are not NGOs—they are in the business, if not to make money, then at least to break even—and thus survival becomes a problem faced with losses, quarter after quarter, year after year. The traffic problem faced by digital outlets is something that TV media has dealt with for long.

THE QUESTION OF REVENUE AND THE PANDEMIC OF FAKE NEWS

In relation to the problems of interaction and traffic, it must be understood that traffic is the beast created by the media, and the elephant in the room is that nobody is spending enough time in understanding the requirements of the future. There is massive cartelisation, particularly in advertising. Oddly enough, even though millennials do not read newspapers, advertisements target them in legacy or newspapers. Recently, Procter and Gamble, one of the world's top advertisers, pulled out of Facebook, because when the so-called advertisements that were being shown were studied, more than half the consumers were found to be bots, not real people. General Motors, too, pulled out all its campaigns from Facebook.

Cartelisation remains the problem and is beyond typical journalism. Therefore, the answer to these concerns lies with understanding media buyers and the cartel. The problem is not monetisation. The problem is answering the product question, and questions by the audience—and that is where time and money need to be spent. Today, the entire front page of *The Times of India* or *Hindustan Times* is a giant, full-page advertisement, with the actual front page revealed when opened—something that would never be found in the *New York Times*, but is the norm in India.

The search for new ways to generate revenue is ongoing. The problem is the existing model of revenue that has been in place at least since the advent of private television in India. One reflexive assumption in the left versus right debate is that the left-leaning prefer NDTV, and the right, Republic or Times Now. These left–right divides are also to be found globally—in the United States, in the United Kingdom. Traditional media is now beginning to realise the value of employing fact checkers

for robust, solid journalism and ensuring that credible news is aired, because if a story turns out to be wrong, a barrage of troll armies will be unleashed. The value of a brand is being appreciated as it draws audiences by the credibility it stands for.

Media outlets also face trust issues. For instance, in the United States, CNN, a prime example of big legacy media, was barred from press conferences and termed dirty media by the most powerful person on earth—all because of an overnight shift in politics. It is evident that there is no room for complacency, and one cannot take refuge behind a big brand and 100 years of journalism to continue to claim the audience's trust.

How is the personality of a journalist faring in this scenario? Recently, all bylines disappeared from the *New York Times* homepage, while the stories were still there. Traditional media houses were seen to be undermining or eclipsing bylines on their homepages. Today, the reader does not look for the name of the journalist on a homepage—that luxury is not available anymore. On the other hand, prominent journalists are voluntarily quitting the social media space as it is too toxic. These obvious challenges do not have easy solutions.

The pandemic of fake news can be dealt with by using machine learning and artificial intelligence, combined with human capabilities. A concerted industry-wide effort is required, wherein publishers come together and build an engine with both man and machine—not man versus machine—to call out fake news. The problem is overwhelming and unlikely to be solved by one media company alone.

THE PROBLEM OF REGULATION AND ETHICS

Even though private TV channels are constantly reprimanded on account of fake news, government regulation is not

considered a solution. Consequently, some years ago, news channels all came together to create the News Broadcasters Association (NBA) for TV. Quite often, viewers write to the NBA with complaints, and TV channels have been known to issue apologies. The threat of government regulation has also brought together all digital first companies in an effort to self-regulate along the lines of the NBA model.

There is also the rise of partisan ideology amongst media outlets. Particular channels present a particular perception on the news, as they are wedded to partisan politics. The problem is not that they have an opinion, or that the media group has an opinion or takes a position, but that for all stories, all content, channels are wedded to partisan ideology, or a position.

Joseph Pulitzer rightly said, 'Put it before them briefly, so they will read it, clearly so they will appreciate it, picturesquely, so they will remember it, and above all, accurately, so they will be guided by its light.' The core of journalism is about ethics, with everybody bound by a code of ethics. While some argue that objectivity–neutrality is merely a veneer, it is the manner in which content is presented that is the very craft, which brings neutrality or objectivity to the article.

THE FUTURE OF NEWS

With the rise of fake news and a plethora of partisan ideologies, what is the future of news? Is news going to be funded solely by vested interests, or will journalistic integrity survive?

Two simple ways to categorise media overall in terms of funding journalism are: one, not-for-profit, with grants; and, two, for profit, where considerable experimentation is still needed. Venture funding can provide one possible solution and is already being utilised.

While investors may be located to fund a futuristic media company, the problem lies with how to make it sustainable, to find revenue streams that are recurring. The other form is subscription in journalism wherein, if one spends enough time in understanding audiences and communities, a product can be built that will pay for itself, as illustrated by *Financial Times* and the *Wall Street Journal*, among others. In the Indian context, it is important to spend time in understanding audiences who will pay for what is produced. Paul Graham, founder of the YCombinator in the Silicon Valley, gives a simple description of what is a good product—something which is found useful by its users, is habit forming, and pays for itself.

Another critical question concerns the number of people that can be employed by the news industry. While some may argue that employment trends are showing a decline, others argue that there has not been a substantial decrease in the number of people being hired at the entry level. Furthermore, the manner in which news is consumed, shared, created and owned has changed dramatically, and has meant that almost anybody can become a news entrepreneur—one does not need to be a Jain or a Bhartiya to own a media company. Entry levels to media ownership have been lowered, which mean more jobs, and more people running digital news sites or digital opinion sites.

Lastly, as the Internet evolves into a more centralised ecosystem around platforms such as Facebook and Google, how do news platforms reduce this dependence, even as Facebook's and Google's user bases grow, given that they have to constantly play by the rules of algorithms that shape our centralised ecosystems, both in terms of content and format? While there is no quick-fix answer, it is a mistake to be enslaved to these platforms. Original storytelling and credibility will remain as important as ever, while the focus should remain on spending time with the audience. Thus, Facebook and Google have not

turned out to be the white knights that were to save journalism and media, which everyone assumed them to be. In fact, these platforms are better viewed as distribution channels, as models of distribution. There are other innovative ways of ensuring that no matter how much the information gets played out on Facebook and other platforms, the traffic or engagement can be redirected back. Innovative ways are numerous, but require investment in terms of time and resources to build solutions.

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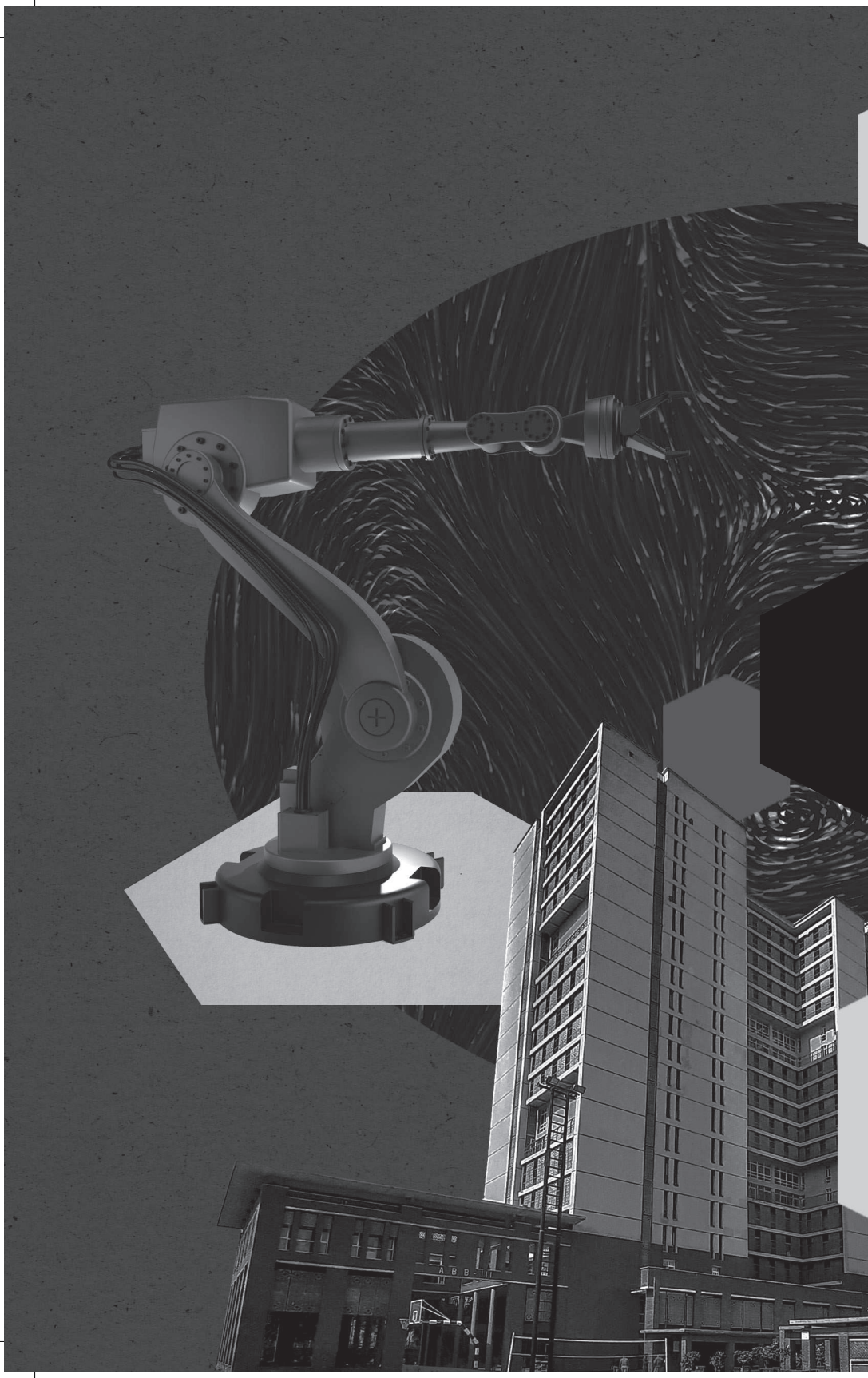

6 AUTOMATION, ARTIFICIAL INTELLIGENCE AND THE FUTURE OF JOBS

TECHNOLOGY AS POWER

The famous futurologist Alvin Toffler said, 'Yesterday violence was power, today wealth is power and tomorrow knowledge will be power.' As things stand today, whoever has the capability to convert knowledge into technology becomes the most powerful. To paraphrase Alvin Toffler, we can say that technology is power. Because technology is power, both corporations and governments are trying to dominate it through the mechanisms of intellectual property rights from the commercial angle, and technology-controlled regimes from the strategic angle. This is in fields as diverse as human genomics and nuclear weapons, and India should learn to counter this through its own attempts at technology leadership.

Automation leads to improved efficiency, higher quality and convenience. Robotics was considered an important component of the third industrial revolution. Now, when we talk about the fourth industrial revolution where the Internet of Things and services are entering the manufacturing environment, automation has an enhanced role to play.

There are disadvantages and hidden risks of automation. It increases the carbon footprint and that too at a time when we are fighting the increasing threat of climate change. Another important threat is the loss of jobs to automation. The World Economic Forum's website states that less than 5 per cent of occupations are 100 per cent automatable. Of course, this could be debated, but if 30 per cent of most jobs can be carried out by machines, then we cannot underestimate the possibility. Those who are unemployed could face significant health problems. There will be a small group of people in high-income cognitively demanding groups who will be less affected. But it is the lower- and middle-income groups that will find the transition troublesome.

Humanoid robots represent yet another new dawn in robotics. Many human jobs such as assisted living and public relations can be taken up by humanoid robots. Humanoid robots such as Sophia, the first robot to get citizenship, have become immensely popular.

Keeping in mind such advancements, the report of the World Economic Forum, 'Future of Jobs' (2018) suggests that technology advancement will require the existing workforce to be reskilled and upskilled. Otherwise, the lower segment of society will be left jobless and without any income.

EMERGING TRENDS IN AUTOMATION AND THE FUTURE OF HUMAN EMPLOYMENT

India presents a very interesting picture. While it is an economically developing country with advanced science and technology, its job sectors have a vast range—from nuclear space to MSMEs—and rural areas have still to catch up with the second industrial revolution. What is the relevance of all these arguments to MSMEs and rural enterprises and rural jobs? The Centre for Sustainable Employment at Azim Premji University has tried to relate GDP growth rate with generation of jobs. The rather grim picture they presented showed that 10 per cent growth in GDP may lead to 1 per cent growth in jobs.

However, there is hope, too. Technology creates productivity; while taking away old jobs it also creates new jobs. Mckinsey Global Institute's work shows that automation technology and the effects it has on jobs will not be any different from the pace of change that the personal computer created, or the impact machinery had in the case of farms. In fact, human capacity to learn, absorb and adapt to new technology is higher than it was 100 years ago. That is not to say that there will not be transition pains. Mckinsey Global Institute studied 2,000 specific tasks

that were carried out in 800 occupations across 58 countries. The study concluded that if one takes the technological capability of automation as it stands today and in the foreseeable future, roughly 6 out of 10 jobs would have the potential for over 30 per cent automation. Six out of 10 jobs in these 58 countries that comprise more than 80 per cent of the GDP of the world, and 50 to 60 per cent of current work, can be automated right away.

Technology itself does not lead to diffusion and adoption of those technologies. There are three other factors: the first is technology solution development. For instance, mobile technologies are not new, but the solution which actually brings together many pieces of that technology and allows for the creation of a new product, WhatsApp, for example, is a more recent development.

Second is the economic feasibility of that technology, and third, the real behavioural change, which is end-user adoption of these technologies. If this is taken into account, roughly 10 per cent of India's jobs by the year 2030 (which will be about 620 odd million jobs at that time), will either cease to exist or will have to be significantly different. At the global level, about 400 million jobs would be impacted.

Mckinsey Global Institute estimates that 800 million more jobs will be created in these 12 years against the 400 million jobs that would be substantially impacted by technologies. These new jobs will be in healthcare, construction, infrastructure, energy transition, and in other sectors such as childcare where unpaid work will be monetised. Four things need to be done for a smooth transition: one, the world needs to maintain growth, and resources need to be utilised efficiently. Second, scale job training and workforce skill deployment needs to be undertaken. Third, improving labour market mobility. Finally, providing income and transition support.

GOVERNMENT AND FRONTIER TECHNOLOGIES

Through all this, the government can either be reactive or proactive. The present government took this initiative and tasked NITI Aayog to develop a national strategy. The objective was, first, to delineate the role of the government—where it should be an enabler, and where it should be at the forefront. Second, how to position India on the global scene—should it remain virtually invisible or become aggressive? Third, will a late entrant get an advantage as in some other technologies? And fourth, concerns surrounding this technology like ethics, privacy, biases, etc.

NITI Aayog concluded that the national strategy should clearly delineate the role of the government in various capacities; that the government should focus on investment in sectors which are characterised by public goods (health, education, etc.) and leave other sectors to private initiative for development (automation, manufacturing, etc.); in line with the government's stress on inclusive growth, the strategy was aligned to frontier technology, which enables inclusive growth and has the maximum impact. With these considerations in mind, the strategy was called 'AI for all'—i.e., technology which helps the maximum (masses) number of people.

What are the pillars of this strategy? First, developing the research ecosystem, for which there were several recommendations. It was realised that Indian institutes tend to work in silos without much coordination between different organs. The first step was to break the silos and create a centre of research excellence which will deal with the building blocks of AI, such as computer vision and other such cross-sectoral technologies. Further, AI is very domain specific. One can apply computer vision for image processing in the health sector, and also for predictive diagnosis in, say, transportation for

road safety. To tackle this, it was suggested that International Centres for Transformational AI (ICTAI) be set up, which will be the research ecosystem for AI. The ICTAI model should be industry-led with collaboration with industry and academia. There should also be a democratisation of infrastructure, for which AIRAWAT—an AI-specific cloud computing platform—was suggested. It was also recommended that the government should actively try and make research attractive so as to encourage people to remain in the country. Presently, almost 70 per cent of those in AI abroad are of Indian origin.

Skilling is also very important. New jobs will be created, an AI workforce will need to be developed, and the existing workforce will need to be reskilled. Unfortunately, IT giants have failed to graduate to the next level of AI and have remained largely service providers.

The next feature is adoption. The government can play the biggest role in generating research by proposing adoption of AI. As demand for AI increases, research will also increase and help build a robust research ecosystem and subsequently more technology development within the country.

The next issue is that of ethics, bias and privacy. The recommendation in this regard is that the government should fund research projects which will help in addressing these concerns. Several companies/corporates are already doing research in how to address bias in AI models. For privacy related issues, collaborations such as the Biobank Project with Tata Memorial Centre is proposing to use blockchain technology to address data privacy issues.

Finally, it is suggested that the government should fund moonshot projects on the lines of what DARPA (Defense Advanced Research Projects Agency) has achieved for

the United States, as this can help in developing research capabilities and technology advancement within the country.

EMERGING CHALLENGES FOR THE IT INDUSTRY

Over the past decades, several thousand engineering colleges had come up in India to feed the demand for engineers for IT companies. But as global technologies shifted and moved to platforms, products, automation and digitisation, jobs for fresh engineers began to dry up. It wasn't so much as a loss of jobs, but a decline in the need for fresh engineers. The Indian IT industry was probably the first to be hit by the impact of automation and digitisation because almost all its competition was global and all its markets were overseas.

It is a Schumpeterian situation. There is some destruction, and there is some creation. The problem, however, is that those who are likely to lose jobs because of automation may not be the people who are finding new jobs. Therefore, at a macro level it may not be too bad, but at a micro, individual level it could be devastating. It is a competitive market, and if it makes money and business sense to automate, automation will take place.

Some automation will be to cut costs, but most of it will be to create new markets, new products, and new services. In India, change takes place slowly. Naukri was launched in 1997; 21 years later there are still job ads in newspapers. Mass sacking of staff is culturally alien to India.

Educational institutions, both private and government, don't respond well to market forces so learning new skills can be a problem. In the heydays of the IT industry in India in the early 1980s, there was almost mass hiring to cater to the need for computer education. Private organisations like NIIT or Aptech did extremely well at the time, but government universities

did not respond. Therefore, while public universities cannot be expected to quickly adapt and teach people new skills, private organisations will undertake skill-based courses, and this is already happening.

FUTURE OF WORK IN AI

Two years ago, Mckinsey, World Economic Forum and the World Bank predicted that 77 per cent of jobs in China will become extinct, 69 per cent of jobs in India, etc. Contrarily, the World Bank published a report this year (2022) which stated that no more than 2 to 7 per cent of jobs will be lost in developing countries: a drop from an assessment of 77 per cent to 7 per cent!

We must recognise that there will be differences in the way AI and related technologies are adapted in different parts of the world. There will be three big buckets. Bucket One is the OECD countries where a large number of jobs will be automated. Bucket Two are the BRICS Plus countries, India, Russia, China, who will adapt, but a little slower. Bucket Three will be the least developed countries (LDCs) which will be late entrants. There is always a difference between what is automatable and what is actually automated. At a Mercedes factory in Stuttgart, 95 per cent of functions are automated. The same is also true for the Hyundai factory in India with 85 per cent automation. Yet, only 10 per cent of functions in a Maruti factory are automated. In countries like India, it's all about labour arbitrage. If the return on investment is not as good as it is, say in the West, one will not automate.

The Federation of Indian Chambers of Commerce and Industry (FICCI) has studied automation and the job scenario in India. It confirmed what has been discussed here: one-third of jobs will be extinct, one-third will be new, and one-third will have to

re-adapt to the future. What is needed is to learn to adapt to a situation which is going to be constantly changing.

New technologies are deflationary. What does that mean? It means that consumers get products at cheaper rates and productivity in companies increases; however, profitability does not. Another point to note is that people do not fear technologies; they fear the control technology might have over them. Technology will bring abundance, particularly in the social sectors. Health, education, poverty and agriculture will be addressed and solutions to them will be found.

But what will the government do about it? The government has only three tools: taxation, infrastructure and procurement. And what will industry do? Industry has four major tools: labour reform, social security, skills and migration. Migration is going to be a major issue because the West is ageing but the developing countries are not. With the resultant migration mobility, India might provide the world about 110 million people to work.

Global productivity growth can improve by about 0.8 to 1.4 per cent a year as a result of automation-related technologies. India must become a technology leader in automation.

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7 SOLUTIONS TO TECHNOLOGY PESSIMISM

Digital technologies have had a profound impact on both individuals and society. They have enabled us to overcome the barriers of both time and space. The move from audio connectivity to visual connectivity has brought about a sense of affinity and intimacy which might not have existed earlier. This has created vastly expanded opportunities to access immense pools of knowledge for anyone who is connected to cyberspace. In a sense, technology has become a tool of democratisation, in terms of empowering the individual. This article highlights some of the negative consequences of the adoption and pervasive use of digital technologies, and the ways in which the harmful effects of these technologies may be dealt with.

TECHNOLOGY ADDICTION: WHAT AND WHY?

There is some technological pessimism regarding technology's adverse impact on life. New pathologies that have entered our lexicon, e.g., Internet addiction disorder, attention deficit disorder, and terms such as 'smombies'—people who are constantly looking at their smartphone screens, even while walking.

There is hardly any doubt about the negative impact of overindulgence in Internet surfing and the use of social media on real-life relationships and life. While being digitally active round the clock can create a host of psychological problems, social media, discussion groups and chat rooms may, in fact, help people find kindred company. This could become one way to overcome social isolation or even reconnect with long-lost friends and family members across the globe.

The challenge lies in finding a balance, which will enable people to reap its benefits and simultaneously avoid the negative consequences. Therefore, we are at an inflection point in history where very few have given critical thought to the new social realities created by technology, and what those realities

might mean for both the individual and society. Technological progress has taken place throughout human history, but, more recently, it has accelerated dramatically—and that is one of the problems. The use of new technology has created the need for new norms of social behaviour.

There is a focus on increasing research on technology addiction, even as there is debate as to whether it is an addiction at all. Unlike alcohol, opium or nicotine, technology is not a substance with proven medical addiction. While there are some harmful effects, the moderate use of technology is a boon. In clinical practice, cases of the harmful effects of technology are being diagnosed only over the last four or five years. At AIIMS, one clinic has been set up to deal with behavioural addiction. Behavioural addiction is an umbrella term that not only includes technology, but also behaviour. It unpacks such questions as the effect of technology on behaviour, mindset and thought processes. Technology can lead to anxiety, restlessness, poor performance in academics and social withdrawal. While there might be little consensus as to whether technology is addictive or not, it is considered harmful when it causes impairment to social and biological functions, such as sleep and appetite; when it is intrusive and difficult to control; and when tolerance to its use grows, with ever increasing amounts of time spent on social media platforms bringing little pleasure.

A specific case may be cited to illustrate the issues of anxiety, insomnia, poor scholastic performance, etc. A young girl's family sought treatment for her addiction to her phone. On investigation, the doctor treating her discovered that as the interaction with her parents was negligible, she relied on her phone to connect with virtual friends through Facebook and WhatsApp. Therefore, in the event of her phone being confiscated, loneliness set in, leading to an intense emotional breakdown. Following anxiolytic medication for two weeks, she

was able to sleep well. She was then taught to switch off her phone first for one hour in a couple of days, then, subsequently, for longer periods. This diminished her anxiety and contributed some sense of accomplishment as well.

CAN TECHNOLOGY DEVELOPERS HELP?

Remedies for such situations cannot always be found by individuals, and society at large needs to provide innovative solutions. However, the debate on tech pessimism and tech addiction ought to balance both individual agency and action by individuals to protect themselves against technology, or even from their own behaviour. It is important to look at what can be accomplished as a 'collective'.

Often, the burden is passed on to consumers, playing on guilt over their own failure to limit their phone use, or the thought of giving away privacy. While this could be true to some degree, there are more structural reasons at play which make technology addictive. Both, the way in which technology is designed and the way in which the market incentivises customers, have a crucial role to play in time spent on the Internet. Irrespective of what users can, or cannot, do while being conscious about adopting best practices, they also must put the responsibility back on both the industry and government, for a more holistic view of the situation.

Consumers use technology or social media to promote their businesses, their products, writing or art. In some ways, these are the positive attributes of social media and, hence, to ask people to withdraw from technology as a solution is unfair and comes from a place of privilege. That is precisely why it is important for people in industry to fix the problem, rather than suggest that users retreat from it. But the question is: How can it be fixed when it is not even up to the individual? Renowned

law and technology professor Lawrence Lessig proposed a theory 15 years earlier: 'We are all, as people who study tech sometimes believe, we are all pathetic dots and we are subject to all these constraints which in turn shape our behavior.'

Numbering four, these constraints are: law, social norms, markets and code. Lessig held that in the space of technology, code is law—the ways in which our technologies are architected also affects our behaviour. Persons who designed the scroll feature on Twitter, Instagram and other apps eventually left these companies to come together to start the 'Center for Humane Tech'. They argue that there are certain technological tweaks which trigger the addiction to technology. While it would be too techno deterministic to declare that tweaking technology will fix behaviour, there is something to be said for how code can actually be tweaked to make better technology.

There was a time when Doordarshan was aired for merely three hours in the evening. Eagerly anticipated, it was the high point of people's lives. But, were people actually technologically addicted at that point of time? Today, technology is available 24x7 on various platforms, with each platform vying with the other to oust it, and an average platform life of merely two to three years.

Second, it is essential to differentiate between technology and the content it provides. People do not get addicted to technology, but do, instead, to content. Most companies are programmed to extract a user's maximum engagement with a platform. While a great deal of information is available from the Internet, to be able to cull out wisdom from it is what needs to be taught. Despite the fact that technology has changed over time, how people use it has not changed significantly.

Another important question that must be asked is: Technology in the hands of whom? At the age of three or four, a child is

unable to differentiate between good and bad content. The same child is likely to start looking at pornography at an early age, and, progressively, might indulge in other kinds of activities. So, who is to blame? Is it the pornographic company? Or, the technology which enables it? The parents? Or, is it the child who started watching at the age of five or six?

Another point is that the differences in technologies are little understood, which causes them to be placed under one umbrella—and then blamed. Today's technology is presented in a manner such that even the harmful aspects, like reducing attention span, appear desirable. However, both programmers/developers and those who deal with the addiction of technology are part of the same problem and the same solution. It must be realised that anyone's child could be impacted by the harms of technology and, therefore, society needs to arrive at a solution collectively. Coming from this perspective, along with the realisation of the positive impacts of technology, decisions taken towards this end will be well informed and for the greater good of society.

As technology enhances its reach and penetrates ever deeper into rural society, an increasing number of users are fast approaching technology addiction. If the problem remains unaddressed, the impact can be unprecedented. With little education or access to any other forms of knowledge in these areas, the information from the Internet is all there is. Unless there is awareness and education, society could be dangerously impacted.

TECHNOLOGY OR CONTENT?

There is some debate as to whether it is technology or content that is causing the harmful effects. Nevertheless, the best approach would be a collective one by the users. Parents

ought to be sensitised first, to the impact of technology on the brain, mental abilities, behaviour and other unknown aspects of human thought. Individuals are not even aware of how much time they subconsciously spend on phones, but it is possible to track this screen time. In addition to parents, students themselves should be sensitised, perhaps with the help of technology itself. Some have tried technology to treat technology dependence. However, there is a fair amount of controversy surrounding that methodology.

With nuclear families on the rise, and with both parents working, children are being left to play with devices. One solution might be to encourage parents to increase their physical activity with their children, instead of going to a gym. This exercise becomes emotionally fulfilling for both parents and children.

While content is often to be blamed, it is the architecture of technology that is responsible in digital platforms and digital technologies. Hence, in addition to the conversation on creating healthier habits in families and in social circles, the manner in which technology has been designed ought to be accounted for as well. The financial incentive for a platform is directly proportional to the time consumers spend on it—the longer the better—it is better for advertising and, for better or worse, is the business model of the Internet. It is evident that a completely different business model for the Internet is essential. The attention economy relies on capturing the user's attention, which also effects the kind of content available. Posting something that gets a million views depends on several other factors, such as the virality of content—abusive, aggressive, misogynistic (read provocative) content is more likely to go viral than more measured content. To emphasise, there are various financial incentives that determine the kind of content that goes viral. There is a great deal of trolling online, and trolling in some ways is responsible for many of

these mental health issues. Hence, it is the technological and business logic of these platforms that might exacerbate this kind of hateful or otherwise harmful content.

The answer is not purely digital—it is a mix of both, a combination of collective regulatory solutions for companies that are collecting data indiscriminately and targeting it at users. Companies need market solutions, and code solutions, which will prevent them from incentivising viral content.

MEASURES TO INCENTIVISE GOOD TECHNOLOGY PRACTICES

Viewed from the perspective of governments—which are not inclined to wait for platforms to fix themselves, or for users to stop using these technologies—the situation is not ideal. There is more appetite for regulation than ever before. Privacy laws are catching up because of the growing appetite for data by businesses that need to be regulated. These laws uphold users' rights to more control over the manner in which they are being targeted and profiled. Anti-trust and competition laws argue for a non-monopolised, decentralised Internet and legislation on ways to break the existing monopoly. Apart from these two main laws, companies are also moving towards responsible tech and self-regulatory practices. Solutions are being offered from both sides—the state and the market.

It is noteworthy that in the matter of content, social issues sell. For instance, forty years ago, smoking was universally accepted. But within two or three decades, smokers were outcasts. Such changes depend on the manner in which facts are presented, and their effect on people's minds and lives.

Professionals in this domain will need to take this up as CSR and craft a message. One, it is self-regulatory. Two, if it helps

society, it reflects well on those companies that bring in a social difference, balancing the profit motive in the bargain, as one is then better than one's competitor company. Today, technology has the option to block certain content for a particular age group. Going forward, while governments and users would want more options to block content, the industry's response cannot be predicted in that scenario.

Some measures can also be adopted towards self-regulation. Parents must spend at least two days a month to gather more information on how technology is affecting their children. This awareness must be spread to all within one's social circle, and parents ought to engage more with their children without the interference of technology. Possibly the worst attitude that could be employed towards technology at this juncture is pessimism. Society cannot regress to the pre-Internet era; yet, at the same time, it must be acknowledged that technology has made some significant, positive contributions to human lives. Second, the issue of policy—too much pessimism creates fertile ground for various actors, including the state, to make overarching and sometimes burdensome regulation, not only from the industry's perspective, but also with regard to those whose freedom of speech might be affected.

Consequently, pessimism is often fertile ground for censorship. It is a space that must be occupied so that others—including, occasionally, the state—do not speak on the consumer's behalf. One final reason to eschew pessimism is the long list of the myriad ways in which the Internet has been wonderful, which counterbalances the occasional perception that life was better when the Internet did not exist.

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8

CYBER SECURITY

INTERNATIONAL INITIATIVES IN CYBERSPACE

Cyberspace is an integral part of our lives, and because it is a borderless medium, a simple national policy is not sufficient. There has to be international cooperation, global norms and systems. Ambassador Latha Reddy, Secretary in the Ministry of External Affairs, points out that the United Nations (UN) has announced some important initiatives. The Secretary-General has set up a high-level panel which will consider digital cooperation, and also a new governmental group of experts—this will be the sixth such group. Simultaneously, Russia has brought a resolution to set up an open-ended group on cyber security, which has also been agreed to. According to Ambassador Reddy, there cannot be a meaningful global dialogue if major users of the Internet are not involved. China is the largest user of the Internet and India the second-largest user globally. Therefore, we must have a voice in determining how cyberspace is to function so that we receive its benefits, but are also protected from its dangers.

What is interesting is that the UN has clearly indicated that it wants to formulate a multi-stakeholder approach, rather than only focusing on the question of agreement between governments. Apart from the UN, there have been discussions at the Paris Peace Forum recently, and a crucial technology accord between major industries has been concluded. There is also the London Process, a series of multi-stakeholder meetings held biennially since 2011 under the name Global Conference on Cyberspace (GCCS). The Internet Governance Forum, the Munich Security Conference, NATO, the digital peace initiative by Microsoft are other initiatives. Separately there is the Talent Manual which has tried to address the question of legal systems for cyber management. The telecom industry is negotiating with the International Telecommunication Union (ITU) so as to have a say in how to secure these systems. In

addition are the Shanghai Cooperation Organization; the World Economic Forum; individual national cyber policy discussions, bilateral, plurilateral, multilateral and regional discussions. How do we combine all these forums and develop one consolidated system to regulate cyberspace in a way that it does not stifle innovation, that respects individual rights and privacy, and yet makes it safe for users.

There is also the dilemma of state actors and non-state actors. How are we going to treat the two? The Global Commission and the UN GGE (Group of Governmental Experts) have come up with some norms which were accepted as voluntary and non-binding. However, for norms to be effective, at some stage they have to be legislated and made binding since we live in a geopolitical atmosphere that is very complex at the moment.

NATIONAL LEGISLATION ON CYBERSPACE

The Ministry of Electronics and Information Technology is responsible for the Information Technology Act, 2000, which provides a broad framework for cyberspace. Under the aegis of the IT Act, a Computer Emergency Response Team (CERT) has been set up. Further, a cyber security policy was formulated and advisories have been given to all ministries and departments to have a chief information security officer in place. Guidelines on implementation of cyber security and an ecosystem have also been developed, whereby cyber security audit is now available with empanelled auditors. Awareness, training and capacity building programmes are also in place. R&D initiatives involving a wide number of organisations and institutions like Indian Institutes of Technology and Indian Institutes of Science are being carried out at various levels.

The National Informatics Centre (NIC) is responsible for the core infrastructure for ICT for governance across the country.

NIC-CERT has been set up and empowered with much better tools and manpower. Financial CERT is also in the process of being established.

Many non-government initiatives have been taken with help from industry, like the Data Security Council of India, where awareness campaigns and training programmes for chief information security officers have been instituted. State governments and even cities have started moving forward with the establishment of security operation centres, albeit at an early stage.

One interesting development is that the early movers in this process are not only trying to protect themselves or their cities, but are offering their services to other cities, discouraging them from setting up separate infrastructure. This leads to strengthening of the infrastructure and also a market-type mechanism where aggressive players or more accomplished teams will actually be able to grow quickly.

But at this point, new technologies are developing rapidly even while existing threats are plenty in variety and number: Internet of Things (IoT), Additive Manufacturing, Augmented Reality, Virtual Reality, Blockchain and Big Data, social media, drones and robotics are among the leading technologies proliferating at great speed. Each one of these represents a huge multiplication of the challenges and requires a completely new set of solutions. India cannot look at cyber security only from the point of view of protecting itself, but needs to look at it in terms of being service providers in IT to the world.

A BRIEF TIMELINE OF CYBERSPACE EVOLUTION

From communication through personal computers prior to 2000, we have progressed to Artificial Intelligence (AI) today.

We moved from a bandwidth of 64 kilobytes to a terabyte bandwidth. One thing is very clear—that the underlying core is ICT for all economic verticals, whether in India or elsewhere.

There are a few crucial elements of ICT which are common across the board. ICT has been software driven; software is nothing but a list of instructions that the system operates, understands and executes. A change in one instruction will change the manner of the function. Software is getting easier to make, smarter to work with, and can be considered one of the main drivers of digital transformation. But this feature is also being used by adversaries to sabotage the system or to disrupt its function. The current scenario is therefore extremely complex, as every device comes with a new software that has a 'Big Data engine' to interface with different devices to try to track such eventualities.

Moreover, there are a few more characteristics of this industry directly linked to cyber security. The first characteristic is heterogeneous data with high variability of data types and formats. Despite its advantages, the major disadvantage is large-scale security attacks which are facilitated by the lack of diversity in computer systems, or heterogeneity.

The second characteristic is that the deliverables are free of cost for the consumer, be it companies such as Google, Meta (formerly Facebook), Yahoo, Twitter, and many others.

The third characteristic of this industry, flowing from the second, is that there is no warranty and no guarantee. How do Google or other companies and platforms provide free services? Selling advertising is one of the most common ways Internet companies generate revenue. Companies use the data they collect to customise and deliver targeted advertising messages to their users. We need to understand how to handle such

complex technology since we are moving towards an era where IoT and networks are embedded in devices.

The government anticipated this and in 2013 it developed a cyber security policy. One of its components was a national alert watch or alert system which would be the Indian computer emergency response team. The national critical information protection centre also was set up. Second, a legal framework was created in the form of the Information Technology Act, which was drafted in 2000, making India one of the pioneers in this space.

The third component of the strategy was international cooperation through agreements with both IT companies and about 20 national governments such as the United States, Russia and Israel. Under this arrangement, there is an exchange of both information and cooperation; reactive and proactive.

Capacity development is another component. The Ministry of Electronics introduced the BTech (Electronics System Engineering) retrofitted programme with a course module that includes cyber security. MTech degrees in cyber security are being offered by 35 institutions. In addition, the non-formal is serviced by many organisations that have come up, both in the public and private sectors, that offer short-term courses on cyber security.

Recently the government has also mandated that 10 per cent of their IT budget will go toward enhancing cyber security. Clause 49A of the SEBI Act was amended, wherein the company has to provide a certificate every year as part of the balance sheet and the annual report, and the same has to be testified in the stock exchange that all internal and security controls are in place.

These strategies have been put in place especially in the

context of technology development in critical areas like Blockchain and AI. There are about 200 Indian start-ups specialising in these areas, particularly in FinTech. Further, as hardware emerges as a new frontier, India is also closing gaps in hardware design and development, as are major technology companies worldwide, with R&D functions in place for core product development.

QUANTUM COMPUTING AND NEW CHALLENGES TO CYBER SECURITY

There are two aspects to cyber security. One is the human aspect and the second is the technology aspect which is basically AI and quantum computing. In the first aspect, which is the human element, given that the surface area of cyber security extends well beyond networks, it is going to be extremely important to find the right person with the right interdisciplinary skills to guard the fort. The second aspect is as we go forward, cyber security is going to be a problem that needs to be dealt with by the top management or the board, and it cannot be left to technical people only as it goes well beyond the technological or the digital narrative. Thirdly, which is also extremely important from the human element point of view, is to understand the nature of supply chains in the whole digital thread.

The technology aspect is a little more interesting and complicated. The argument against AI is driven by fear. Singularity is the future point at which AI will exceed human intelligence, where immediately, the machine will make themselves rapidly smarter, reaching a superhuman level of intelligence that we as humans can't fathom. To explain this a little further, the key process is presumably the creation of one class of machine by the other, and that is the challenge. It might look like fiction today but it is quite probable.

The three 21st-century technologies, which are genetics, nanotechnology, and robotics which we call GNR, are so powerful that they can spawn whole new classes of accidents and abuses. Most dangerously, for the first time, these accidents and abuses are widely within the reach of individuals or small groups. So here is the challenge, and we have the process ability, not just weapons of mass destruction, but what we call knowledge-enabled mass destruction, which is KMD. This destructiveness is hugely amplified by the power of self-replication.

Under Section 16/2 of the Copyrights Design and Patent Act 1988, AI systems cannot violate copyrights or regulations as copyrights can only be influenced by a person. Hence there are two feeds for AI: one is data and the second is computer speed. This together is inferred to as quantum computers. Due to the inherent speed boost, it offers to solve complex mathematical problems. All encryptions are maths and the way you crack it and the speed at which you do it is how you break all encryptions. So here is the red flag. According to the Institute of Quantum Computing at the University of Waterloo in Canada, it is estimated there is a one-in-seven chance that some fundamental public key crypto will be broken by quantum by 2026, and a one-in-two chance that the same public crypto will be broken by 2031. Thus, any nation that is able to position itself as a pioneer in quantum computing will be in an advantageous position to access information from across the world, while safeguarding its own data.

This is where the challenge for Aadhar came. When one talks about intergenerational equity, we mean if are we able to guarantee in 10 or 20 years that we will be able to protect our data, quantum computers can happen. Two countries with considerable resources are spending so much research

and effort on quantum computers; the challenge of smaller countries is: Where do you have the resources to do this research to find something faster, smarter and better?

Again, the question will be: If humans can be persuaded to part with a secret in appropriate circumstances, cryptography will be broken. And this will be the challenge going forward for AI and quantum combined together in the world of cyber security.

EMERGING CHALLENGES

Some of the emerging challenges related to cyber security have led to an increasing demand for data localisation. There are some problems inherent with large data centres as outsourcing can easily lead to manipulation.

The threats of cyberspace are not far removed from international geopolitics. China has been spending considerable resources in leapfrogging technologies like quantum computers and AI, partly aided by the military. In China, the military can cooperate with civil government and its major companies can also be managed by the military with resources that India cannot afford.

Information warfare, i.e., misinformation and propaganda on tech platforms in the cyber security landscape, is another emerging vulnerability.

There are roadblocks for the international community to come together and produce a binding law that controls the downside of cyberspace as geopolitics plays a huge role. For instance, Europe and America are sceptical of Russia and China, and while India may be able to get into a dialogue with most nations, international agreements are not easy. Why is this? One is cyber attribution to hold actors accountable for

malicious activity. If one is not able to attribute the incident, what law can be put in place? The other is sovereignty in how the data is to be shared, how the incident is to be shared; issues which are in the realms of both diplomacy and technology.

The layperson in not untouched by this threat and can be easily made a pawn in cyberspace warfare. There are three ways in which this can happen—through the use of infected pendrives; by downloading unsuspecting forwards received on mobile phones; and via email. Our lives can be compromised and controlled by remote control, from elsewhere.

Therefore, what is needed is a multi-stakeholder approach where every stakeholder, the layperson, civil society, educational institutions, industry, defence, etc., are equal stakeholders. Individuals have to ensure that they don't use pirated software, and use systems backed with antivirus facilities. Any incident must be reported to CERT or to the concerned NCIIPC, both of which have listed do's and don'ts on their websites. We can connect our system to CERT and check if it is infected. It can be disinfected once, after which one needs to buy the software. Google and social media companies hold sessions in schools on how to secure their systems.

Most of the security research in IoT is focused on the network layer (inter-network connections) and the transport layer (providing communication services directly to the application processes running on different hosts). But the vulnerabilities actually lie in the application layer (which allows users to access, retrieve and manage files in a remote computer). The other issue is deterrence. With generative adversarial neural networks (GANs) and convolutional neural networks, especially recurrent convolutional neural networks, there is a 50 per cent probability of beating the best cyber defences as they exist today. What India can do to avoid such vulnerabilities is to

establish the chain of custody of the smallest component that goes into the entire digital thread.

To conclude, first, users need to be educated. Second, there is need for more capacity building to position India as a hub for cyber security services, make ourselves more secure, and treat this as an opportunity and not just as a threat. Third, we need to control our own data. The EU's response to India's draft data bill is hypocritical, given that their General Data Protection Regulation (GDPR) is so onerous. Fourth, we need a stronger voice globally in both the UN and other bodies where the Indian government is represented. We also need a strong voice in track 1.5 and track 2 dialogues. And finally, the United States developed the Jason Advisory Group with the finest minds in the country to anticipate future trends and challenges. India needs a Jason equivalent.

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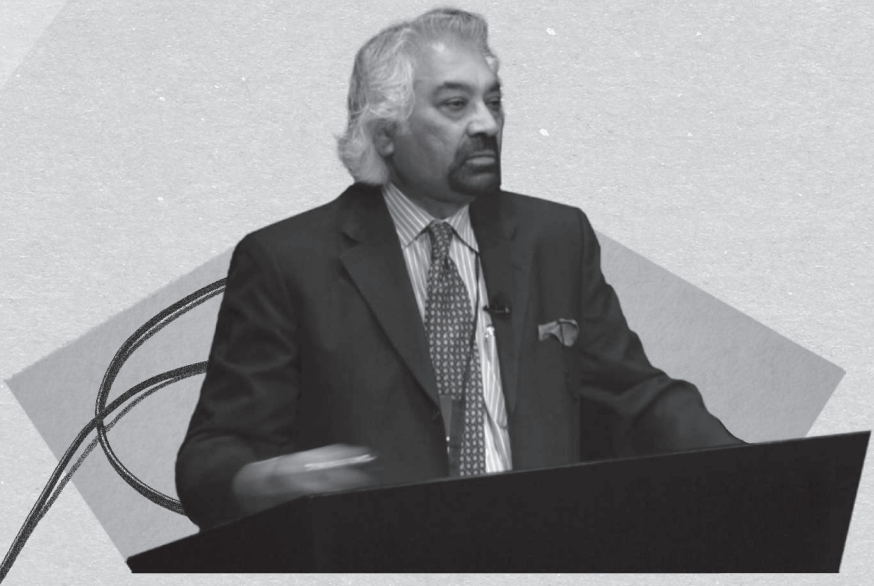

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INFORMATION TECHNOLOGY: COMPUTING, COMMUNICATIONS AND MACHINE INTELLIGENCE—THE NEXT 25 YEARS

Information Technology (IT) is best defined by what it enables—an Uber ride hailing service, interacting on social media or using online speech recognition, to name just a few. IT has advanced enormously in recent years, and the applications we take for granted today would have been unimaginable 20 years ago.

IT now touches almost every human being; cell phones have reached 99 per cent global penetration, and 65 per cent have Internet access. IT is also a true democratiser: whether you are in a penthouse in New York City or in a remote village in Congo, we all use pretty much the same technology.

IT now has two new powerful frontiers: 5G Wireless and Artificial Intelligence (AI). Both promise amazing new opportunities.

Let me begin by describing the Information Technology ecosystem. The IT industry can be organised in a three-tiered stack. The top layer has companies that deliver applications we all use: Ola ride hailing, a Paytm transaction or an Amazon purchase.

The next layer of companies is services providers or operators. Jio and Airtel for wireless infrastructure, Tata Teleservices for Internet infrastructure, and Amazon AWS for computing infrastructure, also called data centres.

Finally, Core IT, sometimes called Core ICT layer, with companies that build the hardware–software systems which make everything else happen. Some examples are Intel for computer servers, Cisco for Internet routers and Huawei for wireless phones. The global market for Core ICT is about 1.6 trillion USD.

Core ICT has three tiers: at the top, systems or devices that service providers like Jio, or we as consumers, may buy—from routers to server farms, and from phones to laptops. The annual a value addition by this tier is about 1.1 trillion USD. China, the United States, South Korea and Taiwan dominate this tier.

The next tier is semiconductor chips, some for data processing, others for wireless transmission or yet others for machine learning, e.g., Beceem, processor chips from Intel, and deep learning chips from Nvidia. The annual market size in this layer is about 500 billion USD. The United States, South Korea, China, Japan and Singapore are the dominant players.

And, finally, at the bottom, the IP layer with algorithms, architecture and design automation that defines what these chips do. This needs a sophisticated skills base and a good many PhDs, who make up about 15 to 25 per cent of the engineering headcount. The biggest barrier to entry into chip design is finding the necessary advanced skills. The United States, with its top engineering schools like MIT and Stanford, dominates this tier. But China is running hard to catch up.

Finally, the delivery view of IT is structures in three layers with end devices at the top, the Internet fabric in the middle, and the servers that run the applications at the bottom.

These servers tend be housed in centralised facilities called data centres and can be large—often 100,000 sq ft in area—and use 3–5 MW of power.

The Internet fabric that connects the servers at the bottom to the end devices at the top utilises optical and wireless transmission, and routers to move the data around. Long-haul links use terrestrial or undersea optical fibre, medium haul

can use millimetric wave radios, while the final access is now almost all wireless.

And, finally, at the top are the end points where the applications are delivered to the user from smart phones to Amazon Alexa or the soon-to-come autonomous cars.

Semiconductor chips range from microprocessors to wireless modems, and to neural nets, but the most pervasive are microprocessors. From 1972 onwards, the trend line for Intel processors largely follows the well-known Moore's Law, which predicts that gate count doubles every 18–20 months. Despite many doomsayers, the industry has maintained this exponential growth for the past 45 years. Since the first microprocessor, the Intel 4004, the number of transistors per chip has gone up by over 10 million times, with the most recent Intel processors having over 20 billion transistors. The new breed of AI chips are even denser, with over 120 billion transistors.

The density advances in chips initially came from Dennard scaling, wherein, as the transistor density doubled, the power per transistor fell in proportion. Dennard scaling has slowed in recent years and we use other approaches to keep Moore's Law intact.

There are many pioneers in microprocessors. Fredrico Faggin built the circuity for the first microprocessor, Intel 4004, in 1972; Ted Hoff was the 4004's architect. They both started an incredible revolution. Gordon Moore's, Intel's Co-Founder and former CEO, observations on transistor density trends became known as Moore's Law.

The next key enabler of IT is wireless technology. The growth of mass-market mobile wireless started in the United States in the early 1980s, and almost two decades later in India. We now

have over 5 billion smart phones globally, with 10 per cent of these in India.

The data rate for wireless has grown from Kbps in the 1990s to Gbps today. The big breakthrough in wireless speeds came with the introduction of MIMO (multiple-input multiple-output) technology in the mid-2000s. Peak speeds now stand at 700 Mbps in LTE Advanced, and 2 Gbps in WiFi. Wireless is perhaps the most transformative technology in the past half century and its value for India is hard to underestimate.

Among the many pioneers in wireless technology in recent decades, three prominent names come to mind. Amos Joel of ATT pioneered the development of 'cellular' technology in the 1960s. At that time, the challenges of handling intercell interference and cell-to-cell handoffs was a major engineering challenge.

Another pioneer is Martin Cooper, known as the father of the cell phone. He did this work at Motorola in the 1970s. Till his breakthrough, mobile phones (better known as car phones), were so large that they had to be installed in the boot of the automobile. Cooper's hand-held phones started the real mobile revolution. In 1992, soon after I arrived at Stanford, Cooper and I started a company called Arraycom, along with a Stanford graduate student, Richard Roy.

I was lucky to invent MIMO technology, which has turned out to be a fundamental breakthrough in wireless networks. When I first proposed MIMO in 1992, it was met with widespread scepticism. But that changed after a few years, thanks to researchers at Bell Labs with superior mathematical skills who put MIMO on a better theoretical footing. Every time you use 4G LTE or WiFi in your smart phone, you are using MIMO. More than 5.6 billion people already use MIMO globally. Also, it is the

key technology for 5G wireless. MIMO has attracted thousands of researchers—there are over 2,000 PhD theses and more than 30,000 research papers and patents in MIMO.

In the history of 2,3 and 4G cellular technologies so far, the delivery endpoint for these three generations has been the mobile phone, with increasing functionality at every generation. 4G with high-speed Internet connectivity, thanks to MIMO, has opened vast new applications.

With 5G, the next generation, the endpoints will expand beyond cell phones to sensors, actuators, vehicles and machinery. These applications require special service requirements that will be supported by this new technology. With 5G, we will enter a new era of wireless connectivity. India's DoT is driving initiatives to both deploy and develop 5G technology.

To quote from the Preamble of the DoT's 5G Report:

> 5G technology has the potential for ushering a major societal transformation in India by enabling a rapid expansion of the role of information technology across manufacturing, educational, healthcare, agricultural, financial and social sectors. India must embrace this opportunity by deploying 5G networks early, efficiently, and pervasively, as well as emerge as a significant innovator and technology supplier at the global level. Emphasis should be placed on 5G touching the lives of rural and weaker economic segments to make it a truly inclusive technology.

Of 5G's three pivotal technologies, the first is enhanced broadband that will take outdoor data rates to 2 Gbps, and indoor data to 20 Gbps, enabling many new services like virtual reality. Next is the massive connectivity that will bring hundreds of billions of IoT devices to the Internet, unleashing a host of new applications. And, finally, ultra-low latency and high-reliability links will enable remote operation of machinery,

drone control, and improve safety of vehicles. Much of 5G's potential, like that of AI, is a few years away. 5G can add about 1 trillion USD to the Indian economy over the next 15 years.

The next big enabler in IT has been the Internet, which allows data to flow seamlessly over networks that are diverse in speed, protocol and medium of transmission. The Internet has now reached 5 billion users worldwide. As regards country-wise Internet penetration, India is in the 60 per cent plus band, which is remarkable growth compared to just three years ago.

The origins of the Internet came from DARPA's interest in a packet-switched network for air defence. It was Len Kleinrock who first demonstrated a packet network between UCLA and Stanford University in 1972. But the power of networking greatly improved once diverse networks were interconnected. That technology came in 1978 from Vinton G. Cerf, then a young professor at Stanford, and Bob Kahn. Their TCP–IP protocols now power the Internet.

The next enabler of IT is AI, a technology that, though slow in coming, now seems in high gear. But what is AI?

AI is the ability of machines (typically computer systems) to perform certain human intelligent tasks such as learning, reasoning, perception. AI may grow beyond this definition. It may one day exceed human intelligence, incorporate networking and storage capabilities not available to humans, and extend to other forms of intelligence that we do not comprehend today.

AI has gone through many false starts. In the 1970s, it was all about knowledge representation and symbolic systems. That proved to be difficult to crack. When I started the Centre for Artificial Intelligence and Robotics for DRDO in 1987, the big

opportunity then seemed to be in Expert Systems. But this, too, proved to be a flop. Neural Networks, known since the 1970s, never delivered useful performance for decades. The big breakthrough came in 2010, with a new twist called Deep Neural Networks (DNN) that is fueling the current optimism.

Of the many AI pioneers, John McCarthy, a Stanford professor, invented the term AI, and did a lot of work on symbolic systems. Raj Reddy at CMU did early work on speech recognition, and AI's fortune changer Jeff Hinton demonstrated amazing success with DNN in 2010.

What are Deep Neural Networks, also known as deep learning? Neural networks, while successful in simple adaptive signal processing (e.g., used in the APSOH sonar built for the Indian Navy in the 1970s), did poorly in AI applicators like speech or image recognition.

The breakthroughs came from use of multiple hidden layers, sometimes hundreds, and importantly, vast amounts of labelled data to train the network. Training is very costly computationally, and deep learning is only now possible thanks to advances in computing and networking. Deep learning is rapidly spreading to hundreds of applications, with remarkable and surprising success.

Deep learning applications may be classified in four layers. First are consumer and business applications, many of which are already in widespread use, with many more to come. The next layer is perception applications, which are in widespread use. The next layer is autonomy for vehicles and robots. This is entering service in limited forms, but full autonomy is probably 15 years away. Finally, there are new applications that might be enabled by the next wave of AI called Artificial General Intelligence, about 25 years away.

An example of consumer apps is real-time language translation for street signs. When a smart phone is pointed at a street sign, it identifies the foreign language, translates the sign to the desired language, and substitutes it on the screen image.

Another capability, observed in China, is seamless interaction with shopping assistants. Although the customer may not know Chinese and the Chinese clerks don't know English, they are able to communicate with amazing ease. As simple as such translation may seem, this requires enormous technology hidden between the covers.

Examples of business apps are credit card fraud detection and loan approvals. Deep learning has saved banks billions of dollars by outperforming humans at these tasks. Moreover, these DNNs are getting better every day as they learn from more and more data. And, of course, they need no salary, never tire and do not go on strikes.

Another example is voice translation from one language to another, a complex process in which an input voice, say in English, is digitised and shipped over the wireless network to massive AI servers, sometimes hundreds of miles away. There, the first DNNs recognise the speech and extract the English words. Next, these word fragments are cleaned up using natural language DNNs to extract an intelligible sentence, which is then translated to, say, Chinese text by another DNN. The last DNNs convert Chinese text to a digitised Chinese voice, if necessary adopting intonation and vocalisation. Finally, the digitised voice is shipped back to the user where flawless Chinese emerges.

One example for a perception application is AmazonGo, now spreading in the US. These are unmanned stores, where cameras and AI engines track your purchases as you walk around shopping. Finally, as you exit, your card is charged and a

bill will print on demand. A key part of this technology is to flag shop lifters by observing facial and gait clues.

The next layer is autonomy of vehicles and robots. There is a huge push for autonomous cars with touted benefits of reducing accidents and freeing up parking spaces hogged by idle cars. While full autonomy, known as level 5, is still 10–15 years away, level 3 is already here, and level 4 within reach soon. Autonomy will have a huge impact on society that can only be dimly comprehended today.

It is interesting to compare human and artificial AI hardware today. Machines need 100,000 times more volume and weight than humans, and almost a million times more power. Clearly, we have a lot more to learn as to how our remarkable brains operate.

On the other hand, machines have their advantages, too: they have virtually unlimited memory, never forget, can communicate instantaneously with thousands of other machines, have access to vast amounts of data from the Internet and sensors, and can use a variety of sensors that humans do not have. So, machines have the advantage of scale over their human rivals.

What are the implications of the advances of IT on jobs? Although, the focus is on AI, other enabling technologies behind AI computing and communications and 5G are very much at play.

Through the history of the three industrial revolutions, predictions of doom for job loss turned out to be too pessimistic. For example, in the textile industry, more and more tasks in the weaving process were automated, causing output to grow explosively. Technology gradually changed the nature of the weaver's job, and the skills required to do it, rather than

eliminating jobs altogether. The key issue to note is that lower skilled jobs that disappeared were replaced by even more, but higher skilled ones. This story was repeated in the telephone industry when manual exchanges were automated. Likewise, in the automobile industry, the only jobs that disappeared for good were those of horses that pulled carriages.

The industrialisation of the textile industry in the United Kingdom devastated India's handloom industry and largely de-industrialised the country. Without the technology and educational base of Britain, India was not able to replace the lost jobs with higher skilled ones. On the other hand, in the auto industry, and related services segment like repair shops, drivers have created tens of millions of new jobs, with little collateral damage.

Post-independence, India has mainly relied on imported technologies and has mostly escaped the wrenching job displacements of the industrialised world.

Let us first examine the vulnerable areas for job losses from IT, particularly in the United States.

One way to characterise this is to classify jobs on two axes—the cognitive axis, plotted horizontally, ranging from repetitive assembly line jobs at the left to highly creative jobs at the right, and the physical/dexterity axis plotted vertically from highly dexterous and physical jobs at the top to sedentary desktop jobs at the bottom.

Given DNN's capabilities, we should expect job losses to begin at the bottom left, with low-skilled white-collar jobs like online support, or clerical workers, progressing to hematologists, radiologists, and moving on to doctors and lawyers. Blue-collar jobs like taxi drivers will be threatened too in the medium term.

Physical and low-skilled jobs, including food services, janitorial services, gardening, will take time to replace, if ever. Jobs requiring physical dexterity and human interaction, such as child and elderly care, are protected for a long time, as also are highly creative jobs. Total job losses could reach 35 to 45 per cent over the next 25 years.

An early warning shot in job loss in manufacturing is demonstrated at Changying Precision Technology factory for cell phones in Dongguan, China. From originally 650 employees, to just 60 employees today, employee strength is expected to dip to 20 in two years, thanks to automation.

The key question is what will replace lost jobs and, indeed, create even more jobs.

One segment of these new jobs will come from technology jobs related to design, manufacture, maintenance and operation of these new technologies. The other segment will come from expanding and improving human interaction: from child and elderly care, teaching, counselling. And, of course, there will be more room for highly creative jobs in the arts and sciences.

One challenge for AI in the next decade will be to understand how to integrate the various areas of AI (from Reasoning to Deep Learning and Robotics) into systems that serve mankind for the better, and that are transparent in their design and applications.

Turning now to India, by any measure the role of IT has been, for the most part, a huge win. It has a growing impact across many sectors from e-governance, to retail to financial services and transportation. The role of the Internet on GDP growth in India has been studied by various think tanks, which estimate

1 per cent in additional GDP in developing countries like India. The use of Internet apps on cell phones has been expanding rapidly. Social media has a growing presence even in rural regions.

Social media has brought some real value, but poses vulnerability to social cohesiveness. China has decided to deal with this by building its own social media companies: Tencent, Baidu, WeChat etc. In Europe, strict oversight laws have been put in place.

In the services layer, India has also performed particularly well. With over 1.1 billion phone connections, Internet penetration is around 560 million, with 30 per cent penetration in rural India thanks to Bharat Net. Our wireless services are among the world's cheapest. Our data tariffs are 20 times cheaper than the United States'. The cost of smart phones has eroded to a mere ₹ 5,000 for low-end phones.

India is also rapidly building up data centres and other core infrastructure, and is on track to meet the increasing Internet use. The area that needs special attention is Internet access to homes and small businesses, which remains poor.

And, finally, at the foundational layer, India depends almost entirely on imports, perhaps around 100 billion USD, from suppliers in the United States, China and East Asia.

A look at Indian HQ companies shows a growing presence in the applications layer, except in the social media segment, a strong presence in the services layer, but , alas, virtually no presence in the core technology layer. With the growing role of IT, this brings multiple vulnerabilities: from national security to economic growth and job creation.

While India's hugely successful software and engineering services companies—from Infosys to TCS, Tech Mahindra and Wipro—have done India proud, they are not the Huawei or Qualcomm or Cisco that India also needs. But new initiatives in AI are emerging from these traditionally service companies.

After India gained independence, India's vision for S&T was defined by Prime Minister Jawaharlal Nehru, who saw the need for telephone networks. Notably, the very first PSU of his government was the Indian Telephone Industries, which he inaugurated in 1948.

Nehru strongly backed visionary scientists like Dr. Homi Bhabha who went on to create world-class research institutions like TIFR. In the 1950s, TIFR built an advanced computer system named TIFRAC under the leadership of Dr. Narasimhan.

In 1966, Bhabha chaired a Committee on Electronics and laid out a roadmap for the Indian electronics industry. His report led to the formation of the Department of Electronics and the Electronics Commission in 1970 and 1971. Prof. M.G.K. Menon, a brilliant Bhabha protégé, became the first Secretary of the Department of Electronics and also Chairman of the Electronics Commission. Menon had a strong impact on Indian electronics policy, and we live under that shadow even today.

It was another decade before India took a new initiative in electronics, this time to build telephone switches, and we turned to the dynamic NRI Sam Pitroda who set up CDOT. Pitroda largely delivered on his promises and CDOT telephone switches entered the Indian network a few years later, but could not keep up with the galloping advances in telecom. Pitroda went on to build a CDOT clone called CDAC. Unfortunately, CDAC has not been able to dent Indian reliance on imports for computing technology.

India's approach to Core IT for the first four decades was on self-reliance by restricting foreign imports. In the 1990s, the galloping advances in computing, the Internet and wireless in the West had completely overtaken local industry, and India opened its doors to imported technology.

Each of the early initiatives was created by India's best minds, with the best of purpose and intention. But over the years the world has moved on and India's internal technological capability, measured in terms of global market share, is now negligible.

Core IT requires highly skilled engineering manpower. For example, in the semiconductor industry, 95 per cent of the manpower is R&D focused and operates at skill levels of MS or PhD engineers. Core IT also needs large R&D investment. For example, in the wireless semiconductor industry, it now takes between 2–5 billion USD to build wireless chips to target high-end Apple or Samsung smart phones.

Another aspect of Core IT is its globalised ecosystem. A smart phone may have components from over 15 countries and 100 suppliers. This also means that there is no such thing as total self-reliance in Core IT—inter-dependence is the global model.

What are the enabling factors that create high technology companies? It is a combination of many things coming together: an entrepreneurial mindset, risk funding, a research ecosystem that attracts and trains our best talent, and, finally, intelligent policy support from the government.

The challenges faced by India to create a Core IT ecosystem are huge. We need hardy entrepreneurs, in a world where only the fittest survive and one is constantly challenged by scrappier newcomers. We also need vast venture funding. The norm in Silicon Valley is that one needs, on average, 1.25 USD of

investment to take a company to 1 USD of sustained revenue. By this measure, India needs 125 billion USD of risk funding to take us to import–export parity. But we have other tools and I believe we can do this at a much lower level of investment, but that is still tens of billions of USD in a sector where 75 per cent investments are wiped out.

In conclusion, the history of post-independence India offers much ground for optimism. India remains a vibrant democracy, with nearly 700 million casting their vote in the last general election—the whole world stood up and cheered. Although born in the trauma of communal violence, the nation has managed to largely contain it. Despite the simplistic pressures, India retains its secular character, and has managed to overcome narrow social prejudices and brought vast numbers of depressed castes into the national mainstream. India's federal structure, with a comfortable balance of power and a tolerance for cultural plurality, is a big achievement. On the minus side, a decent living standard still eludes many of our citizens. And, India is yet to join the club of advanced technology countries with a strong innovation and intellectual property base.

India now faces two tsunamis in IT—5G and AI—that are washing up on its shores. While they bring many opportunities for economic growth, the undercurrents also create new vulnerabilities. However, India's policy level leadership is determined to grasp new opportunities to make India a key player in Core IT, and so there is room for optimism.

Arogyaswami Paulraj

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