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Introduction to Emerging Technology

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1. Chapter One: Introduction to Emerging Technologies

1.1 Revolution of Technologies

Britannica dictionary defines revolution as "in social and political science, a major, sudden, and hence typically violent alteration in government and in related associations and structures". The term is used by analogy in such expressions as the Industrial Revolution, where it refers to a radical and profound change in economic relationships and technological conditions.

From this definition, we can see revolution is a radical and profound change in economic relationships and technological conditions. Therefore, we can devide revolution of technology profound change in our human being life into 4-steps such as agriculture revolution (First revolution), industrial revolution (Second revolution), information revolution (Third revolution), and knowledge revolution (Fourth revolution) that will come in the future.

Three revolution from first revolution to third revolution has already passed. However, fourth revolution is coming now and its impact is bigger than any other revolutions that we had have an experience in the past. Therefore, young generations of future will take this fourth revolution and have to live under this situation. It means that we have to prepare from primary school to university. Fourh revolution can also call as smart revolution because future's revolution will be smart society by new knowledge, ICT, AI, and etc.

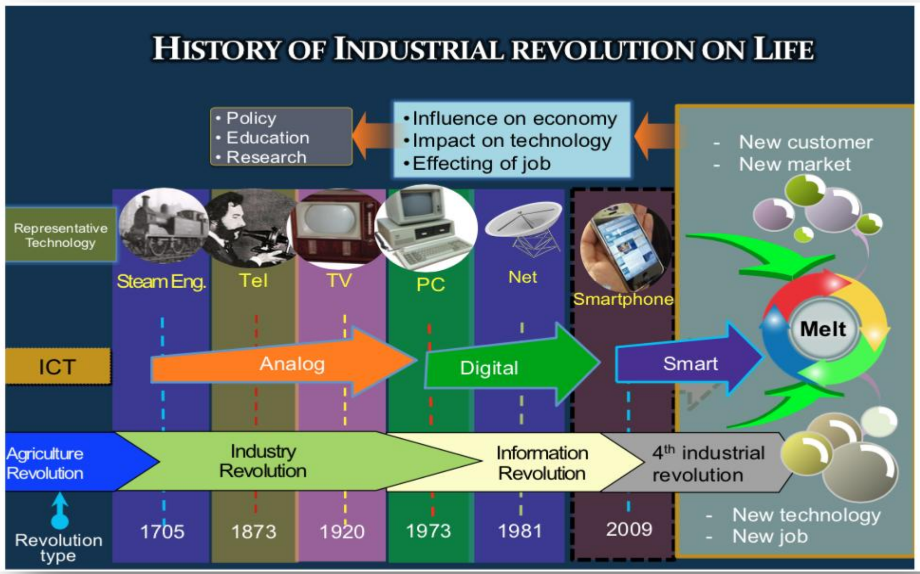


Figure 1 The history of industrial revolution and representative technology

This material deals with what we have to prepare and how we have to teach and learn for the future. Figure 1 shows the pattern of revolution, ICT paradigm, and representative technology in each revolution. The characteristics of each revolution will be described in the each section.

Agriculture revolution

Agriculture revolution was started from 16000. Human being make a life with a hunting, getting a catch fruit and vegetable, and others. This life style continues to agriculture and settles down at one place. Human being always has to move to catch something and to eat. They cannot sometimes obtain eating material because of cold or heavy raining or other difficult situations. Even after they set up at one place, their eating material always is shortage because of seed, no agriculture technology or limited land. This life style continues till first agriculture revolution.

However, this life style of human being had been closed because the agricultural revolution was developed through plant and crop at one place.

Timeline of the Agricultural Revolution

- **First agriculture revolution:** The first agricultural revolution is the period of transition from a hunting-and-gathering society to one based on stationary farming.
- Generally saying as Neolithic Revolution, it is about 12000 years ago. It is difficult to tell exact time periods because they were separate revolutions and happened before written recore or history. The Neolithic Revolution would allow for a steady food supply as well as more permanent home. It was also the invention of agriculture.
- The technology developed for this period includes simple metal tools to cultivate the land.
- **Second agriculture revolution:** The second agricultural revolution went hand in hand with the Industrial Revolution in the 18th and early 19th. New technology was introduced to agriculture for mass crop. Farmers were no longer to limited farms and commercial farming became an idea worth exploring. Growing population and industrial revolution sparked the need for this revolution.
- The technology developed for this revolution includes the seed drill, which enabled farmers to easily plant rows, new fertilizers were also introduced as well as artificial feed.

- **Third agriculture revolution:** The green Revolution was the introduction of advanced technology and agricultural practices to farms to make farms more efficient. This revolution was sparked by the increasing awareness that the Earth is not renewable and that farms could not keep expanding outward and efficiency of land.
- **Fourth agriculture revolution:** The cureent agriculture is changing because of AI and ICT. That is, AI and ICT is introducing to agriculture to analyze and to adjust humidity, temperature without weaher condition. Current agriculture do not have competitiveness without recognition of customer's taste.

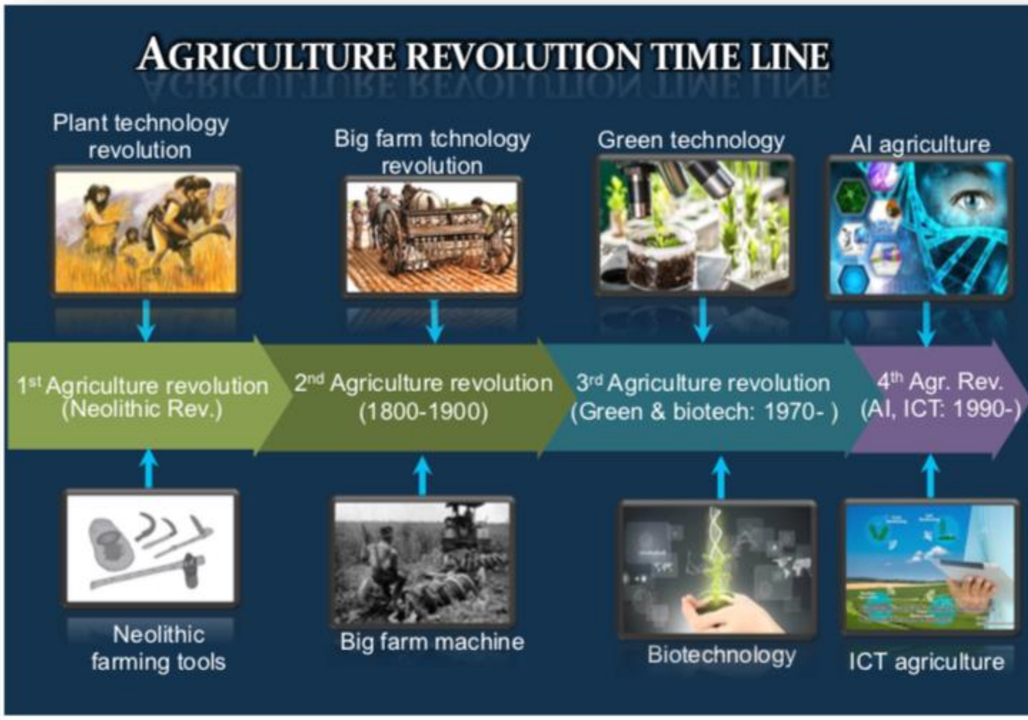


Figure 2 Agriculture revolutions: This area also is changing by AI and ICT as 4th revolution

Industrial revolution

The industrial revolution took place during the late 1700s and early 1800s. The industrial revolution began in Great Britain and quickly spread throughout the world. The agricultural societies became more industrialized and urban. The railroad, the cotton gin, electricity and other inventions permanently changed society. (Fig. 1=3) This revolution affected social, cultural, and economic conditions. This revolution left a profound impact on how people lived and the way businesses operated as well as the creation of capitalism and the modern cities of today.

By the mid-18th century, the population growth and increasing foreign trade caused a greater demand for manufactured goods. Mass production was achieved by replacing water and animal power with steam power. Industrialization was fast by the invention of new machinery and technology. James Watt's improvements to the steam engine and Matthew Boulton on the creation of the rotative engine were crucial for industrial production. Their machinery could function much faster with rotary movements and without human power. Coal became a key factor in the success of industrialization. Coal was used to produce the steam power on which industry depended. Improvements in mining technology ensured that more coal could be extracted to power the factories and run railway trains and steamships. Britain's cotton and metalworking industries became internationally important.

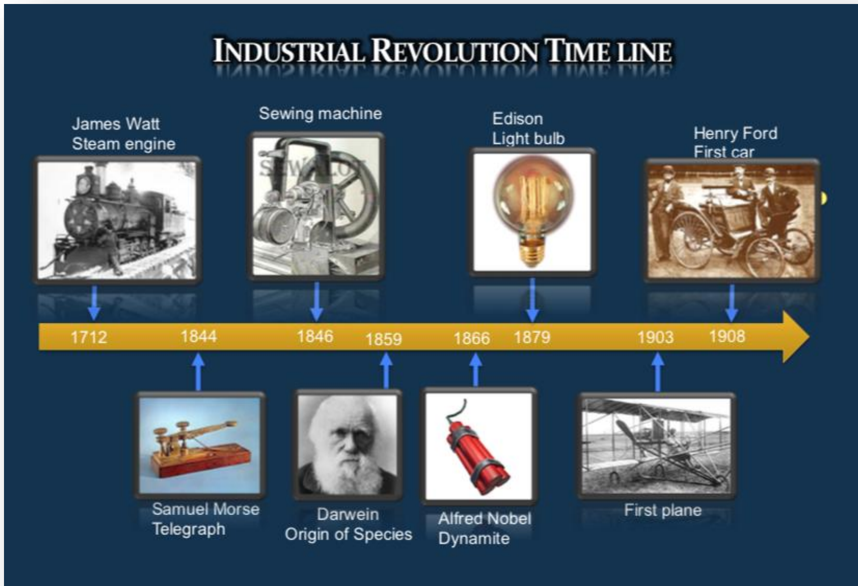


Figure 3 Industrial revolution: This area also is changing by AI and ICT as 4th revolution

Information revolution

The information revolution started from invention of broad cast technology on 1922 (Fig. 1-4). However, revolution was directly wrought by computer technology, the storage device, and access to information since the mid-1980s. Many information material could be stored on the device and was manipulated on computer networks. Their technology allow instant retrieval from anywhere in the world and storage at speeds. During this revolution, individuals can easily communicate with each other worldwide and share information by using the same computer networks. Information revolution was driven by three factors.

Firstly, information-based occupations grew throughout the 20th century. Almost office work dealt with information. They produced a latent demand for more efficient storage and processing systems.

Secondly, All occupation and office work were provided by the advent of cheap PC in the 1980s and the 1990s that followed the development of the microprocessor in the 1970s. Previously, computer technology had been so expensive that it could only be used by large organizations for special purposes. However, it was so cheap that its cost was no longer a significant issue. Cheap personal computers spread out information and materials with user-friendly operating systems. It enabled vastly more people to make direct and convenient use of computerized information.

The third factor, it was the Internet that made a crucial contribution from the early 1990s. A global computer network could be utilized to connect information providers and information consumers anywhere in the world. The information revolution has already had major effects on both business and personal life. It allows many personal and business networks can be connected quickly by the Internet. People can communicate worldwide via e-mail and other Internet-based social network. Jobs have declined in such areas as banking, real estate, interviewing, and etc. Also new professions and business have been created such as web designer, IT service, contents, and so on. The best one is that this has led to concerns over the potential for growing economic and social patterns. However, there are concerns over privacy and security to get over. The information revolution is still in its early stages. It will give an impact more on everywhere and its opportunities will emerge more in the 4th industrial revolution with AI, biotechnology, and etc.

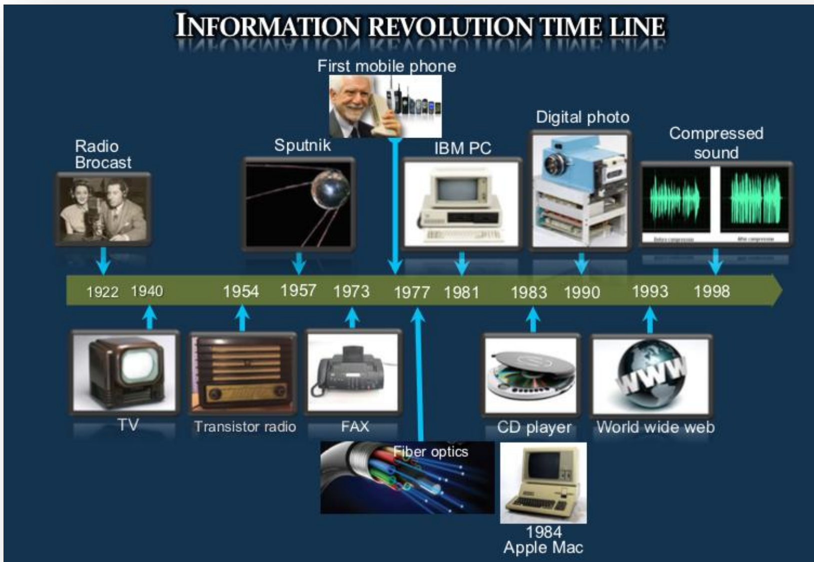


Figure 4 Information revolution gives a directly influence on 4th industrial revolution

The 4th Industrial revolution

The Fourth Industrial Revolution (March, 2017, ISBN-10: 9781524758868), Professor Klaus Schwab, founder and executive chairman of the World Economic Forum, was described. He describes that the enormous potential for the technologies of the Fourth Industrial Revolution as well as the possible risks. He also said, "The changes are so profound that, from the perspective of human history, there has never been a time of greater promise or potential peril. My concern, however, is that decision-makers are too often caught in traditional, linear (and non-disruptive) thinking or too absorbed by immediate concerns to think strategically about the forces of disruption and innovation shaping our future."

The Fourth Industrial Revolution describes the exponential changes to the way we live, work and relate to one another due to the adoption of cyber-physical systems, the Internet of Things (IoT), big data, AI (Artificial Intelligence), and its combined technologies. As we implement smart technologies in our factories and workplaces, connected machines will interact, visualize the entire production chain and make decisions autonomously for home and car. This revolution is expected to impact all disciplines, industries, social pattern, and economies. While in some ways it's an extension of the computerization of the 3rd Industrial Revolution, due to the velocity, scope and systems impact of the changes of the fourth revolution. The Fourth Industrial Revolution is disrupting almost every industry in every country and creating massive change in a non-linear way at unprecedented speed. This revolution will give an impact bigger than the previous one to under developing or advanced country at the same time. The country that do not prepared will be merged socially and economically.

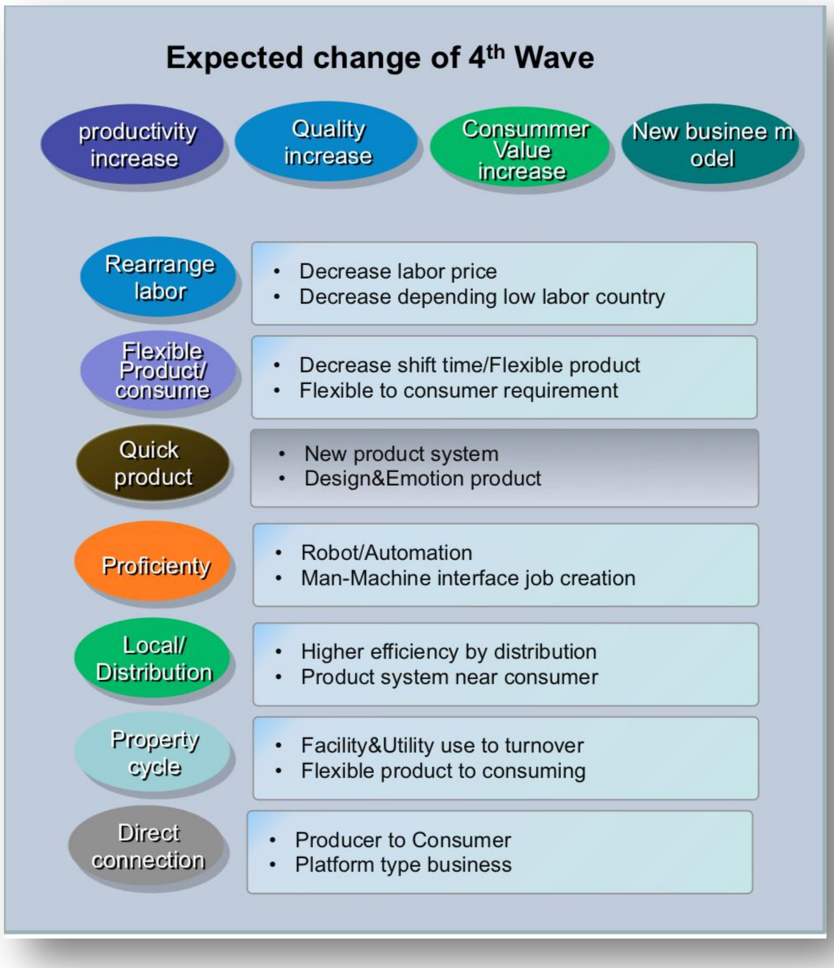


Figure 5 Expected area of 4th industrial revolution (EU committee's report, 2016)

Figure 6 Related topics for preparation of 4th industrial revolution .

1.2 Role of data for emerging Technologies

We are living in the age of big data. Data is regarded as the new oil and strategic asset, and drives or even determines the future of science, technology, the economy, and possibly everything in our world today and tomorrow. Data have not only triggered tremendous hype and buzz, but more importantly presents enormous challenges that in turn bring incredible innovation and economic opportunities.

This reshaping and paradigm shifting is driven not just by data itself but all other aspects that could be created, transformed, and/or adjusted by understanding, exploring, and utilizing data. The preceding trend and its potential have triggered new debate about data-intensive scientific discovery as a emerging technologies, the so-called “fourth industrial revolution,”

There is no doubt, nevertheless, that the potential of data science and analytics to enable data-driven theory, economy, and professional development is increasingly being recognized. This involves not only core disciplines such as computing, informatics, and statistics, but also the broad-based fields of business, social science, and health/medical science.

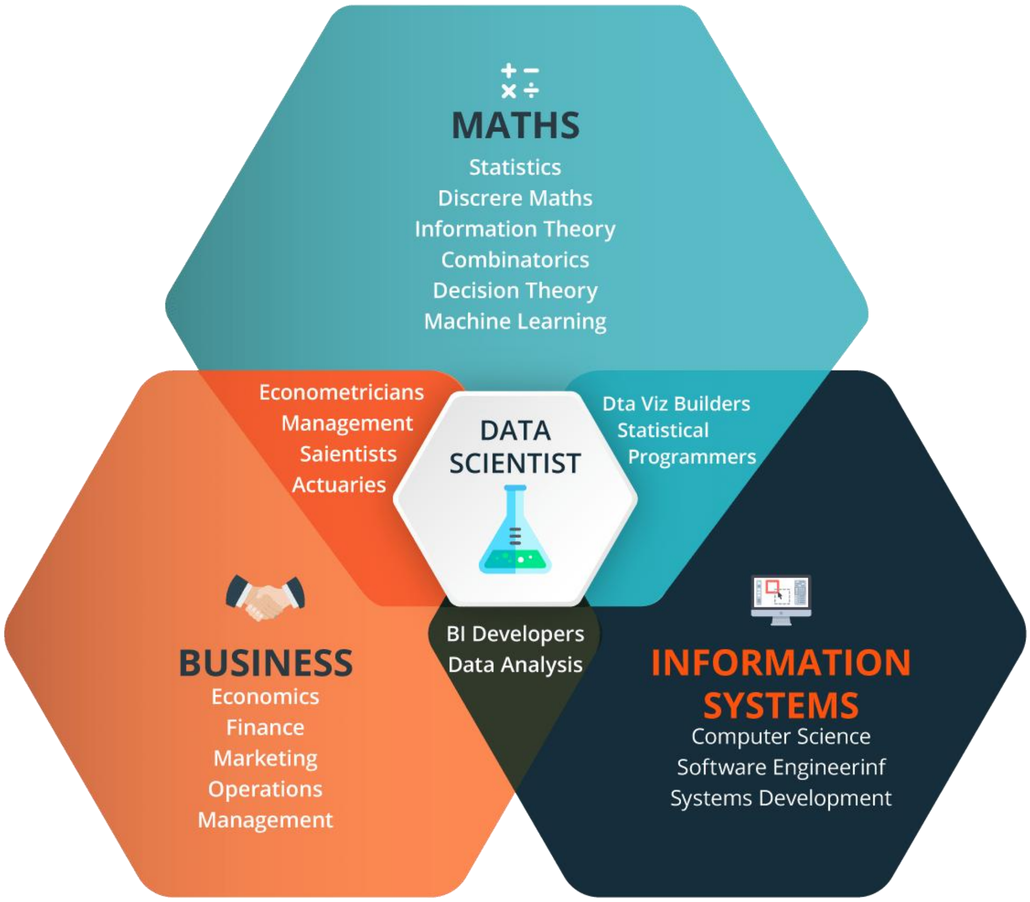


Figure 7 Data Science Domains and Disciplines

Data Science Disciplinary

The art of data science has attracted increasing interest from a wide range of domains and disciplines. Accordingly, communities or proposers from diverse backgrounds, with contrasting aspirations, have presented very different views or foci. Some examples are that data science is the new generation of statistics, is a consolidation of several interdisciplinary fields, or is a new body of knowledge. Data science also has implications for providing capabilities and practices for the data profession, or for generating business strategies. Statisticians have had much to say about data science, since it is they who actually created the term “data science” and promoted the upgrading of statistics to data science a a broader discipline.

Intensive discussions have taken place within the research and academic community about creating data science as an academic discipline. This involves not only statistics, but also a multidisciplinary body of knowledge that includes computing, communication, management, and decision. The concept of data science is correspondingly defined from the perspective of disciplinary and course development: for example, treating data science as a mixture of statistics, mathematics, computer science, graphic design, data mining, human-computer interaction, and information visualization .

In contrast to big data that has been driven by data-oriented business and private enterprise, researchers and scientists also play a driving role in the data science agenda. Migrating from the original push in the statistics communities, various disciplines have been involved in promoting the disciplinary development of data science. The aim is to manage a growing gap between our awareness of that information and our understanding of it. In addition to the promotion activities in core analytics disciplines such as statistics, mathematics, computing, and artificial intelligence, the extended recognition and undertaking of domain-specific data science seems to repeat the evolutionary history of the computer and computer-based applications.

1.3 Enabling device and networks for emerging technologies

In the world of digital electronic systems, there are four basic kinds of devices: memory, microprocessors, logic and networks. Memory devices store random information such as the contents of a spreadsheet or database. Microprocessors execute software instructions to perform a wide variety of tasks such as running a word processing program or video game. Logic devices provide specific functions, including device-to-device interfacing, data communication, signal processing, data display, timing and control operations, and almost every other function a system must perform.

Programmable logic refers to a general class of devices which can be configured to perform a variety of logic functions. The devices range from simple PROM, programmable read-only memory, devices which can implement simple combinatorial logic, to PAL's, programmable array logic, to FPGA's, field programmable gate arrays. All these devices share the feature that they are programmed to perform specific functions. Programmable logic as we know it today started with devices known as Programmable Array Logic. These devices get their name from the programmable AND array which is part of the device. These devices have pins which can be programmed to be logic inputs. Each pin will be one logic variable. Each output can be programmed to be active for a particular sum of products of the input terms.

In technology, 'networking' is connecting a system of computers to share information. Computer networks are very essential to todays globalization as the world evolves to an advanced planet in Information Technology. Internet is just that type of service, and new ideas and better systems are being developed everyday. One of the key contributing factors of the Information Technology rise in the world is network and data communication because technology's advancement is not only on the gadgets but the system as well.

Programmable Logic Device

Logic devices can be classified into two broad categories - fixed and programmable.

- **Fixed Logic Devices**

As the name suggests, the circuits in a fixed logic device are permanent, they perform one function or set of functions - once manufactured, they cannot be changed.

With fixed logic devices, the time required to go from design, to prototypes, to a final manufacturing run can take from several months to more than a year, depending on the complexity of the device. And, if the device does not work properly, or if the requirements change, a new design must be developed

- **Programmable Logic Devices**

A programmable logic device(PLD) is an electronic component used to build reconfigurable digital circuits. Unlike a logic gate, which has a fixed function, a PLD has an undefined function at the time of manufacture. Before the PLD can be used in a circuit it must be programmed, that is, reconfigured by using a specialized program.

Simple programmable logic devices (SPLD) are the simplest, smallest and least-expensive forms of programmable logic devices. SPLDs can be used in boards to replace standard logic components (AND, OR, and NOT gates), such as 7400-series TTL.

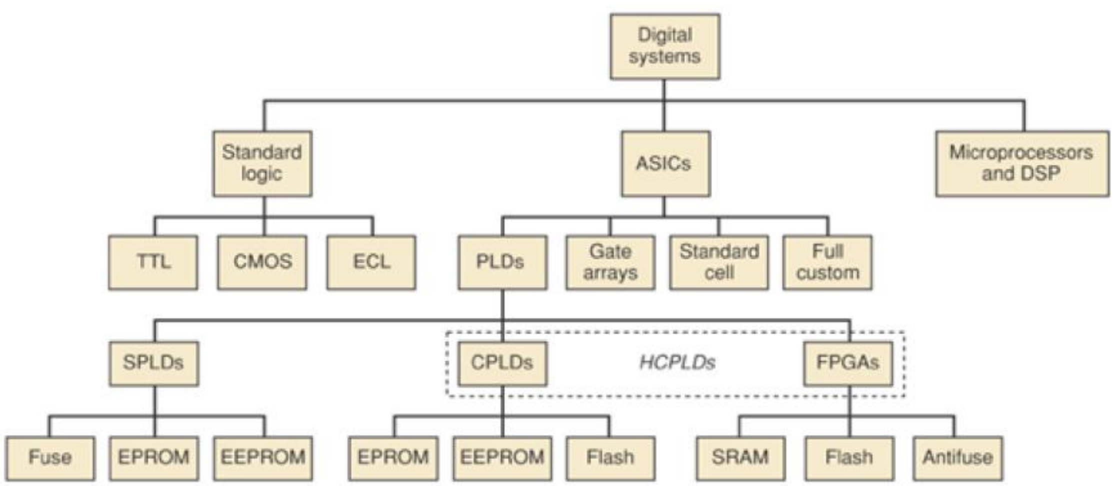


Figure 8 PLDs family tree with process technology

They typically comprise 4 to 22 fully connected macrocells. These macrocells typically consist of some combinatorial logic (such as AND OR gates) and a flip-flop. In other words, a small Boolean logic equation can be built within each macrocell. This equation will combine the state of some number of binary inputs into a binary output and, if necessary, store that output in the flip-flop until the next clock edge. Of course, the particulars of the available logic gates and flip-flops are specific to each manufacturer and product family. But the general idea is always the same.

Most SPLDs use either fuses or non-volatile memory cells (EPROM, EEPROM, FLASH, and others) to define the functionality.

On the other hand PLDs are standard, off-the-shelf parts that offer customers a wide range of logic capacity, features, speed, and voltage characteristics - and these devices can be changed at any time to perform any number of functions.

With programmable logic devices, designers use inexpensive software tools to quickly develop, simulate, and test their designs. Then, a design can be quickly programmed into a device, and immediately tested in a live circuit. The PLD that is used for this prototyping is exactly the same PLD that will be used in the final production of a piece of end equipment, such as a network router, a DSL modem, a DVD player, or an automotive navigation system. There are no NRE costs and the final design is completed much faster than that of a custom, fixed logic device.

Another key benefit of using PLDs is that during the design phase customers can change the circuitry as often as they want until the design operates to their satisfaction. That's because PLDs are based on re-writeable memory technology - to change the design, simply reprogram the device. Once the design is final, customers can go into immediate production by simply programming as many PLDs as they need with the final software design file.

These devices are also known as:

- Programmable array logic (PAL)
- Generic array logic (GAL)
- Programmable logic arrays (PLA)
- Field-programmable logic arrays (FPLA)
- Programmable logic devices (PLD)

PLDs are often used for address decoding, where they have several clear advantages over the 7400-series TTL parts that they replaced: One chip requires less board area, power, and wiring than several do. The design inside the chip is flexible, so a change in the logic does not require any rewiring of the board. Rather, simply replacing one PLD with another part that has been programmed with the new design can alter the decoding logic.

Programmable Logic Devices (PLDs) are digital devices with configurable logic and flip-flops linked together with programmable interconnect. Logic devices provide specific functions, including:

Device-to-device interfacing

- Data communication
- Signal processing
- Data display
- Timing
- Control operations
- Almost every other function a system must perform

Figure 9 Programmable Logic Devices

Networking

Computer networks are very essential to todays globalization as the world evolves to everything connecting in Information Technology. One of the key contributing factors of the Information Technology rise in the world is network and data communication because technology's advancement is not only on the gadgets but the system as well.

History of Computer Networks

Networking started long ago by ARPANET. When Russia launched their SPUTNIK Satellite in Space in 1957.The American started an agency named Advance Research Project Agency (ARPA) and launched their 1st satellite within 18 month after establishment. Then sharing of the information in another computer they use ARPANET. In the 1960s, computer networking was essentially synonymous with mainframe computing and telephony services and the distinction between local and wide area networks did not yet exist. Mainframes were typically "networked" to a series of dumb terminals with serial connections running on RS-232 or some other electrical interface.

Then in 1969, ARPANET comes in INDIA and INDIAN switched this name to NETWORK. Development of the network began in 1969, based on designs developed during the 1960s. The ARPANET evolved into the modern Internet. If a terminal in one city needed to connect with a mainframe in another city, a 300-baud long-haul modem would use the existing analog Public Switched

Telephone Network (PSTN) to form the connection. The technology was primitive indeed, but it was an exciting time nevertheless.

The quality and reliability of the PSTN increased significantly in 1962 with the introduction of pulse code modulation (PCM), which converted analog voice signals into digital sequences of bits. DS0 (Digital Signal Zero) became the basic 64-Kbps channel, and the entire hierarchy of the digital telephone system was soon built on this foundation.

When the backbone of the Bell system became digital, transmission characteristics improved due to higher quality and less noise. This was eventually extended all the way to local loop subscribers using ISDN. The first commercial touch-tone phone was also introduced in 1962.

In the 1980s, the growth of client/server LAN architectures continued while that of mainframe computing environments declined. However, the biggest development in the area of LAN networking in the 1980s was the evolution and standardization of Ethernet. While the DIX consortium worked on standard Ethernet in the late 1970s, the IEEE began its Project 802 initiative, which aimed to develop a single, unified standard for all LANs.

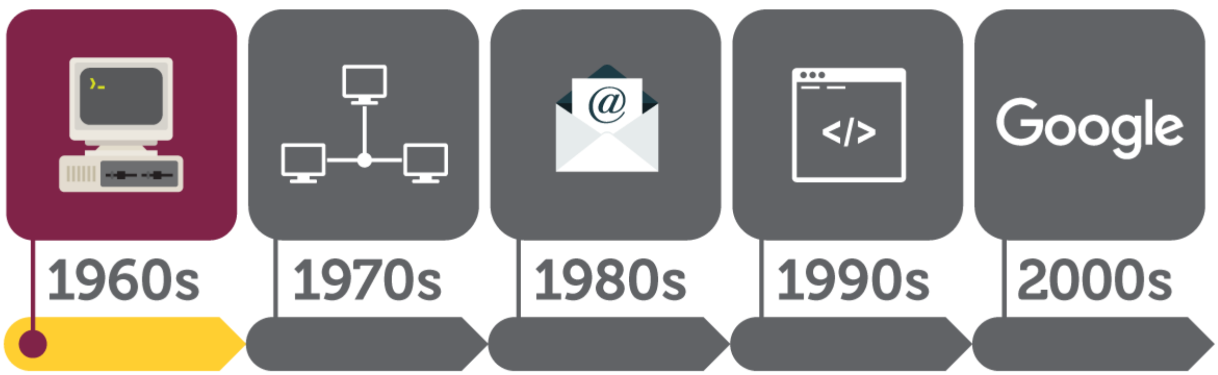


Figure 10 Evolution of Networking Technology

The development of the Network File System (NFS) by Sun Microsystems in 1985 resulted in a proliferation of diskless UNIX workstations with built-in Ethernet interfaces that also drove the demand for Ethernet and accelerated the deployment of bridging technologies for segmenting LANs. Also around 1985, increasing numbers of UNIX machines and LANs were connected to ARPANET, which until that time had been mainly a network of mainframe and minicomputer systems. The first UNIX implementation of TCP/IP came in v4.2 of Berkeley's BSD UNIX, from which other vendors such as Sun Microsystems quickly ported their versions of TCP/IP.

The network processor trend goes back to the days of the Internet boom in the late 1990s. It was launched with all the hype surrounding anything related to the Internet as "the new technology on the block". As usual with a new technology, marketing people promised a new revolution in sight and it resulted in tens of startup companies dedicated to this area. Several applications were envisioned for it at different layers of the network architecture. As time went by, not all the high expectations were realized and the bubble burst out as the Internet bubble itself.

The high demand for increased processing speed (as a result of communication speed surpassing processing speed) and the demand for adaptability (as a result of convergence of voice and data networks) and the prospect of whole new set of emerging services added to the need for a new paradigm in network devices. High level of programmability was sought to support new services and protocols but at very high performance. Besides, because of faster change of pace, short time-to-market and longer product life-time were other important factors driving the concept of network processor.

In the 1980s, general or normal processors were used for networking process which was quite slow and took longer period to load. But later on the processor changed and now the networking processors are different and are made in such a way to boost the networking in any way possible.

Back in the late 80s, they used specialized softwares to configure networks. It was then they started using Microsoft's Windows Server application. The software was then upgraded to 2003 Server, 2008 Server and the latest is 2010 Server by Microsoft.

The development environment includes the Internet Exchange Architecture Software Development Kit (IXA SDK) which provides easy-touse graphical simulation environment for developing, debugging, and optimizing a network application.[12] The other advantage of Intel SDK is that it has preserved the programming environment so the developers can easily migrate from the older products to the new one and only be concerned about the new features and tools provided by the new product.

Software Defined Networking, or SDN, is cloud-based software that allows for management of the network from one central point. The key is virtualization, which makes it so software can run separately from hardware. It would be automatically responsive, and information technology personnel could view all problems from one location and have a much easier time troubleshooting.

The Security is a very important thing in networking world. Security purpose should be undertaken because without security, through networking one can hack through any information and alter the information for their own purpose. During the 1980s, the security that was used was not much but it was more than enough because during that time networking was a closed design. They used the network in the organization itself and used firewalls to prevent hackers from hacking. Nowadays there are a lot of security measures that can be chosen.

The networking industries have evolved enormously from the late 1980s till today. The hardware have been upgraded and the software has changed a lot.

Future Trend of Networks

As corporate bandwidth requirements continue to surge exponentially with every passing year, it becomes clear that bandwidth demands as well as the business requirements of the modern digital workspace are setting the stage for the implementation of new, advanced technologies.

These technologies give rise to fresh possibilities and further fuel the demand for adding intelligent systems to our daily lives and greater reliance on tech support, both in the home and work fronts. With software trends emerging regularly in the IT scene, digital services and people are becoming further intertwined to characterize everything that’s new the world of network technology this year.

These recent advancements are more than likely to disrupt existing operations and foster an era of digitization and intelligence throughout the business sector.

Topics of future trends in networking technology include the following**:**

- **5G technology**

5G technology serves to enhance not just the mobile device experience but the entirety of the communications tech environment. 5G will provide that by annexing radio spectrum that are 1 millisecond. This will allow further development in such arenas as driverless cars. Imagine movies downloaded in a matter of seconds.

The greater bandwidth of 5G alongside support for extremely low latency will help fuel groundbreaking applications in the virtual and augmented reality and health-care industries. Look for the fields of vehicle-to-vehicle communication and tactile feedback remote surgery, both of which require strong cellular support to unlock their full potential. Moreover, IoT gadgets are growing fast in almost all verticals, such as business, retail, homes, industries, and others.

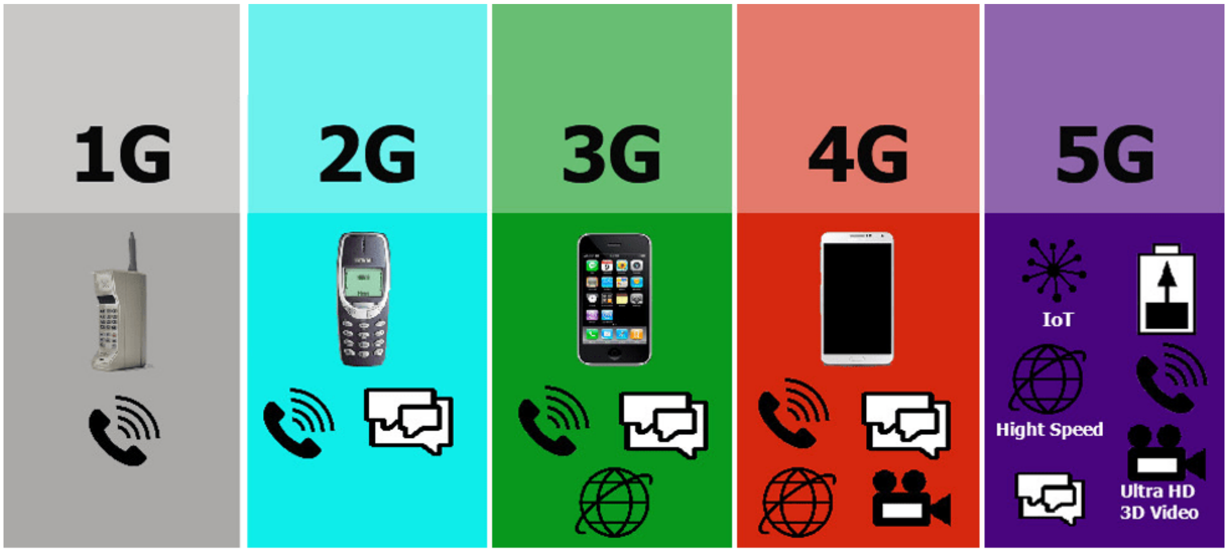


Figure 11 Bandwitdth Expansion and 5 G Technology

5G would be made possible by SDN and support a variety of devices and applications. One such application is virtual reality, or computer simulated, 3D images. 5G could also provide extended bandwidths to make gaming or accessing social networks more exciting using wearable, devices that communicate with the network, are mobile, and have the ability to be easily transported by wearing them.

Another promising application is no-touch computing, in which we can speak or direct our computers to perform without use of a mouse or keyboard. Expect to see a huge surge in the number of systems connecting to always-on 5G networks in the next few years.

- **Network developments in edge computing**

Although cloud systems have made a big splash earlier, right now it's all about cloud-to-the-edge technology. Edge computing networks are the solution for several computing hurdles, including low connectivity and overcrowded bandwidth. Edge computing promises solutions that decrease latency by keeping all computations close to system endpoints.

Edge computing is one technological area that's expanded greatly in the past few years. Combined with IoT and AI, it's led to innovative methods, like using AI to secure IoT systems. And that's not all: deep learning is being leveraged by datacenters to improve network speed and reduce the mass of transferred data at the edge of networks..

- **Rise of decentralization**

Regular architectures directed traffic onto the datacenter for centralizing Internet access and security. However, greater collaboration between suppliers and partners and extensive cloud usage has disputed this model. The growth of direct cloud interconnection and cloud security services are encouraging many companies to adopt a decentralized approach for optimizing their connectivity to cloud platforms.

- **Changing perspectives on ML and AI**

Machine learning(ML) and AI will continue to remain hot favorites among vendor marketing teams. Unfortunately, the majority of those teams will fail to properly understand what either of these technologies is as well as the right way to harness their potential. Nearly all network devices are currently instrumented, transmitting telemetry to large data lakes. However, our capacity to find true insights is still lacking. Like IoT, gathering data is easy, but it's more challenging to convert that data into usable insights.

- **More attention to network security**

Network security is one of the key motivators for the rise of new IT services. With hackers and cybercriminals becoming more sophisticated, IT infrastructure is extending gradually into cloud-based, virtual platforms, leaving most client and company data exposed to security risks. Aside from implementing standard firewalls and monitoring user access, companies must implement stronger cyber security strategies that allow developers to consider innovative defense approaches. Because one of the potential drawbacks of new networking technology is the security gaps exposed to hackers. That's why insightful cyber security measures are necessary.

- **Going wireless**

Advanced wireless technology as well as related security and management has led numerous companies to go wireless-first. Doing so eliminates the charges related to moves, additions and modifications to the fixed and wired LAN infrastructure. Moreover, it promises greater reliability and resilience. Cloud-specific "as-a-service" deployments and advanced monitoring tools and features are being deployed as well to provide increased performance insight and visibility.

- **Cloud repatriation**

Cloud repatriation is when apps move from the cloud back to on-premises. This indicates that datacenters have not lost their relevance yet. The majority of repatriation activity centers on businesses attempting to discover balance or equilibrium. This does not signify that the cloud is losing relevance; merely that is has been somewhat over-hyped.

- **Smart automation expands**

Companies often spend huge amounts on network automation so they don't fall behind. Pointed solutions and manual scripting cannot scale to complement the considerable rise in network demands. Thus, expect to see a surge in smart and innovative network automation solutions that manage devices, ensure compliance across hybrid and on-premises deployments, and automate services. The upcoming generation of networks will feature machine learning and AI to ward off security challenges and network complexity.

- **Networking technology: Keep up with the changes**

Communications and information technology are advancing rapidly and it is necessary for companies to consider which of the emerging technologies is ideal for their business. Implementing the right networking technology allows the organization to get the most benefits.

1.4 Human to Machine Interface

The Association for Computing Machinery (ACM) defines human–computer interaction as "a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them". An important facet of HCI is user satisfaction (or simply End User Computing Satisfaction). "Because human–computer interaction studies a human and a machine in communication, it draws from supporting knowledge on both the machine and the human side.

On the machine side, techniques in computer graphics, operating systems, programming languages, and development environments are relevant. On the human side, communication theory, graphic and industrial design disciplines, linguistics, social sciences, cognitive psychology, social psychology, and human factors such as computer user satisfaction are relevant.

And, of course, engineering and design methods are relevant. Due to the multidisciplinary nature of HCI, people with different backgrounds contribute to its success. HCI is also sometimes termed human–machine interaction (HMI), man-machine interaction (MMI) or computer-human interaction (CHI).

Humans interact with computers in many ways; the interface between humans and computers is crucial to facilitate this interaction. Desktop applications, internet browsers, handheld computers, and computer kiosks make use of the prevalent graphical user interfaces (GUI) of today.

HMI is all about how people and automated systems interact and communicate with each other. That has long ceased to be confined to just traditional machines in industry and now also relates to computers, digital systems or devices for the IoT. More and more devices are connected and automatically carry out tasks. Operating all of these machines, systems and devices needs to be intuitive and must not place excessive demands on users.

Smooth communication between people and machines requires interfaces: The place where or action by which a user engages with the machine. Simple examples are light switches or the pedals and steering wheel in a car: An action is triggered when you flick a switch, turn the steering wheel or step on a pedal. However, a system can also be controlled by text being keyed in, a mouse, touch screens, voice or gestures.

Voice user interfaces (VUI) are used for speech recognition and synthesizing systems, and the emerging multi-modal and GUI allow humans to engage with embodied character agents in a way that cannot be achieved with other interface paradigms. The growth in human–computer interaction field has been in quality of interaction, and in different branching in its history.

Instead of designing regular interfaces, the different research branches have had a different focus on the concepts of multimodality rather than unimodality, intelligent adaptive interfaces rather than command/action based ones, and finally active rather than passive interfaces.[

Poorly designed human-machine interfaces can lead to many unexpected problems. A classic example is the Three Mile Island accident in USA, a nuclear meltdown accident, where investigations concluded that the design of the human-machine interface was at least partly responsible for the disaster. Similarly, accidents in aviation have resulted from manufacturers' decisions to use non-standard flight instrument or throttle quadrant layouts: even though the new designs were proposed to be superior in basic human-machine interaction, pilots had already ingrained the "standard" layout and thus the conceptually good idea actually had undesirable results.

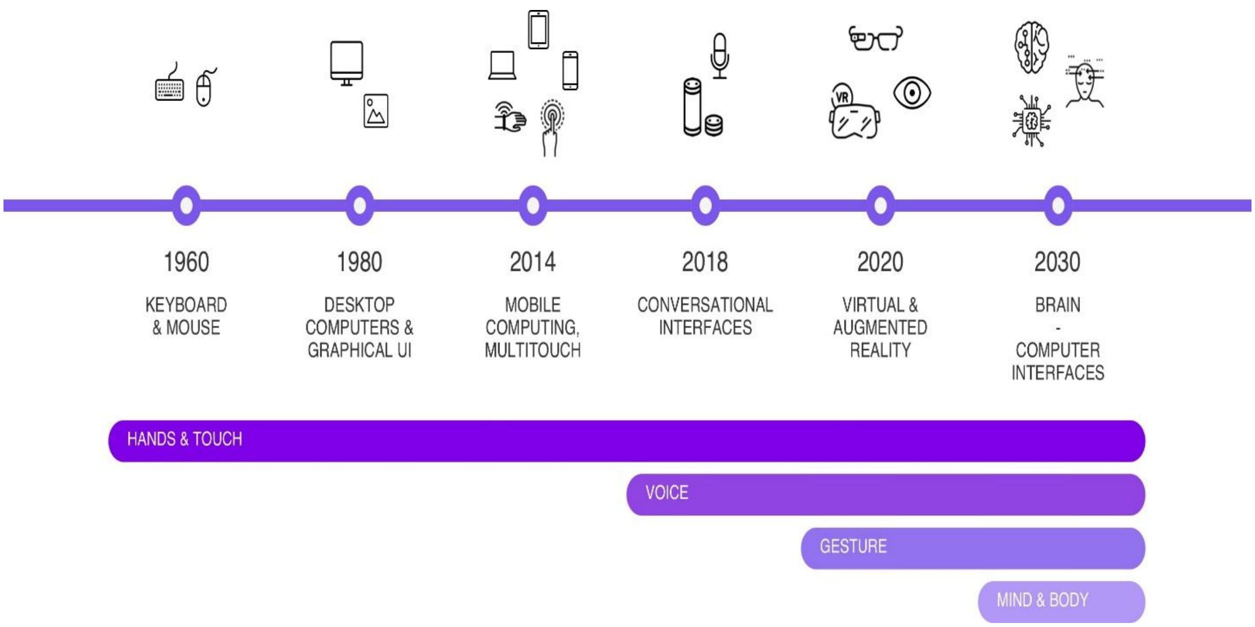


Figure 12 Technology Trends of Human Machine Interface

The devices are either controlled directly: Users touch the smartphone's screen or issue a verbal command. Or the systems automatically identify what people want: Traffic lights change color on their own when a vehicle drives over the inductive loop in the road's surface. Other technologies are not so much there to control devices, but rather to complement our sensory organs. One example of that is virtual reality glasses. There are also digital assistants: Chatbots, for instance, reply automatically to requests from customers and keep on learning.

Eliza, the first chatbot, was invented in the 1960s, but soon ran up against its limitations: It couldn't answer follow-up questions. That's different now. Today's chatbots "work" in customer service and give written or spoken information on departure times or services, for example. To do that, they respond to keywords, examine the user's input and reply on the basis of preprogramed rules and routines. Modern chatbots work with artificial intelligence. Digital assistants like Google Home and Google Assistant are also chatbots.

They all learn from the requests and thus expand their repertoire on their own, without direct intervention by a human. They can remember earlier conversations, make connections and expand their vocabulary. Google's voice assistant can deduce queries from their context with the aid of artificial intelligence, for example. The more chatbots understand and the better they respond, the closer we come to communication that resembles a conversation between two people. Big data also plays a role here: If more information is available to the bots, they can respond in a more specific way and give more appropriate replies.

Yet voice recognition is still not perfect. The assistants do not understand every request because of disturbance from background noise. In addition, they're often not able to distinguish between a human voice and a TV, for example. The voice recognition error rate in 2013 was 23 percent, according to the U.S. Consumer Technology Association (CTA). In 2016, Microsoft's researchers brought that down to below six percent for the first time. But that's still not enough.

Infineon intends to significantly improve voice control together with the British semiconductor manufacturer XMOS. The company supplies voice processing modules for devices in the Internet of Things. A new solution presented by Infineon and XMOS at the beginning of 2017 uses smart microphones. It enables assistants to pinpoint the human voice in the midst of other noises: A combination of radar and silicon microphone sensors from Infineon identifies the position and the distance of the speaker from the microphones, with far field voice processing technology from XMOS being used to capture speech.

Gesture control has a number of advantages over touch screens: Users don't have to touch the device, for example, and can thus issue commands from a distance. Gesture control is an alternative to voice control, not least in the public sphere. After all, speaking with your smart wearable on the subway might be unpleasant for some and provoke unwanted attention. Gesture control also opens up the third dimension, away from two-dimensional user interfaces.

Google and Infineon have developed a new type of gesture control. They use radar technology for this: Infineon's radar chip can receive waves reflected from the user's finger. That means if someone moves their hand, it's registered by the chip. Google algorithms then process these signals. That even works in the dark, remotely or with dirty fingers. The same uniform hand movements apply to all gesture control devices. The gesture control chip can be used in all possible devices, such as loudspeakers or smart watches. Modern human-machine interaction has long been more than just moving a lever or pressing a button. Technologies that augment reality can also be an interface between human and machine.

Topics in human-computer interaction include the following**:**

User customization

End-user development studies how ordinary users could routinely tailor applications to their own needs and to invent new applications based on their understanding of their own domains. With their deeper knowledge, users could increasingly be important sources of new applications at the expense of generic programmers with systems expertise but low domain expertise.

Embedded computation

Computation is passing beyond computers into every object for which uses can be found. Embedded systems make the environment alive with little computations and automated processes, from computerized cooking appliances to lighting and plumbing fixtures to window blinds to automobile braking systems to greeting cards. The expected difference in the future is the addition of networked communications that will allow many of these embedded computations to coordinate with each other and with the user. Human interfaces to these embedded devices will in many cases be disparate from those appropriate to workstations.

Augmented reality

Augmented reality refers to the notion of layering relevant information into our vision of the world. Existing projects show real-time statistics to users performing difficult tasks, such as manufacturing. Future work might include augmenting our social interactions by providing additional information about those we converse with.

Social computing

In recent years, there has been an explosion of social science research focusing on interactions as the unit of analysis. Much of this research draws from psychology, social psychology, and sociology. For example, one study found out that people expected a computer with a man's name to cost more than a machine with a woman's name. Other research finds that individuals perceive their interactions with computers more positively than humans, despite behaving the same way towards these machines.

Knowledge-driven human–computer interaction

In human and computer interactions, a semantic gap usually exists between human and computer's understandings towards mutual behaviors. Ontology, as a formal representation of domain-specific knowledge, can be used to address this problem, through solving the semantic ambiguities between the two parties.

Emotions and human-computer interaction

In the interaction of humans and computers, research has studied how computers can detect, process and react to human emotions to develop emotionally intelligent information systems. Researchers have suggested several 'affect-detection channels'. The potential of telling human emotions in an automated and digital fashion lies in improvements to the effectiveness of human-computer interaction. The influence of emotions in human-computer interaction has been studied in fields such as financial decision making using ECG and organizational knowledge sharing using eye tracking and face readers as affect-detection channels. In these fields it has been shown that affect-detection channels have the potential to detect human emotions and that information systems can incorporate the data obtained from affect-detection channels to improve decision models.

Brain–computer interfaces

A brain–computer interface (BCI), is a direct communication pathway between an enhanced or wired brain and an external device. BCI differs from neuromodulation in that it allows for bidirectional information flow. BCIs are often directed at researching, mapping, assisting, augmenting, or repairing human cognitive or sensory-motor functions.

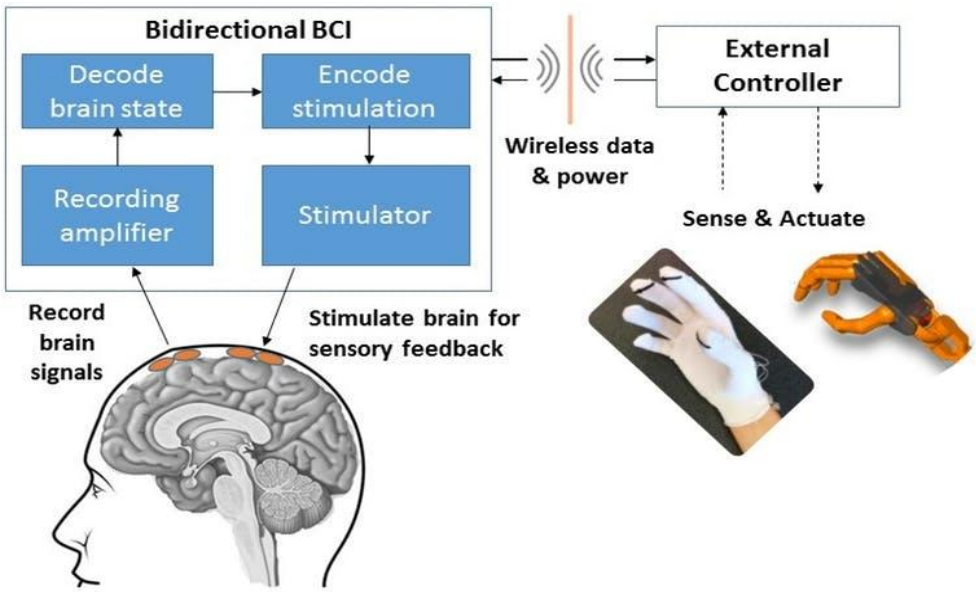


Figure 13 Brief concept Drawing of Brain Computer Interface

1.5 Future Trend in Emerging Technologies

2 Chapter Two: Overview for Data Science

2.1 An Overview of Data Science

Data science is a multi-disciplinary field that uses scientific methods, processes, algorithms and systems to extract knowledge and insights from structured, semi structured and unstructured data. Data science continues to evolve as one of the most promising and in-demand career paths for skilled professionals.

Today, successful data professionals understand that they must advance past the traditional skills of analyzing large amounts of data, data mining, and programming skills. In order to uncover useful intelligence for their organizations, data scientists must master the full spectrum of the data science life cycle and possess a level of flexibility and understanding to maximize returns at each phase of the process.

Data scientists need to be curious and result-oriented, with exceptional industry-specific knowledge and communication skills that allow them to explain highly technical results to their non-technical counterparts. They possess a strong quantitative background in statistics and linear algebra as well as programming knowledge with focuses in data warehousing, mining, and modeling to build and analyze algorithms. In this chapter, we will talk about basic definitions of data and information, data types and representation, data value change and basic concepts of big data.

2.2 What is data and information

What is data?

Data can be defined as a representation of facts, concepts, or instructions in a formalized manner, which should be suitable for communication, interpretation, or processing by human or electronic machine.

Data is represented with the help of characters such as alphabets (A-Z, a-z), digits (0-9) or special characters (+,-,/,*,<,>,= etc.)

What is Information?

Information is organized or classified data, which has some meaningful values for the receiver. Information is the processed data on which decisions and actions are based.

Information is a data that has been processed into a form that is meaningful to recipient and is of real or perceived value in the current or the prospective action or decision of recipient.

For the decision to be meaningful, the processed data must qualify for the following characteristics −

- Timely − Information should be available when required.
- Accuracy − Information should be accurate.
- Completeness − Information should be complete.

Data Vs Information

Data can be described as unprocessed facts and figures. Plain collected data as raw facts cannot help in decision-making. However, data is the raw material that is organized, structured, and interpreted to create useful information systems.
Data is defined as 'groups of non-random symbols in the form of text, images, and voice representing quantities, action and objects'.
Information is interpreted data; created from organized, structured, and processed data in a particular context.

Data Processing Cycle

Data processing is the re-structuring or re-ordering of data by people or machine to increase their usefulness and add values for a particular purpose. Data processing consists of the following basic steps - input, processing, and output. These three steps constitute the data processing cycle.

Figure 14 Data Processing Cycle

- **Input** – In this step, the input data is prepared in some convenient form for processing. The form will depend on the processing machine. For example, when electronic computers are used, the input data can be recorded on any one of the several types of input medium, such as magnetic disks, tapes, and so on.
- **Processing** – In this step, the input data is changed to produce data in a more useful form. For example, pay-checks can be calculated from the time cards, or a summary of sales for the month can be calculated from the sales orders.
- **Output** – At this stage, the result of the proceeding processing step is collected. The particular form of the output data depends on the use of the data. For example, output data may be pay-checks for employees.

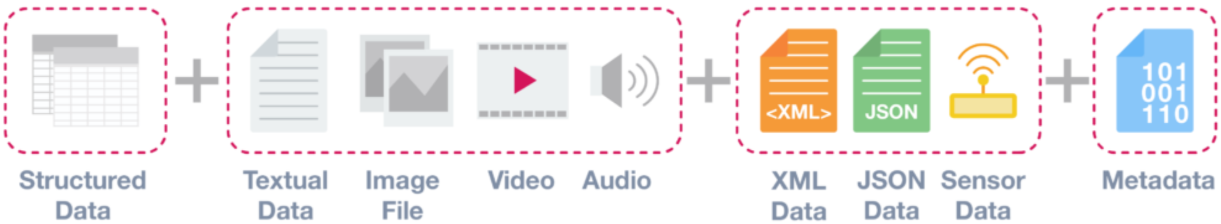
2.3 Data types and its representation

In computer science and computer programming, a data type or simply type is an attribute of data which tells the compiler or interpreter how the programmer intends to use the data. Almost all programming languages explicitly include the notion of data type, though different languages may use different terminology. Common data types include:

O Integers
O Booleans
O Characters
O floating-point numbers
O alphanumeric strings

A data type constrains the values that an expression, such as a variable or a function, might take. This data type defines the operations that can be done on the data, the meaning of the data, and the way values of that type can be stored. On other hand, for the analysis of data, it is important to understand that there are three common types of data types or structures:

Figure 15 Data types for Analysis



Structured Data

Structured data is data that adheres to a pre-defined data model and is therefore straightforward to analyze. Structured data conforms to a tabular format with relationship between the different rows and columns. Common examples of structured data are Excel files or SQL databases. Each of these have structured rows and columns that can be sorted.

Structured data depends on the existence of a data model – a model of how data can be stored, processed and accessed. Because of a data model, each field is discrete and can be accesses separately or jointly along with data from other fields. This makes structured data extremely powerful: it is possible to quickly aggregate data from various locations in the database.

Structured data is is considered the most 'traditional' form of data storage, since the earliest versions of database management systems (DBMS) were able to store, process and access structured data.

Unstructured Data

Unstructured data is information that either does not have a predefined data model or is not organized in a pre-defined manner. Unstructured information is typically text-heavy, but may contain data such as dates, numbers, and facts as well. This results in irregularities and ambiguities that make it difficult to understand using traditional programs as compared to data stored in structured databases. Common examples of unstructured data include audio, video files or No-SQL databases.

The ability to store and process unstructured data has greatly grown in recent years, with many new technologies and tools coming to the market that are able to store specialized types of unstructured data. MongoDB, for example, is optimized to store documents. Apache Graph, as an opposite example, is optimized for storing relationships between nodes.

The ability to analyze unstructured data is especially relevant in the context of Big Data, since a large part of data in organizations is unstructured. Think about pictures, videos or PDF documents. The ability to extract value from unstructured data is one of main drivers behind the quick growth of Big Data.

Semi-structured Data

Semi-structured data is a form of structured data that does not conform with the formal structure of data models associated with relational databases or other forms of data tables, but nonetheless contain tags or other markers to separate semantic elements and enforce hierarchies of records and fields within the data. Therefore, it is also known as self-describing structure. Examples of semi-structured data include JSON and XML are forms of semi-structured data.

The reason that this third category exists (between structured and unstructured data) is because semi-structured data is considerably easier to analyze than unstructured data. Many Big Data solutions and tools have the ability to 'read' and process either JSON or XML. This reduces the complexity to analyze structured data, compared to unstructured data.

Metadata – Data about Data

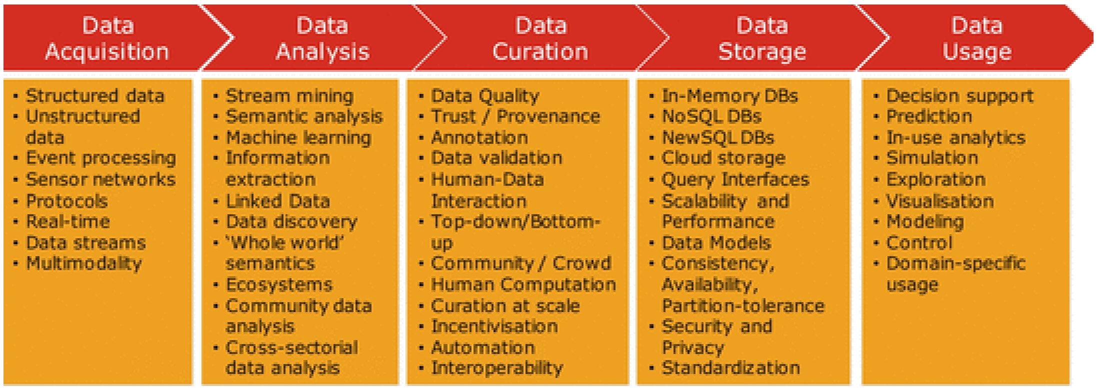
A last category of data type is metadata. From a technical point of view, this is not a separate data structure, but it is one of the most important elements for Big Data analysis and big data solutions. Metadata is data about data. It provides additional information about a specific set of data.

In a set of photographs, for example, metadata could describe when and where the photos were taken. The metadata then provides fields for dates and locations which, by themselves, can be considered structured data. Because of this reason, metadata is frequently used by Big Data solutions for initial analysis.

Data value Chain

The Data Value Chain is introduced to describe the information flow within a big data system as a series of steps needed to generate value and useful insights from data. The Big Data Value Chain identifies the following key high-level activities:

Figure 16 Data Value Chain



Data Acquisition

It is the process of gathering, filtering, and cleaning data before it is put in a data warehouse or any other storage solution on which data analysis can be carried out. Data acquisition is one of the major big data challenges in terms of infrastructure requirements. The infrastructure required to support the acquisition of big data must deliver low, predictable latency in both capturing data and in executing queries; be able to handle very high transaction volumes, often in a distributed environment; and support flexible and dynamic data structures.

Data Analysis

It is concerned with making the raw data acquired amenable to use in decision-making as well as domain-specific usage. Data analysis involves exploring, transforming, and modelling data with the goal of highlighting relevant data, synthesising and extracting useful hidden information with high potential from a business point of view. Related areas include data mining, business intelligence, and machine learning. Chapter 4 covers data analysis.

Data Curation

It is the active management of data over its life cycle to ensure it meets the necessary data quality requirements for its effective usage . Data curation processes can be categorized into different activities such as content creation, selection, classification, transformation, validation, and preservation. Data curation is performed by expert curators that are responsible for improving the accessibility and quality of data. Data curators (also known as scientific curators, or data annotators) hold the responsibility of ensuring that data are trustworthy, discoverable, accessible, reusable, and fit their purpose. A key trend for the curation of big data utilizes community and crowd sourcing approaches.

Data Storage

It is the persistence and management of data in a scalable way that satisfies the needs of applications that require fast access to the data. Relational Database Management Systems (RDBMS) have been the main, and almost unique, solution to the storage paradigm for nearly 40 years. However, the ACID (Atomicity, Consistency, Isolation, and Durability) properties that guarantee database transactions lack flexibility with regard to schema changes and the performance and fault tolerance when data volumes and complexity grow, making them unsuitable for big data scenarios. NoSQL technologies have been designed with the scalability goal in mind and present a wide range of solutions based on alternative data models.

Data Usage

It covers the data-driven business activities that need access to data, its analysis, and the tools needed to integrate the data analysis within the business activity. Data usage in business decision-making can enhance competitiveness through reduction of costs, increased added value, or any other parameter that can be measured against existing performance criteria

2.4 Basic concepts of big data

Big data is a blanket term for the non-traditional strategies and technologies needed to gather, organize, process, and gather insights from large datasets. While the problem of working with data that exceeds the computing power or storage of a single computer is not new, the pervasiveness, scale, and value of this type of computing has greatly expanded in recent years.

In this section, we will talk about big data on a fundamental level and define common concepts you might come across. We will also take a high-level look at some of the processes and technologies currently being used in this space.

What Is Big Data?

An exact definition of "big data" is difficult to nail down because projects, vendors, practitioners, and business professionals use it quite differently. With that in mind, generally speaking, big data is:

- large datasets
- the category of computing strategies and technologies that are used to handle large datasets

In this context, “large dataset” means a dataset too large to reasonably process or store with traditional tooling or on a single computer. This means that the common scale of big datasets is constantly shifting and may vary significantly from organization to organization.

Why Are Big Data Systems Different?

The basic requirements for working with big data are the same as the requirements for working with datasets of any size. However, the massive scale, the speed of ingesting and processing, and the characteristics of the data that must be dealt with at each stage of the process present significant new challenges when designing solutions. The goal of most big data systems is to surface insights and connections from large volumes of heterogeneous data that would not be possible using conventional methods.

In 2001, Gartner’s Doug Laney first presented what became known as the “three Vs of big data” to describe some of the characteristics that make big data different from other data processing:

Volume

The sheer scale of the information processed helps define big data systems. These datasets can be orders of magnitude larger than traditional datasets, which demands more thought at each stage of the processing and storage life cycle.

Often, because the work requirements exceed the capabilities of a single computer, this becomes a challenge of pooling, allocating, and coordinating resources from groups of computers. Cluster management and algorithms capable of breaking tasks into smaller pieces become increasingly important.

Velocity

Another way in which big data differs significantly from other data systems is the speed that information moves through the system. Data is frequently flowing into the system from multiple sources and is often expected to be processed in real time to gain insights and update the current understanding of the system.

This focus on near instant feedback has driven many big data practitioners away from a batch-oriented approach and closer to a real-time streaming system. Data is constantly being added, massaged, processed, and analyzed in order to keep up with the influx of new information and to surface valuable information early when it is most relevant. These ideas require robust systems with highly available components to guard against failures along the data pipeline.

Variety

Big data problems are often unique because of the wide range of both the sources being processed and their relative quality.

Data can be ingested from internal systems like application and server logs, from social media feeds and other external APIs, from physical device sensors, and from other providers. Big data seeks to handle potentially useful data regardless of where it's coming from by consolidating all information into a single system.

The formats and types of media can vary significantly as well. Rich media like images, video files, and audio recordings are ingested alongside text files, structured logs, etc. While more traditional data processing systems might expect data to enter the pipeline already labeled, formatted, and organized, big data systems usually accept and store data closer to its raw state. Ideally, any transformations or changes to the raw data will happen in memory at the time of processing.

Other Characteristics

Various individuals and organizations have suggested expanding the original three Vs, though these proposals have tended to describe challenges rather than qualities of big data. Some common additions are:

- **Veracity**: The variety of sources and the complexity of the processing can lead to challenges in evaluating the quality of the data (and consequently, the quality of the resulting analysis)
- **Variability**: Variation in the data leads to wide variation in quality. Additional resources may be needed to identify, process, or filter low quality data to make it more useful.
- **Value**: The ultimate challenge of big data is delivering value. Sometimes, the systems and processes in place are complex enough that using the data and extracting actual value can become difficult.

What Does a Big Data Life Cycle Look Like?

So how is data actually processed when dealing with a big data system? While approaches to implementation differ, there are some commonalities in the strategies and software that we can talk about generally. While the steps presented below might not be true in all cases, they are widely used.

The general categories of activities involved with big data processing are:

- Ingesting data into the system
- Persisting the data in storage
- Computing and Analyzing data
- Visualizing the results

Before we look at these four workflow categories in detail, we will take a moment to talk about **clustered computing**, an important strategy employed by most big data solutions. Setting up a computing cluster is often the foundation for technology used in each of the life cycle stages.

Clustered Computing

Because of the qualities of big data, individual computers are often inadequate for handling the data at most stages. To better address the high storage and computational needs of big data, computer clusters are a better fit.

Big data clustering software combines the resources of many smaller machines, seeking to provide a number of benefits:

- **Resource Pooling**: Combining the available storage space to hold data is a clear benefit, but CPU and memory pooling is also extremely important. Processing large datasets requires large amounts of all three of these resources.
- **High Availability**: Clusters can provide varying levels of fault tolerance and availability guarantees to prevent hardware or software failures from affecting access to data and processing. This becomes increasingly important as we continue to emphasize the importance of real-time analytics.
- **Easy Scalability**: Clusters make it easy to scale horizontally by adding additional machines to the group. This means the system can react to changes in resource requirements without expanding the physical resources on a machine.

Using clusters requires a solution for managing cluster membership, coordinating resource sharing, and scheduling actual work on individual nodes. Cluster membership and resource allocation can be handled by software like **Hadoop's YARN** (which stands for Yet Another Resource Negotiator) or **Apache Mesos**.

The assembled computing cluster often acts as a foundation which other software interfaces with to process the data. The machines involved in the computing cluster are also typically involved with the management of a distributed storage system, which we will talk about when we discuss data persistence.

Ingesting Data into the System

Data ingestion is the process of taking raw data and adding it to the system. The complexity of this operation depends heavily on the format and quality of the data sources and how far the data is from the desired state prior to processing.

One way that data can be added to a big data system are dedicated ingestion tools. Technologies like **Apache Sqoop** can take existing data from relational databases and add it to a big data system. Similarly, **Apache Flume** and **Apache Chukwa** are projects designed to aggregate and import application and server logs. Queuing systems like **Apache Kafka** can also be used as an interface between various data generators and a big data system. Ingestion frameworks like **Gobblin** can help to aggregate and normalize the output of these tools at the end of the ingestion pipeline.

During the ingestion process, some level of analysis, sorting, and labelling usually takes place. This process is sometimes called ETL, which stands for extract, transform, and load. While this term conventionally refers to legacy data warehousing processes, some of the same concepts apply to data entering the big data system. Typical operations might include modifying the incoming data to format it, categorizing and labelling data, filtering out unneeded or bad data, or potentially validating that it adheres to certain requirements.

With those capabilities in mind, ideally, the captured data should be kept as raw as possible for greater flexibility further on down the pipeline.

Persisting the Data in Storage

The ingestion processes typically hand the data off to the components that manage storage, so that it can be reliably persisted to disk. While this seems like it would be a simple operation, the volume of incoming data, the requirements for availability, and the distributed computing layer make more complex storage systems necessary.

This usually means leveraging a distributed file system for raw data storage. Solutions like **Apache Hadoop's HDFS** filesystem allow large quantities of data to be written across multiple nodes in the cluster. This ensures that the data can be accessed by compute resources, can be loaded into the cluster's RAM for in-memory operations, and can gracefully handle component failures. Other distributed filesystems can be used in place of HDFS including **Ceph** and **GlusterFS**.

Data can also be imported into other distributed systems for more structured access. Distributed databases, especially NoSQL databases, are well-suited for this role because they are often designed with the same fault tolerant considerations and can handle heterogeneous data. There are many different types of distributed databases to choose from depending on how you want to organize and present the data.

Computing and Analyzing Data

Once the data is available, the system can begin processing the data to surface actual information. The computation layer is perhaps the most diverse part of the system as the requirements and best approach can vary significantly depending on what type of insights desired. Data is often processed repeatedly, either iteratively by a single tool or by using a number of tools to surface different types of insights.

Batch processing is one method of computing over a large dataset. The process involves breaking work up into smaller pieces, scheduling each piece on an individual machine, reshuffling the data based on the intermediate results, and then calculating and assembling the final result. These steps are often referred to individually as splitting, mapping, shuffling, reducing, and assembling, or collectively as a distributed map reduce algorithm. This is the strategy used by **Apache Hadoop's MapReduce**. Batch processing is most useful when dealing with very large datasets that require quite a bit of computation.

While batch processing is a good fit for certain types of data and computation, other workloads require more **real-time processing**. Real-time processing demands that information be processed and made ready immediately and requires the system to react as new information becomes available. One way of achieving this is **stream processing**, which operates on a continuous stream of data composed of individual items. Another common characteristic of real-time processors is in-memory computing, which works with representations of the data in the cluster's memory to avoid having to write back to disk.

Apache Storm, **Apache Flink**, and **Apache Spark** provide different ways of achieving real-time or near real-time processing. There are trade-offs with each of these technologies, which can affect which approach is best for any individual problem. In general, real-time processing is best suited for analyzing smaller chunks of data that are changing or being added to the system rapidly.

The above examples represent computational frameworks. However, there are many other ways of computing over or analyzing data within a big data system. These tools frequently plug into the above frameworks and provide additional interfaces for interacting with the underlying layers. For instance, **Apache Hive** provides a data warehouse interface for Hadoop, **Apache Pig** provides a high level querying interface, while SQL-like interactions with data can be achieved with projects like **Apache Drill**, **Apache Impala**, **Apache Spark SQL**, and **Presto**. For machine learning, projects like **Apache SystemML**, **Apache Mahout**, and **Apache Spark's MLlib** can be useful. For straight analytics programming that has wide support in the big data ecosystem, both **R** and **Python** are popular choices.

Visualizing the Results

Due to the type of information being processed in big data systems, recognizing trends or changes in data over time is often more important than the values themselves. Visualizing data is one of the most useful ways to spot trends and make sense of a large number of data points.

Real-time processing is frequently used to visualize application and server metrics. The data changes frequently and large deltas in the metrics typically indicate significant impacts on the health of the systems or organization. In these cases, projects like **Prometheus** can be useful for processing the data streams as a time-series database and visualizing that information.

One popular way of visualizing data is with the **Elastic Stack**, formerly known as the ELK stack. Composed of Logstash for data collection, Elasticsearch for indexing data, and Kibana for visualization, the Elastic stack can be used with big data systems to visually interface with the results of calculations or raw metrics. A similar stack can be achieved using **Apache Solr** for indexing and a Kibana fork called **Banana** for visualization. The stack created by these is called **Silk**.

Another visualization technology typically used for interactive data science work is a data "notebook". These projects allow for interactive exploration and visualization of the data in a format conducive to sharing, presenting, or collaborating. Popular examples of this type of visualization interface are **Jupyter Notebook** and **Apache Zeppelin**.

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3. Chapter Three: Intoroduction to Artificial Intillegence (AI)

3.1. An overview of AI

In recent years, accelerated urbanization, globalization and the abundance of products, services and information has begun to fundamentally transform our society. As individuals, we are experiencing an increasingly complex and demanding environment. In response, mobile applications and automated services are being developed, allowing us to more effectively navigate this complex new world. All this is made possible by powerful algorithms that are slowly acquiring fundamental human-like capabilities, such as vision, speech and navigation. Collectively, these computer algorithms are called artificial intelligence (AI). Beyond emulating these ordinary human capabilities, AI is quickly moving forward to master more specialized tasks performed routinely by human experts.

In today's world, technology is also growing very fast, and we are getting in touch with different new technologies day by day. In the modern world computers and the algorithms that govern them are seen everywhere; from the smartphones in our pockets, to the transportation systems we ride to work, to the computers that control our economy and banks. Many of these algorithms fall under the general umbrella of the field of artificial intelligence (AI). Artificial Intelligence is a field that originally was founded by computer scientists in the 1950s but has since become a multidisciplinary field with applications in nearly every aspect of human life.

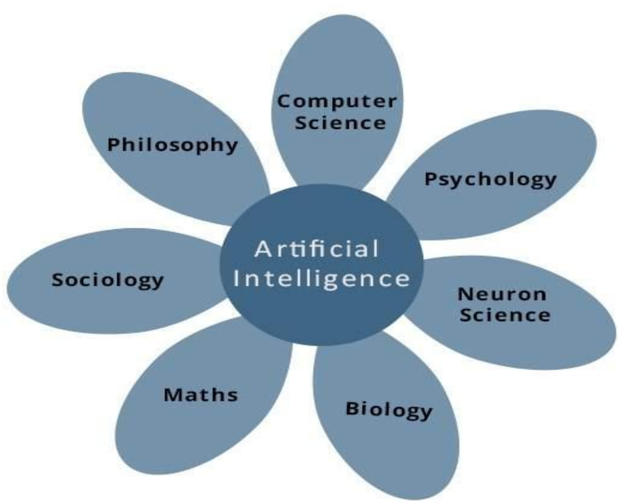

Figure1: Areas which contribute to Artificial Intelligence (AI)

The field of Artificial Intelligence was initially founded to answer the question: *is it possible to build a machine that has intelligence, specifically a human level of intelligence*. A necessary step in the pursuit of creating a machine intelligence was understanding the very nature of ***knowledge representation***, ***reasoning***, ***learning***, ***perception***, and ***problem solving***. Through an understanding of these areas AI researchers discovered much narrower applications that a machine can perform and the field of artificial intelligence was expanded. And now Artificial Intelligence (AI) is one of the fascinating and universal fields of Computer Science which has a great scope in future, which holds a tendency to cause a machine to work as a human.

Artificial intelligence (AI) is transforming many aspects of our personal and professional lives, from logistics systems that select the fastest shipping routes to dig-ital assistants that unlock doors, turn on lights, and get to know our shopping preferences. The most advanced AI systems use machine learning technology to analyze current conditions and learn from experience. Within the workplace, these self-directed agents are giving rise to the intelligent enterprise: organizations where people make decisions with the help of intelligent machines.[1]

3.3. What is AI

According to the father of Artificial Intelligence, John McCarthy, it is "The science and engineering of making intelligent machines, especially intelligent computer programs". Artificial Intelligence is a way of making a computer, a computer-controlled robot, or a software think intelligently, in the similar manner the intelligent humans think. AI is accomplished by studying how human brain thinks, and how humans learn, decide, and work while trying to solve a problem, and then using the outcomes of this study as a basis of developing intelligent software and systems.[1]

Artificial Intelligence (AI) is about ***algorithms*** enabled by constraints exposed by ***representations*** that support ***models*** targeted at ***thinking***, ***perception*** and ***action***. Where an *Algorithm* is an unambiguous specification of how to solve a particular problem. A *model* is a representation of entities and relationships between them. For example a Computer model, can be a simulation used to reproduce behavior of a system, which in turn can be used to make predictions.

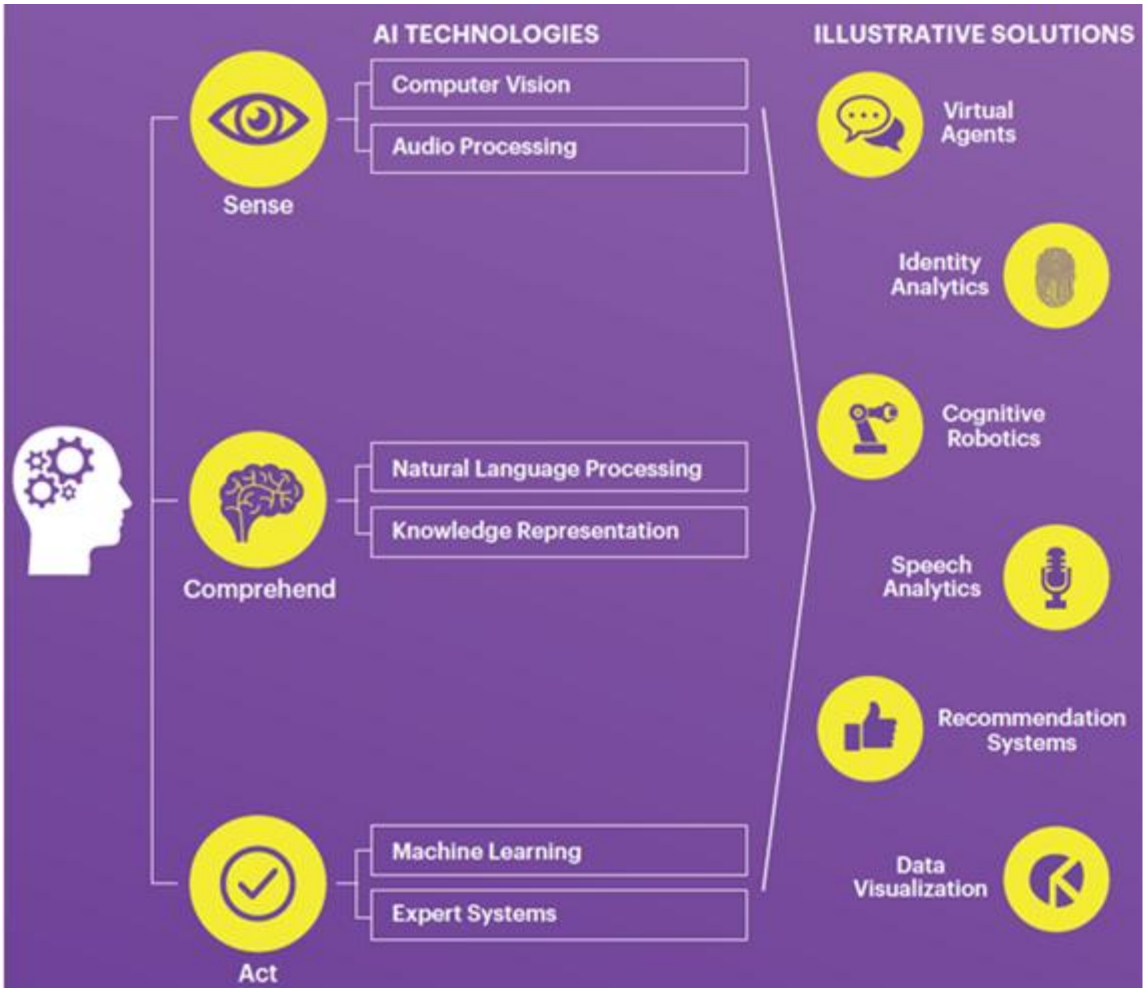

Figure 2: Overview of modern AI

Artificial intelligence (**AI**): A broad discipline with the goal of creating intelligent machines, as opposed to the natural intelligence that is demonstrated by humans and animals. AI is the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.

AI is the creation of a computer program that can learn to think and function on its own, kind of like robots that don't need to be told what to do all the time. In the modern age, AI is the enabler technology. The following are technologies that uses AI:

i. **Machine Learning** – A subset of AI that often uses statistical techniques to give machines the ability to "learn" from data without being explicitly given the instructions for how to do so. This process is known as “training” a “model” using a learning “algorithm” that progressively improves model performance on a specific task.

ii. **Robotics** – Robotics deals with the design, construction, operation, and use of robots, as well as computer systems for their control, sensory feedback, and information processing. These technologies are used to develop machines that can substitute for humans and replicate human actions.

iii. **Machine Automation** – Machine automation is any Information Technology (IT) that designed to control the work of machines.

iv. **Virtual Reality –** Virtual Reality is the computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors**.**

v. **Cloud Computing** – Cloud Computing the practice of using a network of remote servers hosted on the Internet to store, manage, and process data, rather than a local server or a personal computer. Cloud Compuing involves delivering hosted services over the Internet. These services are broadly divided into three categories: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS).

vi. **Augmented Reality** – Augmented Reality refers to a technology that superimposes a computer-generated image with sound, text and effects on a user's view of the real world, thus enhancing the user’s real world experience.

vii. **Neural Networks** – A neural network is a type of machine learning which models itself after the human brain. This creates an artificial neural network that via an algorithm allows the computer to learn by incorporating new data.

viii. **Big Data/ Internet Of Things(IoT)** – Big Data refers to extremely large data sets that may be analysed computationally to reveal patterns, trends, and associations, especially relating to human behaviour and interactions. Internet of Things (IoT) refers to the set of devices and systems that interconnect real-world sensors and actuators to the Internet.

ix. **Computer Vision**: Enabling machines to analyse, understand and manipulate images and video.

The modern AI is based on '*machine learning*' that enables software to perform difficult tasks more effectively by learning through training instead of following sets of rules. Deep learning, a subset of machine learning, is alos delivering breakthrough results in fields including computer vision and language processing.[3]

Knowledge engineering is a core part of AI research. Machines can often act and react like humans only if they have abundant information relating to the world. Artificial intelligence must have access to objects, categories, properties and relations between all of them to implement knowledge engineering. Initiating common sense, reasoning and problem-solving power in machines is a difficult and tedious task.

Machine perception deals with the capability to use sensory inputs to deduce the different aspects of the world, while computer vision is the power to analyze visual inputs with a few sub-problems such as facial, object and gesture recognition.

Robotics is also a major field related to AI. Robots require intelligence to handle tasks such as object manipulation and navigation, along with sub-problems of localization, motion planning and mapping. [2]

Components of an AI System include the following:

i. **Applications**: Image recognition, Speech recognition, Chatbots, Natural language generation, and Sentiment analysis.
ii. **Types of Models**: Deep learning, Machine learning, and Neural Networks.
iii. **Software/Hardware for training and running models**: Graphic Processing Units (GPUs), Parallel processing tools (like Spark), Cloud data storage and computer platforms.
iv. **Programming languages for building models**: Python, TensorFlow, Java, and C/C^{++}, etc.

3.4. History of AI

It all started with Augusta Ada Lovelace (1842), the world's first programmer, who wrote programs about 100 years before there were computers to run them. And she said, "*The analytical engine has no pretensions to originate anything. It can do whatever we know how to order it to perform.*" And then nothing much happened until about 1950, when Alan Turing wrote his famous paper, which introduced the **Turing Test**. And then the modern era really began with a paper written by Marvin Minsky in 1960, titled "*Steps Toward Artificial Intelligence.*" The following section summarizes the short history of AI.[4]

1956	The term "artificial intelligence" is coined by John McCharty at a Dartmouth conference and AI is founded as an academic discipline.
1956–1974	The golden years of AI enjoy government funding in promising, logic-based problem-solving approaches.
1974–1980	Overly high expectations coupled with the limited capacities of AI rograms leads to the first "AI winter", with reduced funding and interest in AI research.
1980–1987	The rise of knowledge-based expert systems brings new successes and a change in the focus of research and funding toward this form of AI.
1987–1993	The second "AI winter" starts with the sudden collapse of the specialized hardware industry in 1987. The AI hype brings with it negative perceptions by governments and investors, as expert systems show their limitations and prove expensive to update and maintain.
1993–2011	Optimism about AI returns and increases. New successes are marked with the help of increased computational power and AI becomes data-driven. In 1997, IBM's DeepBlue beats world champion Gary Kasparov at chess. In 2002, Amazon uses automated systems to provide recommendations. In 2011, Apple releases Siri and IBM Watson beats two human champions at the TV quiz Jeopardy.
2012–today	Increased availability of data, connectedness and computational power allow for breakthroughs in machine learning, mainly in neural networks and deep learning, heralding a new era of increased funding and optimism about the AI potential. In 2012, Google driverless cars navigate autonomously and in 2016 Google AlphaGo beats a world champion in the complicated board game Go.

3.5. Levels of AI

The different types of AI depend on the level of intelligence embedded into a machine. We can clearly categorize AI into three levels [5]:

1. **Artificial Narrow Intelligence (Weak AI or Narrow AI):** Narrow AI is a type of AI which is able to perform a dedicated task with intelligence. The most common and currently available AI is Narrow AI in the world of Artificial Intelligence. Narrow AI cannot perform beyond its field or limitations, as it is only trained for one specific task. Hence it is also termed as weak AI. Narrow AI can fail in unpredictable ways if it goes beyond its limits. *Apple Siriis* a good example of Narrow AI, but it operates with a limited pre-defined range of functions.[5] IBM's Watson supercomputer also comes under Narrow AI, as it uses an Expert system approach combined with Machine learning and natural language processing. Some examples of Narrow AI are
    - Playing chess,
    - Purchasing suggestions on e-commerce site,
    - Self-driving cars,
    - Speech recognition, and
    - Image recognition.
2. **Artificial General Intelligence (General AI or Strong AI)**: General AI is a type of intelligence which could perform any intellectual task with efficiency like a human. The idea behind the general AI is to make such a system which could be smarter and think like a human by its own. Currently, there is no such system exist which could come under general AI and can perform any task as perfect as a human.The worldwide researchers are now focused on developing machines with General AI. As systems with general AI are still under research, and it will take lots of efforts and time to develop such systems.[5]
3. **Artificial Super Intelligence (Super AI)**: Super AI is a level of Intelligence of Systems at which machines could surpass human intelligence, and can perform any task better than human with cognitive properties. It is an outcome of general AI. Some key characteristics of strong AI include the ability to think, to reason, solve the puzzle, make judgments, plan, learn, and communicate by its own. Super AI is still a hypothetical concept of Artificial Intelligence. Development of such systems in real is still world changing task.[5]

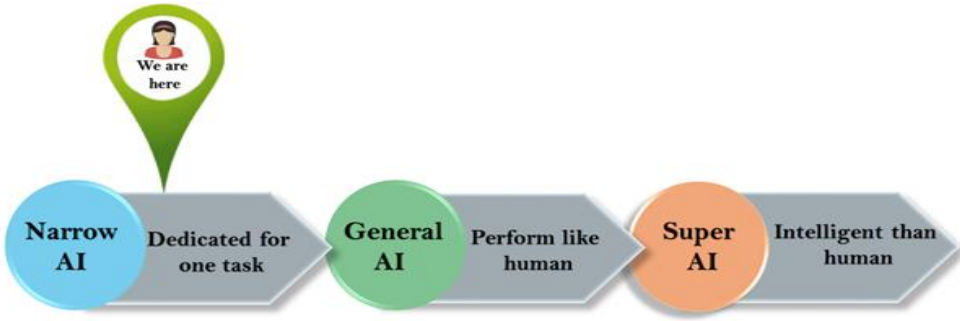

Figure 3: Levels of AI

3.6. Types of AI

Artificial Intelligence can be divided in various types, there are mainly two types of main categorization which are based on capabilities and based on functionally of AI. Following is flow diagram which explain the types of AI.

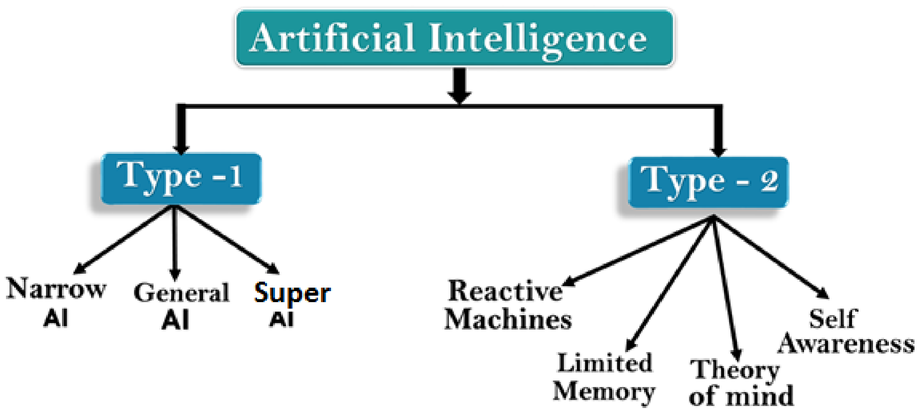

Figure 4: The Types of AI

Please refere to the above section the first types of AI based on capability also refered to as levels of AI. Based on funcationality, we have four types of AI, which are described below:

1. **Reactive Machines**: Purely reactive machines are the most basic types of Artificial Intelligence. Such AI systems do not store memories or past experiences for future actions. These machines only focus on current scenarios and react on it as per possible best action. IBM's Deep Blue system is an example of reactive machines. Google's AlphaGo is also an example of reactive machines.

2. **Limmited Memory**: Limited memory machines can store past experiences or some data for a short period of time. These machines can use stored data for a limited time period only. Self-driving cars are one of the best examples of Limited Memory systems. These cars can store recent speed of nearby cars, the distance of other cars, speed limit, and other information to navigate the road.
3. **Theory of Mind**: Theory of Mind AI should understand the human emotions, people, beliefs, and be able to interact socially like humans. This type of AI machines are still not developed, but researchers are making lots of efforts and improvement for developing such AI machines. *Sophia* – the humanoid robot is one example of such effort where a number of young Ethipians have contributed on the development.[6]
4. **Self–Awareness**: Self-awareness AI is the future of Artificial Intelligence. These machines will be super intelligent, and will have their own consciousness, sentiments, and self-awareness. These machines will be smarter than human mind. Self-Awareness AI does not exist in reality still and it is a hypothetical concept.

3.7. Applications of AI

Currently, AI is being applied across several industries. Though one cannot say that AI is replacing humans but it is certainly making the work of human beings more efficient. The following are among the common application areas of Artificial Intelligence in the real world.

Agriculture

Agriculture and farming is one of the oldest and most important professions in the world. Humanity has come a long way over the millennia in how we farm and grow crops with the introduction of various technologies. As the world population continues to grow and land becomes more scarce, people have needed to get creative and become more efficient about how we farm, using less land to produce more crops and increasing the productivity and yield of those farmed acres. Worldwide, agriculture is a $5 trillion industry, and now the industry is turning to AI technologies to help *yield healthier crops*, *control pests*, *monitor soil and growing conditions*, *organize data for farmers*, *help with workload*, and improve a wide range of agriculture-related tasks in the entire food supply chain.[7]

Factors such as climate change, population growth and food security concerns have propelled the agricultural industry into seeking more innovative approaches to protecting and improving crop yield. As a result, AI is steadily emerging as part of the industry's technological evolution.[8]

Figure 5: Applications of AI in agriculture.

The most popular applications of AI in agriculture appear to fall into three major categories:

1. **Agricultural Robots** – Companies are developing and programming autonomous robots to handle essential agricultural tasks such as harvesting crops at a higher volume and faster pace than human laborers.

   Example AI Applications:

   i) **See & Spray Robot**[9] – Leverages computer vision to monitor and precisely spray weeds on cotton plants. Precision spraying can help prevent herbicide resistance.

   ii) **Harvest CROO Robotics** – Crop Harvesting robot in an effort to help address challenges in the labor force.

2. **Crop and Soil Monitoring** – Companies are leveraging computer vision and deep-learning algorithms to process data captured by drones and/or software-based technology to monitor crop and soil health.

   Example AI Applications:

   i) **PEAT** – Machine Vision for Diagnosing Pests or Soil Defects. Deforestation and degradation of soil quality remain significant threats to food security and have a negative impact on the the economy. PEAT, a Burline based startup, has developed a deep learning application called ***Plantix*** that reportedly identifies potential defects and nutrient deficiencies in soil. Analysis is conducted by software algorithms which correlate particular foliage patterns with certain soil defects, plant pests and diseases.

3. **Predictive Analytics** – Machine learning models are being developed to track and predict various environmental impacts on crop yield such as weather changes.

   Example AI Applications:

   i) **aWhere** – Satellites for Weather Prediction and Crop Sustainability – uses machine learning algorithms in connection with satellites to predict weather, analyze crop sustainability and evaluate farms for the presence of diseases and pests.

   ii) **FarmShots** – Satellites for Monitoring Crop Health and Sustainability – focused on analyzing agricultural data derived from images captured by satellites and drones to detect diseases, pests, and poor plant nutrition on farms.

AI-driven technologies are emerging to help improve efficiency and to address challenges facing the agricultural industry including, crop yield, soil health and herbicide-resistance. Agricultural robots are poised to become a highly valued application of AI in this sector.[7]

Health

Artificial intelligence's (AI) transformative power is reverberating across many industries, but in one – healthcare – its impact promises to be truly life-changing. From hospital care to clinical research, drug development and insurance, AI applications are revolutionizing how the health sector works to reduce spending and improve patient outcomes.[10]

Companies are applying machine learning to make better and faster diagnoses than humans. One of the best known healthcare technologies is IBM Watson. It understands natural language and is capable of responding to questions asked of it. The system mines patient data and other available data sources to form a hypothesis, which it then presents with a confidence scoring schema. Other AI applications include chatbots, a computer program used online to answer questions and assist customers, to help schedule follow-up appointments or aid patients through the billing process, and virtual health assistants that provide basic medical feedback.

Areas where AI is used in health care include:

1. **Personal Health Virtual Assistant** – In the present era, most people have access to a smartphone. They are likely to have their virtual assistant on their mobile devices. Advanced AI algorithms power assistants like Cortana, Google Assistant, Siri. When combined with healthcare apps, they will provide massive value to the users.[10]
   Eample AI Applications:
   i) **Dip.io** – uses the traditional urinalysis dipstick to monitor a range of urinary infections. Users take a picture of the stick with their smartphones, and computer vision algorithms calibrate the results to account for different lighting conditions and camera quality. The test detects infections and pregnancy-related complications.
   ii) Apple is building a clinical research ecosystem around the iPhone and **Apple Watch** – which generates continuous signal about your heart, activity, and sleep. Data is at the core of AI applications, and Apple can provide medical researchers with two streams of patient health data that were not as easily accessible until now.
2. **Medical Imaging Analysis -** Another important field in healthcare which is using AI is radiology. AI systems can help with diagnostic processes. It can examine medical images like X-rays, CT scans, MRIs, etc. and can provide feedback on what it thinks a human eye can miss. Thus, medical imaging analysis becomes much more accurate and effective. It reduces the chances of errors.[10]
   Example AI Applications:

i) **IBM Watson** – In the field of oncology, it can provide clinicians with evidence-based treatment options for the cancer patients based on the training provided by Memorial Sloan Kettering (MSK) physicians.

ii) **IDx** software – for diabetic retinopathy detection from eye scans. This condition happens when high levels of blood sugar lead to damage in the blood vessels of the retina.

iii) **Viz.ai** was approved to analyze CT scans and notify healthcare providers of potential strokes in patients.

3. **Precision Medicine** – Genomic is the branch of molecular biology which deals with the structure, evolution, function, and mapping of genomes. It looks for the links to disease from the information obtained from the DNA. When combined with AI, it is possible to spot cancer and some vascular diseases at a very early stage. Moreover, it can predict the health issues the patients might face based on their genes. Also, AI helps with medical parts machining thus reducing the chances of error in operation.[10]
4. **Healthcare Bots** – AI technology is also gaining traction in the customer service domain. The world is likely to see healthcare bots very soon. Patients will be able to interact with these AI bots on the website through a chat window or via telephone. Healthcare bots will be used to schedule appointments with the patient's healthcare provider. These bots can help patients with their medication as well. They can also improve customer service by offering 24 x 7 support.[10]
5. **Operational applications of AI** – Hospital operations are complex, highly variable and deeply interconnected systems – this is why it is operationally very challenging to simultaneously deliver high utilization of assets, low wait times for patients, and a large number of available slots for patients seeking an appointment over the next few days.

Business (Emerging market)

Artificial Intelligence has enormous potential to augment human intelligence and to radically alter how we access products and services, gather information, make products, and interact. In emerging markets, AI offers an opportunity to lower costs and barriers to entry for businesses and deliver innovative business models that can leapfrog traditional solutions and reach the underserved.[11]

AI is steadily passing into everyday business use. From workflow management to trend predictions, AI has many different uses in business. It also provides new business opportunities. Application of artificial intelligence in business us AI technologies to:

- **Improve Customer Services**: Use virtual assistant programs to provide real–time support to users (for example, with billing and other tasks).
- **Automate Workloads**: Collect and analyse data from smart sensors, or use machine learning (ML) algorithms to categorise work, automatically route service requests, etc.
- **Optimise Logistics**: Use AI powered image recognition tools to monitor and optimise infrastructure, plan transport routes, etc.
- **Increase Manufacturing Output and Efficiency**: Automate production line by integrating industrial robots into the workflow and teaching them to perform labour-intensive or mundane tasks.
- **Prevent Outages**: Use anomaly detection techniques to identify patterns that are likely to disrupt business, such as an IT outage. Specific AI software may also help to detect and deter security intrusions.
- **Predict Performance**: Use AI applications to determine when you might reach performance goals, such as response time to help desk calls.
- **Predict Behaviour**: Use machine learning algorithms to analyse patterns of online behaviour to, for example, serve tailored product offers, detect credit card fraud or target appropriate adverts.
- **Manage and Analyse Data**: AI can help interpret and mine data more efficiently than ever before and provide meaningful insight into assets, brand, staff or customers.
- **Improve Marketing and Advertising**: AI can help in effectively tracking user behaviour and automate many routine marketing tasks.

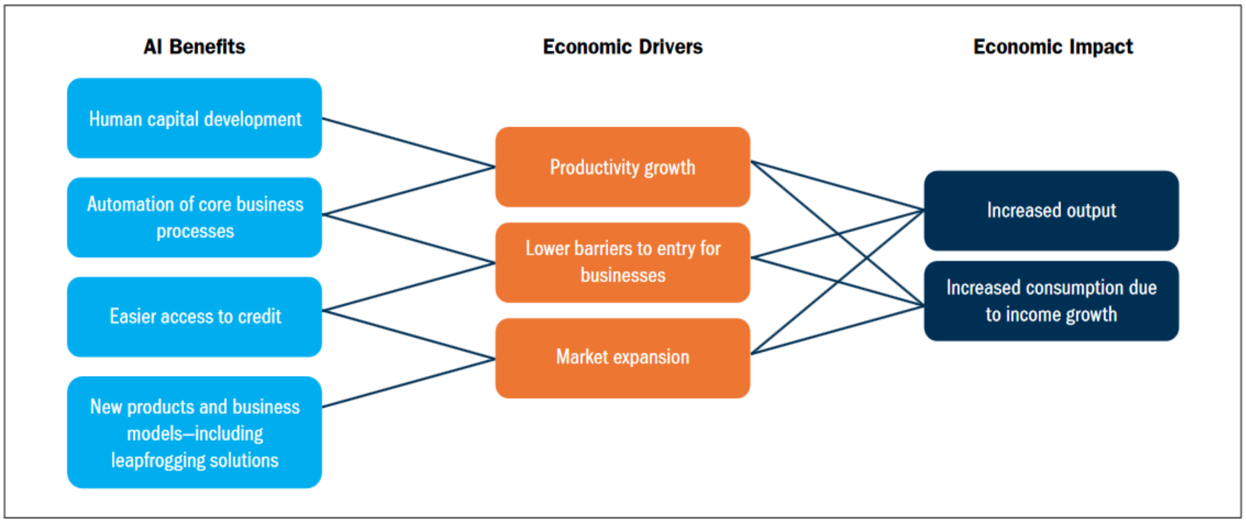

Figure 6: Channels to Economic Development supported by AI technologies.

The following are examples of AI applications used in business in various areas:

1. Applications of AI in **Business Management** include:
    - spam filters
    - smart email categorisation
    - voice to text features
    - smart personal assistants, such as Siri, Cortana and Google Now
    - automated responders and online customer support
    - process automation
    - sales and business forecasting
    - security surveillance
    - smart devices that adjust according to behaviour
    - automated insights, especially for data-driven industries (eg financial services or e-commerce)
2. Artificial intelligence in **e–Commerce**:
    - Smart searches and relevance features
    - Personalisation as a service
    - Product recommendations and purchase predictions
    - Fraud detection and prevention for online transactions
    - Dynamic price optimisation

3. Artificial intelligence in **Marketing**:
    - Recommendations and content curation
    - Personalisation of news feeds
    - Pattern and image recognition
    - Language recognition - to digest unstructured data from customers and sales prospects
    - Ad targeting and optimised, real-time bidding
    - Customer segmentation
    - Social semantics and sentiment analysis
    - Automated web design
    - Predictive customer service

Education

The increasing adoption of the AI technology for various applications in the education sector and growing need for multilingual translators integrated with the AI technology are expected to drive the growth of the AI in education market.

AI can automate grading, giving educators more time, and can also assess students and adapt to their needs, helping them work at their own pace. AI tutors can provide additional support to students, ensuring they stay on track. AI could change where and how students learn, perhaps even replacing some teachers. The following are the areas of applications of AI in education:

1. **Administrative Tasks Automation**: AI has great potential in automating and expediting administrative tasks for both organizations and professors. Grading homework, evaluating essays and offering value to student responses is where educators spend the most time. AI can already automate the grading process in multiple choice tests in order to allow educators to spend more time with students one-on-one, but the technology may soon be able to do more than this. Software developers are creating new ways to grade written responses and essays as well. The admission process is also set to benefit with AI. Admissions processes can also be streamlined and improved, reducing the workload for high volume admissions offices. Automating the process of paperwork and support for

students with common admissions questions via chatbot and interactive website materials can improve the process for both administrators and future students.[12]

2. **Smart Content**: The concept of smart content is a hot topic now as robots can create digital content with the same degree of grammatical prowers as their human counterparts, and this technology has finally reached the classroom. AI can help digitize textbooks or create customizable learning digital interfaces that apply to students of all age ranges and grades.

   Example AI applications include:

   - **Cram101** – Uses AI to condense the content in textbooks into a more digestible study guide with chapter summaries, practice tests and flashcards.
   - **Netex** – Learning platform allows lecturers and professors to design a digital curriculum and content across a variety of devices, including video, audio and an online assistant. Virtual content such as digital lectures and video conferences are also a reality now thanks to AI.[12]

3. **Smart Tutors and Personalization**: AI can do more than condense a lecture into flashcards and smart study guides as it can also tutor a student based on the difficulties they're having with class material. In the past, students had a limited window of time in which they could see their professors, meaning office hours or hoping they answer their emails. [12]

   Example AI applications include:

   - **Carnegie Learning** – Use data from specific students in order to give them feedback and work with them directly. While this AI application is still in its early stages, it will soon be able to work as a full-fledged digital professor that helps a student with their educational needs in just about any area of need. Also, these platforms will soon be able to adapt to a wide variety of learning styles in order to help every educator and student.

4. **Virtual Lectures and Learning Environment**: This may replace a lecturer with a robot – virtual human guides and facilitators that can think, act and react with humans by using gesture recognition technology in a natural way, responding both verbal and nonverbal cues. AI together with 3D gaming and computer animation can be used to create real virtual characters and social interactions. With the rise of augmented and virtual reality,

and the benefits of bringing these into the classroom for students to have a more immersive learning experience and to see places and explore things that otherwise they would not, AI can be a tremendous benefit for this. Through AI, resources could be found instantly based on student responses, or for the entire classroom to experience. Capabilities such as these are not something that will be limited by the time and place of the classroom setting. AI could show students what they want to explore, find ways to bring the content to life instantly.[12]

5. **Teachers' Support**: In addition to helping with grading, AI will also provide support for teachers in other ways. Some of the routine task can be managed by AI, as well as communication with students. For example, a professor can use an AI Chatbot to communicate with students as a teaching assistant all semester without students knowing they were not talking to a human.[12]
6. **Students' Communication**: Students and teachers will be able to communicate instantly with one another as well as to connect with other forms of AI around the world. Students instantly paired with peers, helping each student to expand their own personal learning networks, with personalized and more authentic connections that will meet the students' interests and needs at any given moment. Think of the benefits for being able to converse with AI or a virtual peer, who has been located based on an assessment of student needs and error analyses.[12]

3.8. AI tools and platforms (egg: scratch/object tracking)

Because hardware, software and staffing costs for AI can be expensive, many vendors are including AI components in their standard offerings, as well as access to Artificial Intelligence as a Service (AIaaS) platforms. AI as a Service allows individuals and companies to experiment with AI for various business purposes and sample multiple platforms before making a commitment. Popular AI cloud offerings include Amazon AI services, IBM Watson Assistant, Microsoft Cognitive Services and Google AI services.

While AI tools present a range of new functionality for businesses ,the use of artificial intelligence raises ethical questions. This is because deep learning algorithms, which underpin many of the most advanced AI tools, are only as smart as the data they are given in training.

Because a human selects what data should be used for training an AI program, the potential for human bias is inherent and must be monitored closely.

[To be continued…]

3.9. Sample application with hands on activity (simulation based)

[to be continued…]

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4. INTERNET OF THINGS (IoT)

4.1 Overview of IoT

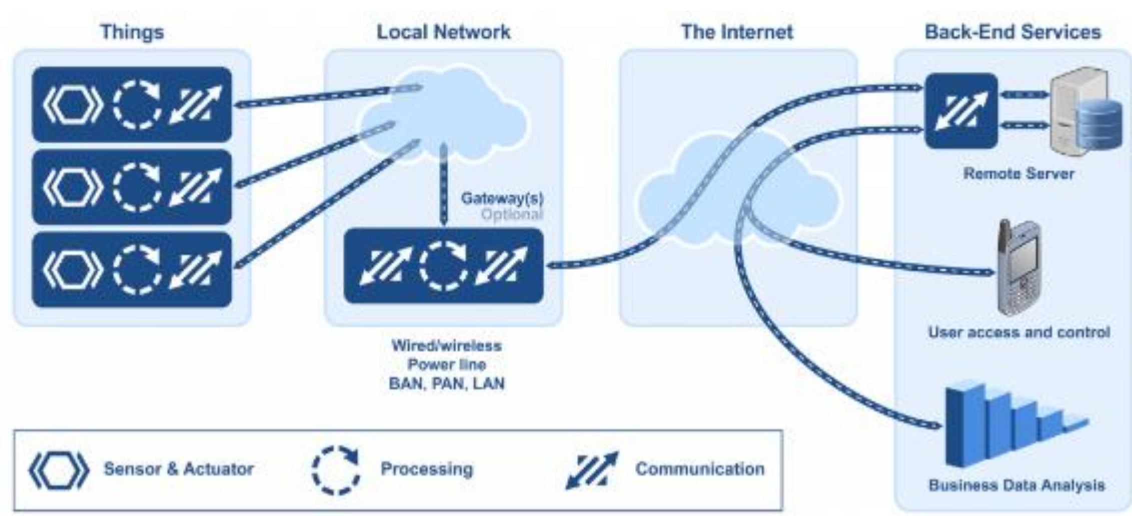
The Internet of Things, or IoT, refers to the set of devices and systems that interconnect real-world sensors and actuators to the Internet. This includes many different systems, including

- Internet-connected cars
- wearable devices including health and fitness monitoring devices, watches, and even human implanted devices;
- smart meters and smart objects;
- home automation systems and lighting controls;
- smartphones that are increasingly being used to measure the world around them; and
- wireless sensor networks that measure weather, flood defenses, tides and more[1].

How to Think about the Internet of Things (IoT)

In broad strokes, there are four main components of an IoT system[2]:

- The Thing itself (that is, the device)
- The local network (this can include a gateway, which translates proprietary communication protocols to Internet Protocol)
- The Internet
- Back-end services (enterprise data systems, or PCs and mobile devices)



F. The Internet of Things from an embedded systems point of view[2]

The growth of the number and variety of devices that are collecting data is incredibly rapid. A study by Cisco1 estimates that the number of Internet-connected devices overtook the human population in 2010 and that there will be 50 billion Internet-connected devices by 2020[1].

There are of course two key aspects to the IoT: the devices themselves and the server-side architecture that supports them. In fact, there is often a third-category as well; in many cases, there may be a low power gateway that performs aggregation, event processing, bridging, etc. that might sit between the device and the wider Internet[1].

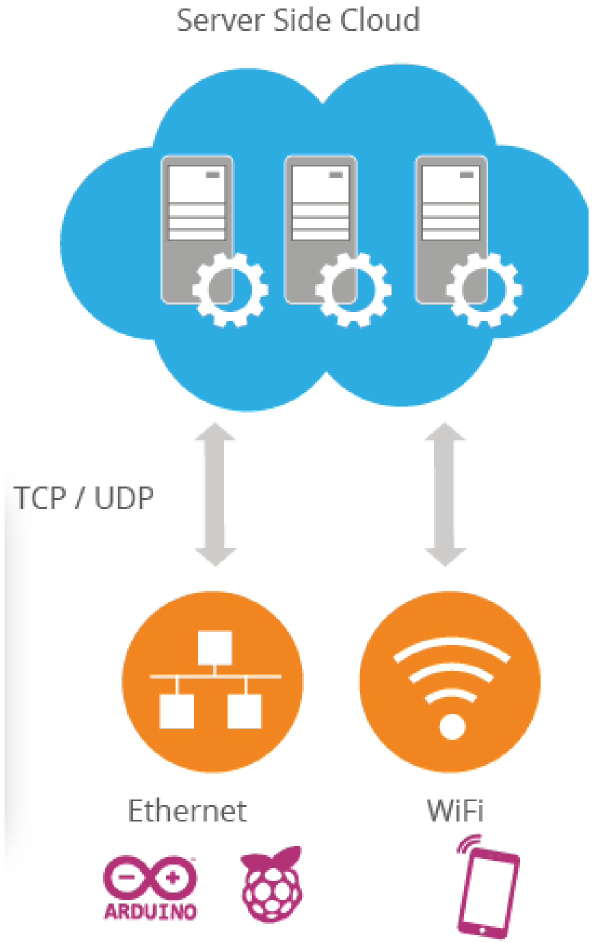
There are effectively three classes of devices:

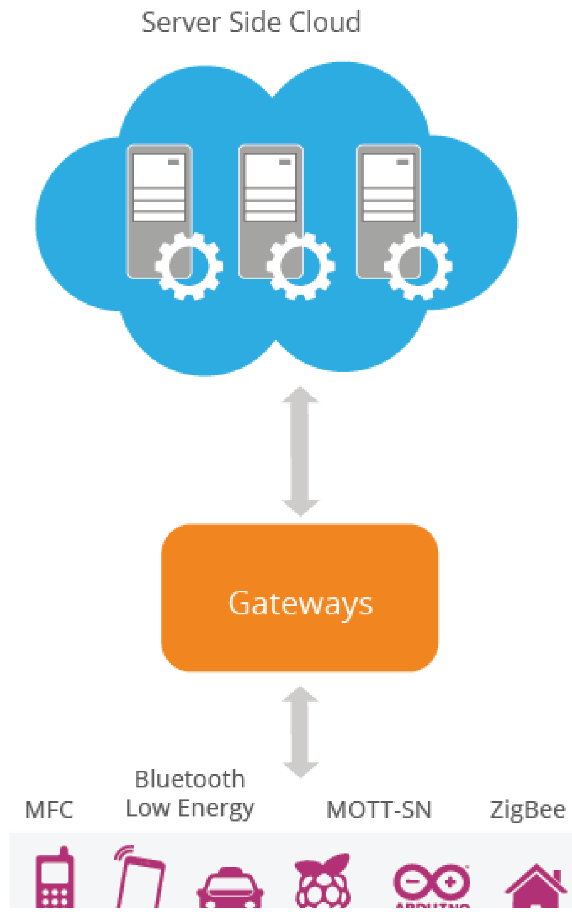
- The smallest devices have embedded 8-bit System-On-Chip (SOC) controllers. A good example of this is the open-source hardware platform Arduino: e.g the Arduino Uno platform and other 8-bit Arduinos. These typically have no operating system[1].
- The next level up is the systems based on Atheros and ARM chips that have a very limited 32-bit architecture. These often include small home routers and derivatives of those devices. Commonly, these run a cut-down or embedded Linux platform, such as OpenWRT, or dedicated embedded operating systems. In some cases, they may not use an OS, e.g. the Arduino Zero, or the Arduino Yun[1].
- The most capable IoT platforms are full 32-bit or 64-bit computing platforms. These systems, such as the Raspberry Pi or the BeagleBone, may run a full Linux OS or another suitable Operating System, such as Android. In many cases, these are either mobile phones or based on mobile-phone technology. These devices may also act as gateways or bridges for smaller devices, e.g. if a wearable connects via Bluetooth Low Energy to a mobile phone or Raspberry Pi, which then bridges that onto the wider Internet[1].

The communication between devices and the Internet or to a gateway includes many different models:

- Direct Ethernet or Wi-Fi connectivity using TCP or UDP (we will look at protocols for this later)
- Bluetooth Low Energy
- Near Field Communication (NFC)
- Zigbee or other mesh radio networks
- SRF and point-to-point radio links
- UART or serial lines
- SPI or I2C wired buses[1]

Figure 1 below illustrates the two major modes of connectivity[1].





4.1.1 What is IoT?

The description of the Internet of Things is related to different definitions used by several groups for promoting the particular concept in the whole world. According to the Internet Architecture Board's (IAB) definition, IoT is the networking of smart objects, meaning a huge number of devices intelligently communicating in the presence of internet protocol that cannot be directly operated by human beings but exist as components in buildings, vehicles or the environment. According to the Internet Engineering Task Force (IETF) organization's definition, IoT is the networking of smart objects in which smart objects have some constraints such as limited bandwidth, power, and processing accessibility for achieving interoperability among smart objects. According to the IEEE Communications category magazine's definition, IoT is a framework of all things that have a representation in the presence of the internet in such a way that new applications and services enable the interaction in the physical and virtual world in the form of Machine-to-Machine (M2M) communication in the cloud. According to the Oxford dictionary's definition, IoT is the interaction of everyday object's computing devices through the Internet that enables the sending and receiving of useful data[3].

The term Internet of Things (IoT) according to the 2020 conceptual framework is expressed through a simple formula such as: -

IoT= Services+ Data+ Networks + Sensors[3]

The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction[4].

A thing in the internet of things can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low or any other natural or man-made object that can be assigned an IP address and is able to transfer data over a network[4].

Simply, the term IoT is a worldwide network of intelligent objects that are interconnected and uniquely representable on the basis of communication-based protocols. The ubiquitous computing technology-related trend improves from the latest technology in the form of the Internet of Things. The Internet of things' objects enables the connection with the internet to work anytime, anywhere and anyplace[3].

The IoT four key technological enablers are: -

- For tagging the things RFID technology used
- For sensing the things sensor technology used
- For thinking the things smart technology used
- For shrinking the things Nanotechnology used[3]

4.1.2 History of IoT

Kevin Ashton, the co-founder of the Auto-ID Center at MIT, first mentioned the internet of things in a presentation he made to Procter & Gamble (P&G) in 1999. Wanting to bring radio frequency ID (RFID) to the attention of P&G's senior management, Ashton called his presentation "Internet of Things" to incorporate the cool new trend of 1999: the internet. MIT professor Neil Gershenfeld's book, When Things Start to Think, also appearing in 1999, didn't use the exact term but provided a clear vision of where IoT was headed[4].

IoT has evolved from the convergence of wireless technologies, microelectromechanical systems (MEMS), microservices and the internet. The convergence has helped tear down the silos between operational technology (OT) and information technology (IT), enabling unstructured machine-generated data to be analyzed for insights to drive improvements[4].

Although Ashton's was the first mention of the internet of things, the idea of connected devices has been around since the 1970s, under the moniker's embedded internet and pervasive computing[4].

The first internet appliance, for example, was a Coke machine at Carnegie Mellon University in the early 1980s. Using the web, programmers could check the status of the machine and determine whether there would be a cold drink awaiting them, should they decide to make the trip to the machine[4].

IoT evolved from machine-to-machine (M2M) communication, i.e., machines connecting to each other via a network without human interaction. M2M refers to connecting a device to the cloud, managing it and collecting data[4].

Taking M2M to the next level, IoT is a sensor network of billions of smart devices that connect people, systems and other applications to collect and share data. As its foundation, M2M offers the connectivity that enables IoT[4].

The internet of things is also a natural extension of SCADA (supervisory control and data acquisition), a category of the software application program for process control, the gathering of data in real-time from remote locations to control equipment and conditions. SCADA systems include hardware and software components. The hardware gathers and feeds data into a computer that has SCADA software installed, where it is then processed and presented in a timely manner. The evolution of SCADA is such that late-generation SCADA systems developed into first-generation IoT systems[4].

The concept of the IoT ecosystem, however, didn't really come into its own until the middle of 2010 when, in part, the government of China said it would make IoT a strategic priority in its five-year plan[4].

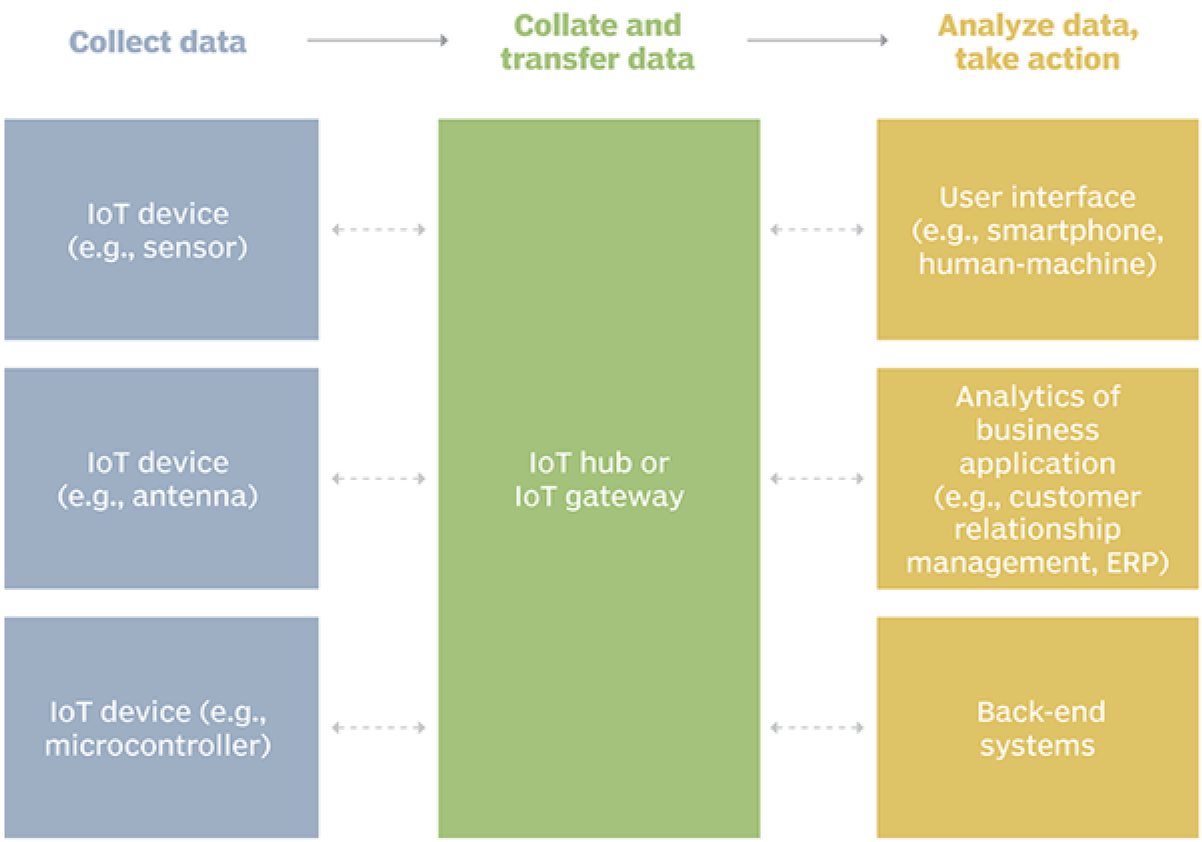
4.1.3 Advantages of IoT

The internet of things helps people live and work smarter as well as gain complete control over their lives. In addition to offering smart devices to automate homes, IoT is essential to business. IoT provides businesses with a real-time look into how their companies' systems really work, delivering insights into everything from the performance of machines to supply chain and logistics operations[4].

IoT enables companies to automate processes and reduce labor costs. It also cuts down on waste and improves service delivery, making it less expensive to manufacture and deliver goods as well as offering transparency into customer transactions[4].

IoT touches every industry, including healthcare, finance, retail, and manufacturing. Smart cities help citizens reduce waste and energy consumption and connected sensors are even used in farming to help monitor crop and cattle yields and predict growth patterns[4].

As such, IoT is one of the most important technologies of everyday life and it will continue to pick up steam as more businesses realize the potential of connected devices to keep them competitive[4].



F. Examples of an IoT system[4]

Benefits of IoT

The internet of things offers a number of benefits to organizations, enabling them to:

- Monitor their overall business processes;
- Improve the customer experience;
- Save time and money;
- Enhance employee productivity;
- Integrate and adapt business models;
- Make better business decisions; and
- Generate more revenue[4].

IoT encourages companies to rethink the ways they approach their businesses, industries, and markets and gives them the tools to improve their business strategies[4].

Pros and cons of IoT

Some of the advantages of IoT include:

- **Improved Customer Engagement: –** Current analytics suffer from blind-spots and significant flaws inaccuracy; and as noted, engagement remains passive. IoT completely transforms this to achieve richer and more effective engagement with audiences[5].

- **Technology Optimization: –** The same technologies and data which improve the customer experience also improve device use, and aid in more potent improvements to technology. IoT unlocks a world of critical functional and field data[5].

- **Reduced Waste**: – IoT makes areas of improvement clear. Current analytics give us superficial insight, but IoT provides real-world information leading to the more effective management of resources[5].

- **Enhanced Data Collection: –** Modern data collection suffers from its limitations and its design for passive use. IoT breaks it out of those spaces and places it exactly where humans really want to go to analyze our world. It allows an accurate picture of everything[5].

Some of the disadvantages of IoT include[4]:

- As the number of connected devices increases and more information is shared between devices, the potential that a hacker could steal confidential information also increases;

- Enterprises may eventually have to deal with massive numbers -- maybe even millions -- of IoT devices and collecting and managing the data from all those devices will be challenging.

- If there's a bug in the system, it's likely that every connected device will become corrupted;

- Since there's no international standard of compatibility for IoT, it's difficult for devices from different manufacturers to communicate with each other.

4.1.4 Challenges of IoT

There are key challenges and implications today that need to be addressed before the mass adoption of IoT can occur[6].

1.1 Privacy and Security

As the IoT becomes a key element of the Future Internet and the usage of the Internet of Things for large-scale, partially mission-critical systems create the need to address trust and security functions adequately. New challenges identified for privacy, trust, and reliability are:

- Providing trust and quality of-information in shared information models to enable re-use across many applications.
- Providing a secure exchange of data between IoT devices and consumers of their information.
- Providing protection mechanisms for vulnerable devices. Table 2 shows various security & privacy requirements at different layers of IoT.

IoT Layers Security requirements

Application	• Application-specific Data Minimization • Privacy Protection and Policy Management •Authentication •Authorization, Assurance •Application specific encryption, cryptography.
Services support	• Protected Data Management and Handling (Search, Aggregation, Correlation, Computation) • Cryptographic Data Storage • Secure Computation, In-network Data Processing, Data aggregation, Cloud Computing
Network layer	• Secure Sensor/Cloud Interaction; • Cross-domain Data Security Handling • Communication & Connectivity Security
Smart object/sensors	• Access Control to Nodes • Lightweight Encryption • Data Format and Structures • Trust Anchors and Attestation

T. The security requirements at a different layer of IOT[6]

2.1 Cost versus Usability

IoT uses technology to connect physical objects to the Internet. For IoT adoption to grow, the cost of components that are needed to support capabilities such as sensing, tracking, and control mechanisms need to be relatively inexpensive in the coming years[6].

3.1 Interoperability

In the traditional Internet, interoperability is the most basic core value; the first requirement of Internet connectivity is that “connected” systems be able to “talk the same language” of protocols and encodings. Different industries today use different standards to support their applications. With numerous sources of data and heterogeneous devices, the use of standard interfaces between these diverse entities becomes important. This is especially so for applications that support cross-organizational and various system boundaries. Thus the IoT systems need to handle a high degree of interoperability[6].

4.1 Data Management

Data management is a crucial aspect of the Internet of Things. When considering a world of objects interconnected and constantly exchanging all types of information, the volume of the generated data and the processes involved in the handling of those data become critical[6].

5.1 Device Level

Energy Issues One of the essential challenges in IoT is how to interconnect “things” in an interoperable way while taking into account the energy constraints, knowing that communication is the most energy-consuming task on devices[6].

4.2 How IoT works

An IoT ecosystem consists of web-enabled smart devices that use embedded processors, sensors and communication hardware to collect, send and act on data they acquire from their environments. IoT devices share the sensor data they collect by connecting to an IoT gateway or another edge device where data is either sent to the cloud to be analyzed or analyzed locally. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devices do most of the work without human intervention, although people can interact with the devices -- for instance, to set them up, give them instructions or access the data[4].

The connectivity, networking and communication protocols used with these web-enabled devices largely depend on the specific IoT applications deployed[4].

4.2.1 Architecture of IoT

According to most of the researcher’s opinions about conventional IoT architecture, it is considered as three layers: -

- Perception Layer
- Network Layer
- Application Layer[3]

In other aspects, some researchers analyzed one more layer which is also included in IoT’s latest architecture that is a support layer that lies between the application layer and network layer. The support layer consists of fog computing and cloud computing. Cloud computing is also the hottest topic today in research. The mostly finalized researchers’ view about IoT architecture is shown in the Figure below[3].

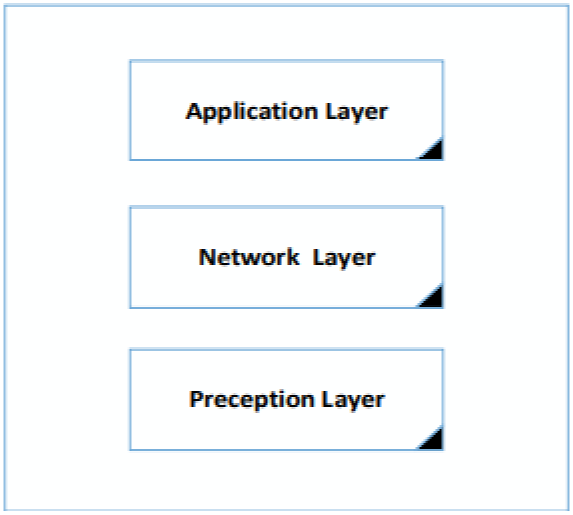
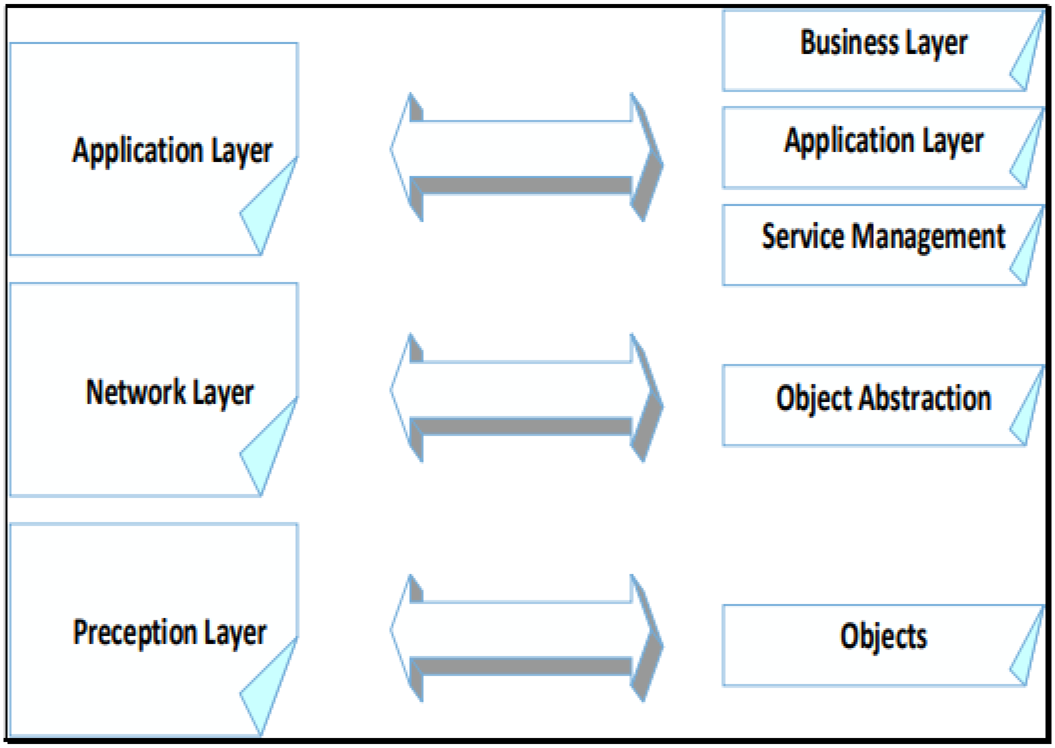


Fig IoT architecture[3]

The perception layer is also called the recognition layer. The perception layer is the lowest layer of the conventional architecture of IoT. This layer's main responsibility is to collect useful information/data from things or the environment (such as WSN, heterogeneous devices, sensors type real-world objects, humidity, and temperature, etc.) and transform them in a digital setup. The main purpose of objects is unique address identification and communication between short-range technologies such as RFID, Bluetooth, Near-Field Communication (NFC), 6LoWPAN (Low Power Personal Area Network)[3].

The Network layer is the brain of conventional IoT architecture. This layer's main responsibility is to help and secure data transmission between the application and perception layer of IoT architecture. This layer mainly collects information and delivers to the perception layer toward several applications and servers. Basically, this layer is a convergence of the internet and communication-based networks. According to a current study performed on several communication-based technologies, researchers concluded that the network layer is the most developed layer of conventional IoT architecture. It is the core layer (network layer) of IoT that is capable of advancing the information for relevant procedures. The data processing relevant tasks handled by IoT management. This layer also ensures unique addressing and routing abilities to the unified integration of uncountable devices in a single cooperative network. Various types of technologies are contributed to this phenomenon such as wired, wireless and satellite. The implementation of 6LoWPAN protocol towards IPV6 for unique addressing of devices IETF demonstrates a high degree of effort involved[3].

The application layer is considered as a top layer of conventional IoT architecture. This layer provides personalized based services according to user-relevant needs. This layer's main responsibility is to link the major gap between users and applications. This IoT layer combines the industry to attain high-level intelligent application type solutions such as disaster monitoring, health monitoring, transposition, fortune, medical and ecological environment and handled global management relevant to all intelligent type applications. According to the latest researchers' opinions about IoT architecture, these are five layers as shown in the Figure below[3].



F Enhanced Five Layer IoT architecture[3]

The above Figure shows the five layers that IoT architecture represents. The bottom layer of the IoT architecture perception layer represents an object layer. The object layer's main responsibility is to collect data from different heterogeneous category devices and then process and digitize the data. It also transfers the processed data into upper layers of IoT architecture. The middle layer of the conventional IoT architecture network layer represents an object abstraction layer. The object abstraction layer acts as a mediating layer between service management and the object layer. In object abstraction, RFID, WIFI and Third Generation (3G) communication technologies are used. The upper layer of IoT architecture, the application layer, is further divided into three sub-layers due to different functionalities. The service management layer's main responsibilities are facilitating information processing, decision-making, and control of pairing requestor information processing for relevant tasks. The application layer provides the customers with smart high-quality facilities according to the pre-request of the customers. The Business layer represents the business model and data that's been received from the application layer[3].

IoT architecture consists of different layers of technologies supporting IoT. It serves to illustrate how various technologies relate to each other and to communicate the scalability, modularity, and configuration of IoT deployments in different scenarios. The figure below shows the detailed architecture of the IoT. The functionality of each layer is described below [6].

1. Smart device/sensor layer: The lowest layer is made up of smart objects integrated with sensors. The sensors enable the interconnection of the physical and digital worlds allowing real-time information to be collected and processed. There are various types of sensors for different purposes. The sensors have the capacity to take measurements such as temperature, air quality, speed, humidity, pressure, flow, movement, and electricity, etc. In some cases, they may also have a degree of memory, enabling them to record a certain number of measurements. A sensor can measure the physical property and convert it into a signal that can be understood by an instrument. Sensors are grouped according to

their unique purpose such as environmental sensors, body sensors, home appliance sensors, and vehicle telematics sensors, etc[6].

Most sensors require connectivity to the sensor gateways. This can be in the form of a Local Area Network (LAN) such as Ethernet and Wi-Fi connections or Personal Area Network (PAN) such as ZigBee, Bluetooth, and Ultra-Wideband (UWB). For sensors that do not require connectivity to sensor aggregators, their connectivity to backend servers/applications can be provided using Wide Area Network (WAN) such as GSM, GPRS, and LTE. Sensors that use low power and low data rate connectivity, they typically form networks commonly known as wireless sensor networks (WSNs). WSNs are gaining popularity as they can accommodate far more sensor nodes while retaining adequate battery life and covering large areas[6].

Here is a list of some of the measurement devices used in IoT:

- accelerometers
- temperature sensors
- magnetometers
- proximity sensors
- gyroscopes
- image sensors
- acoustic sensors
- light sensors
- pressure sensors
- gas RFID sensors
- humidity sensors
- microflow sensors[5]

2. Gateways and Networks: Massive volume of data will be produced by these tiny sensors and this requires a robust and high performance wired or wireless network infrastructure as a transport medium. Current networks, often tied with very different protocols, have been used to support machine-to-machine (M2M) networks and their applications. With demand needed to serve a wider range of IoT services and applications such as high-speed transactional services, context-aware applications, etc, multiple networks with various technologies and access protocols are needed to work with each other in a heterogeneous configuration. These networks can be in the form of private, public or hybrid models and are built to support the communication requirements for latency, bandwidth or security. Various gateways (microcontroller, microprocessor...) & gateway networks (WI-FI, GSM, GPRS…)[6].

3. Management Service Layer: The management service renders the processing of information possible through analytics, security controls, process modeling and management of devices[6].

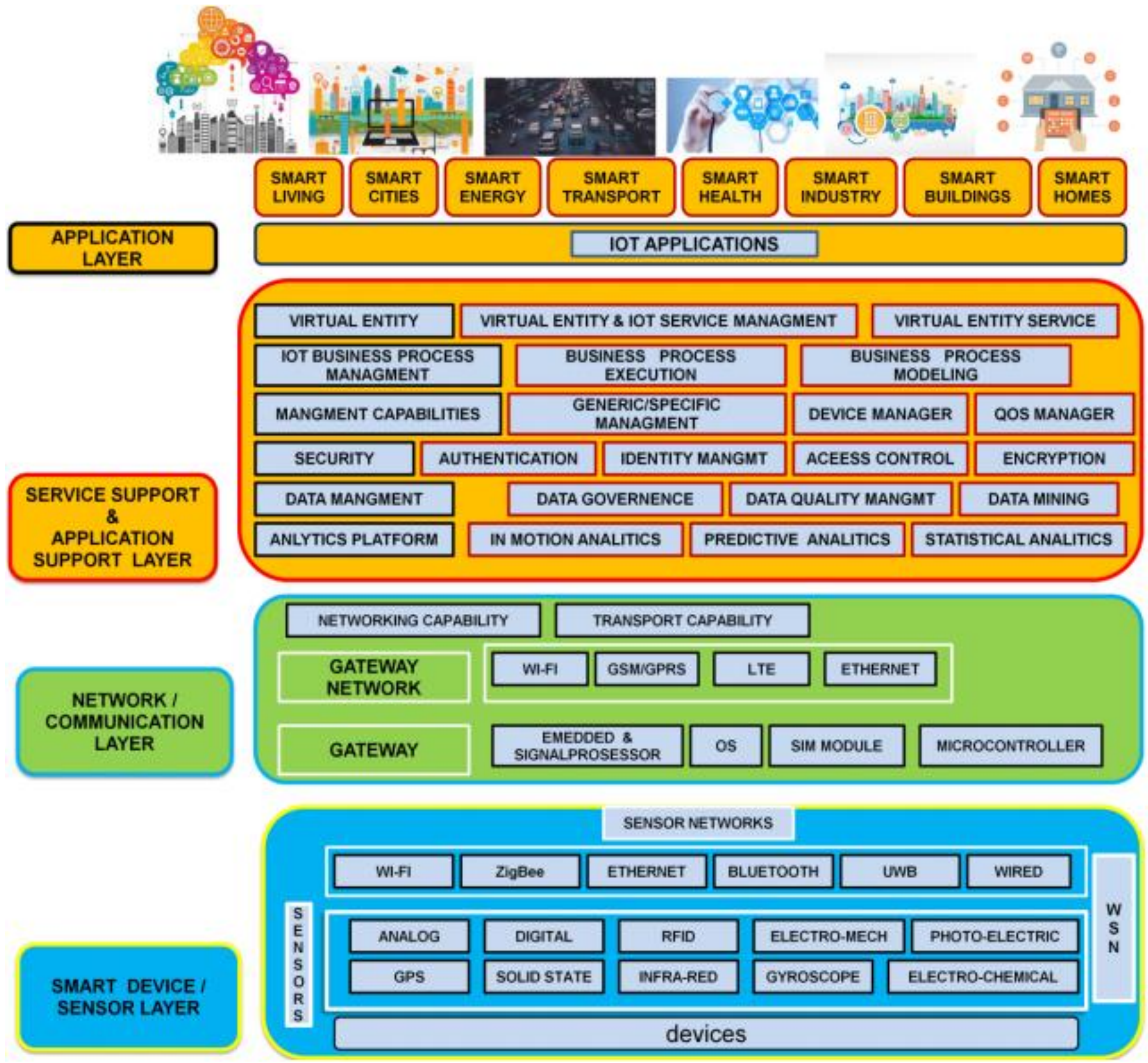
   One of the important features of the management service layer is the business and process rule engines. IoT brings connection and interaction of objects and systems together providing information in the form of events or contextual data such as the temperature of goods, current location and traffic data. Some of these events require filtering or routing to post-processing systems such as capturing periodic sensory data, while others require a response to immediate situations such as reacting to emergencies on patient's health conditions. The rule engines support the formulation of decision logic and trigger interactive and automated processes to enable a more responsive IOT system[6].

   In the area of analytics, various analytics tools are used to extract relevant information from a massive amount of raw data and to be processed at a much faster rate. Analytics such as in-memory analytics allows large volumes of data to be cached in random access memory (RAM) rather than stored in physical disks. In-memory analytics reduces data query time and augments the speed of decision making. Streaming analytics is another form of analytics where analysis of data, considered as data-in-motion, is required to be carried out in real-time so that decisions can be made in a matter of seconds[6].

Data management is the ability to manage data information flow. With data management in the management service layer, information can be accessed, integrated and controlled. Higher layer applications can be shielded from the need to process unnecessary data and reduce the risk of privacy disclosure of the data source. Data filtering techniques such as data anonymization, data integration, and data synchronization, are used to hide the details of the information while providing only essential information that is usable for the relevant applications. With the use of data abstraction, information can be extracted to provide a common business view of data to gain greater agility and reuse across domains[6].

Security must be enforced across the whole dimension of the IoT architecture right from the smart object layer all the way to the application layer. Security of the system prevents system hacking and compromises by unauthorized personnel, thus reducing the possibility of risks[6].

4. Application Layer: The IoT application covers "smart" environments/spaces in domains such as Transportation, Building, City, Lifestyle, Retail, Agriculture, Factory, Supply chain, Emergency, Healthcare, User interaction, Culture and Tourism, Environment and Energy[6].



F. IoT Architecture[6]

4.2.2. Devices and network

4.2.3 IoT trends

Since 2010, industry leaders have been predicting an explosion in the number of connected devices. These predictions have ranged from 50 billion by 2020 to 1 trillion by 2025! The latter forecast has obviously not materialized, but according to some estimates, we are not far from reaching 50 billion in the next three years. A wide range of fields that have been adopting IoT infrastructures includes connected and smart cities, manufacturing, energy and utilities, transport, logistics and even agriculture[7].

Unlike traditional data applications, IoT has no practical limit as to the number of devices deployed. There can only be so many PCs, laptops, mobile phones and tablets per person—how many gadgets can one person use at a time? However, the number of IoT devices is only limited by the scope of the applications themselves. For example[7]:

- An agriculturalist who owns 2,000 acres of land may have several sensors per acre to measure moisture, sunlight, and wind.
- A smart city may have several hundred sensors along each major road providing smart lighting, smart parking or to measure pedestrian and vehicular traffic.

Depending on the application, the number of connections will continue to increase at breakneck speeds. According to some experts, IoT devices are expected to exceed mobile phones as the largest category of connected devices sometime in 2018—growing at a compound annual growth rate of 23% [7].

As the amount of IoT devices grows, the underlying telecommunications networks that support and serve them must also adapt. Telecommunication infrastructures must be designed to accommodate the traffic they carry. Voice, video, and data each have particular characteristics and requirements for successful transmission over the network. IoT traffic differs significantly in its nature and thus has unique network requirements that must be taken into account when designing the network that will carry them[7].

IoT network requirements
Depending on the specific devices and applications involved, an IoT network may require:

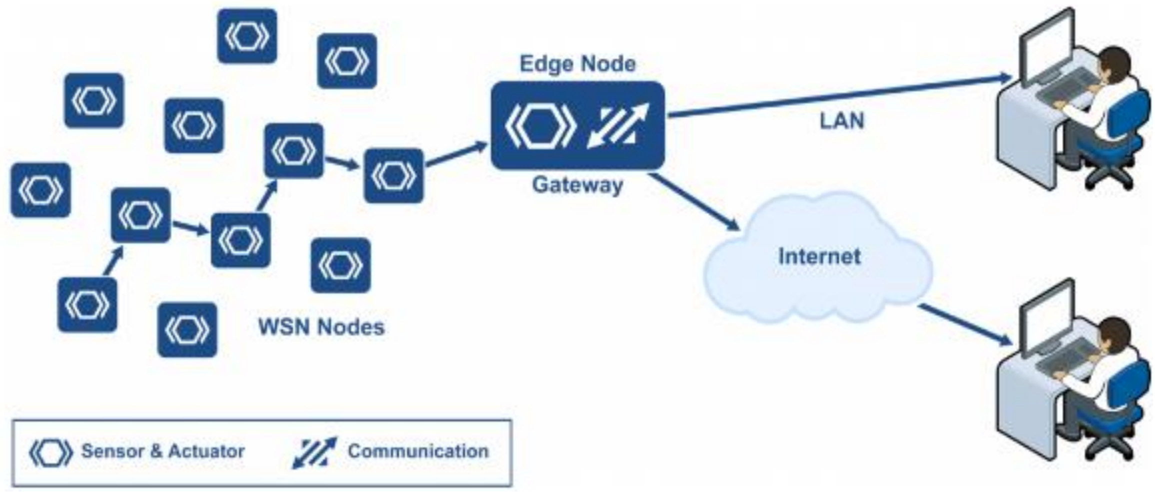
- The ability to connect large numbers of heterogeneous IoT elements
- High reliability
- Real-time awareness with low latency
- The ability to secure all traffic flows
- Programmability for application customization
- Traffic monitoring and management at the device level
- Low-cost connectivity for a large number of devices/sensors[8]

4.2.4 IoT networks

A. Your Local Network

Your choice of communication technology directly affects your device's hardware requirements and costs. And IoT devices are deployed in so many different ways — in clothing, houses, buildings, campuses, factories, and even in your body — that no single networking technology can fit all bills[2].

Let's take a factory as a typical case for an IoT system. A factory would need a large number of connected sensors and actuators scattered over a wide area, and wireless technology would be the best fit[2].



F. Wireless sensor network installed in a factory, connected to the Internet via a gateway[2]

A *wireless sensor network* (WSN) is a collection of distributed sensors that monitor physical or environmental conditions, such as temperature, sound, and pressure. Data from each sensor passes through the network node-to-node[2].

WSN Nodes

WSN nodes are low-cost devices, so they can be deployed in high volume. They also operate at low power so that they can run on battery, or even use *energy harvesting*. A WSN node is an embedded system that typically performs a single function (such as measuring temperature or pressure or turning on a light or a motor). Energy harvesting is a new technology that derives energy from external sources (for example, solar power, thermal energy, wind energy, electromagnetic radiation, kinetic energy, and more). The energy is captured and stored for use by small, low-power wireless autonomous devices, like the nodes on a WSN[2].

B. WSN Edge Nodes

A WSN edge node is a WSN node that includes Internet Protocol connectivity. It acts as a gateway between the WSN and the IP network. It can also perform local processing, provide local storage, and feature a user interface[2].

C. WSN Technologies

The battle over the preferred networking protocol is far from over. There are multiple candidates.

1. Wi-Fi

The first obvious networking technology candidate for an IoT device is Wi-Fi because it is so ubiquitous. Certainly, Wi-Fi can be a good solution for many applications. Almost every house that has an Internet connection has a Wi-Fi router[2].

However, Wi-Fi needs a fair amount of power. There are myriad devices that can't afford that level of power: battery-operated devices, for example, or sensors positioned in locations that are difficult to power from the grid[2].

2. Low-Power Solutions

The newest networking technologies allow for low-cost, low-power solutions. These technologies support the creation of very large networks of very small intelligent devices.

Currently, major R&D efforts include[2]:

- Low-power and efficient radios, allowing several years of battery life
- Energy harvesting as a power source for IoT devices
- Mesh networking for unattended long-term operation without human intervention (for example, M2M networks)
- New application protocols and data formats that enable autonomous operation

For example, EnOcean has patented an energy-harvesting wireless technology to meet the power consumption challenge. EnOcean's wireless transmitters work in the frequencies of 868 MHz for Europe and 315 MHz for North America. The transmission range is up to 30 meters in buildings and up to 300 meters outdoors[2].

3. IEEE 802.15.4

One of the major IoT enablers is the IEEE 802.15.4 radio standard, released in 2003. Commercial radios meeting this standard provide the basis for low-power systems. This IEEE standard was extended and improved in 2006 and 2011 with the 15.4e and 15.4g amendments. Power consumption of commercial RF devices is now cut in half compared to only a few years ago, and we are expecting another 50% reduction with the next generation of devices[2].

4. 6LoWPAN

Devices that take advantage of energy-harvesting must perform their tasks in the shortest time possible, which means that their transmitted messages must be as small as possible. This requirement has implications for protocol design. And it is one of the reasons why 6LoWPAN (short for *IPv6 over Low power Wireless Personal Area Networks*) has been adopted by ARM (Sensinode) and Cisco (ArchRock). 6LoWPAN provides encapsulation and header compression mechanisms that allow for briefer transmission times[2].

Standard	**IEE 802.15.4**	**Bluetooth**	**Wi-Fi**
Frequency	868/915 MHZ, 2.4 GHz	2.4 GHz	2.4, 5.8 GHz
Data rate	250 Kpbs	723 Kpbs	11 to 105 Mpbs
Data rate	250 Kpbs	723 Kpbs	11 to 105 Mpbs
Power	Very Low	Low	High

Battery Operation	Alkaline (months to years)	Rechargeable (days to weeks)	Rechargeable (hours)

T. Wireless radio technologies

There are many wireless networks available that are specialized for various industries. The following is a brief list:

6LoWPAN	DASH7	Wireless M-Bus
ANT	ISA100	Z-Wave
Bluetooth	Wireless HART	Zigbee and Zigbee IP

F. wireless networks[2]

Any protocol that carries IP packets has an advantage over all others. The connectivity requirements for IoT devices are so diverse that a single technology cannot meet all the range, power, size and cost requirements. Nonetheless, we believe that 6LoWPAN will be the choice for WSNs and light IP-based protocols[2].

D. IPv6 is Key for IoT

If your IoT network is local and M2M-only, then the wireless protocols discussed above are all good candidates. But if your goal is to remotely control devices or otherwise transmit data over the Internet, then you need IPv6[2].

The usefulness of IoT devices resides not only in local communication but also in global communication. If at all possible, it is crucial that your IoT networks (LANs, PANs, and BANs) all make use of the suite of Internet Protocols (IP, UDP, TCP, SSL, HTTP, and so on). A stable server is also required – ITT Systems has a list of free Servers you can download – which will ensure your project runs smoothly across all platforms. Furthermore, your networks must support *Internet Protocol version 6*, as the current IPv4 standard faces a global addressing shortage, as well as limited support for multicast, and poor global mobility[2].

IPv6's addressing scheme provides more addresses than there are grains of sand on earth — some have calculated that it could be as high as 10^{30} addresses *per person* (compare that number to the fact that there are 10^{28} atoms in a human body)! With IPv6, it is much simpler for an IoT device to obtain a global IP address, which enables efficient peer-to-peer communication[2].

The importance of IP to the Internet of Things does not automatically mean that non-IP networks are useless. It just means that non-IP networks require a gateway to reach the Internet[2].

Referring back to the illustration at the top of the page, you can see clearly that your local network is only one part of the Internet of Things. 6LowPAN, because it carries an IPv6 address with a compressed header, offers Internet connectivity without too much additional overhead. 6LoWPAN has also an advantage over other personal area networks because peer-to-peer communication is simpler to implement when each device has a global address[2].

4.2.5 IoT device examples and applications

Connected devices are part of a scenario in which every device talks to other related devices in an environment to automate home and industrial tasks, and to communicate usable sensor data to users, businesses and other interested parties. IoT devices are meant to work in concert for people at home, in industry or in the enterprise. As such, the devices can be categorized into three main groups: consumer, enterprise and industrial[9].

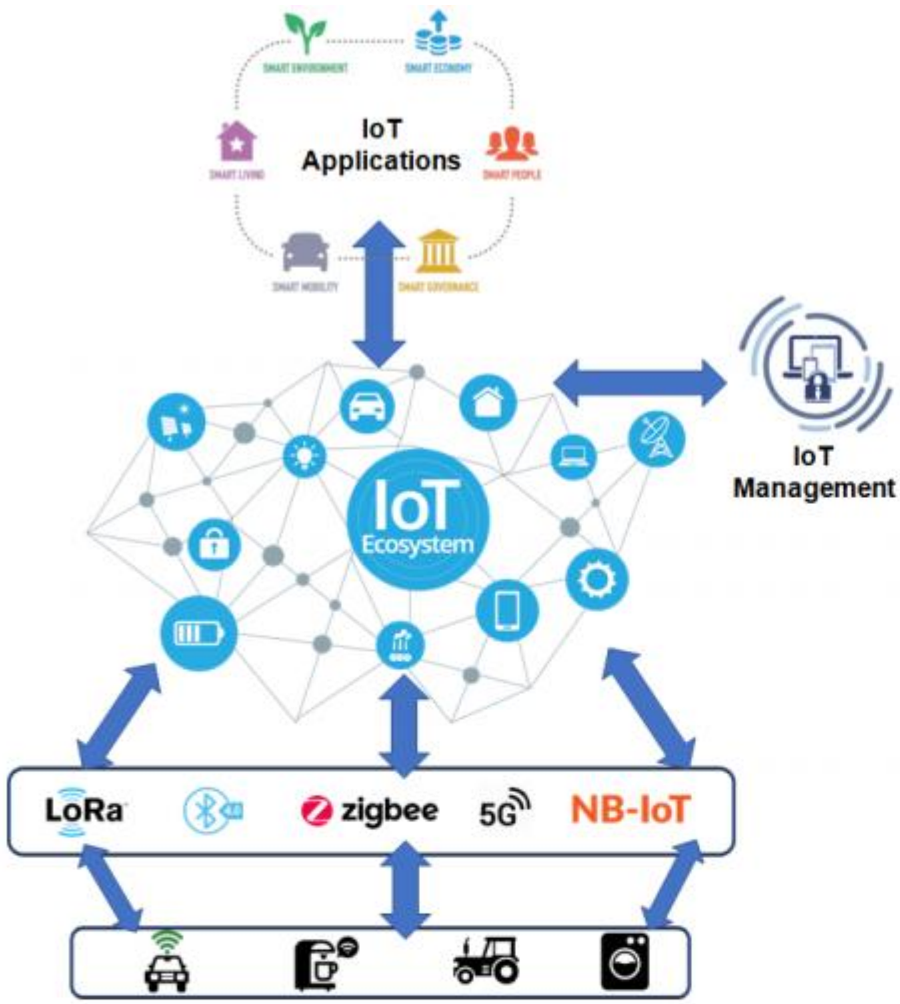
Consumer connected devices include smart TVs, smart speakers, toys, wearables, and smart appliances. Smart meters, commercial security systems and smart city technologies -- such as those used to monitor traffic and weather conditions -- are examples of industrial and enterprise IoT devices. Other technologies, including smart air conditioning, smart thermostats, smart lighting, and smart security, span home, enterprise and industrial uses[9].

In a smart home, for example, a user arrives home and his car communicates with the garage to open the door. Once inside, the thermostat is already adjusted to his preferred temperature, and the lighting is set to a lower intensity and his chosen color for relaxation, as his pacemaker data indicates it has been a stressful day[9].

In the enterprise, smart sensors located in a conference room can help an employee locate and schedule an available room for a meeting, ensuring the proper room type, size and features are available. When meeting attendees enter the room, the temperature will adjust according to the occupancy, and the lights will dim as the appropriate PowerPoint loads on the screen and the speaker begins his presentation[9].

4.2.6 A Networks and Devices Management Platform for the Internet of Things

IoT refers to a new generation of the Internet to devices of the physical world (vehicles, embedded devices, home appliances [1]), virtual objects (including virtual currency), and the integrating of embedded computing and communication systems. In other words, the IoT infrastructure enables services to interconnect devices with existing communication Technologies offering a solution for these devices interoperability. The figure below shows a simplified representation of an IoT network. It encompasses end devices, gateways, communication links, IoT applications, and services. A typical scenario involving those entities include end devices collecting data from an environment (e.g., temperature, luminosity, movement) and reporting it to a supervision entity (hosted by an IoT platform and service provider) via different communication technologies and gateways. IoT applications generate many research challenges and business opportunities. It contributes to attracting the attention of the community including the academy, industry, and government[10].



F. Illustration of an IoT Scenario

Moreover, an IoT network typically includes a number of devices with constrained resources (power, processing, memory, among others) and some of those devices may be massively deployed over large areas like smart cities, industrial plants, whereas others may be deployed in hard-to-reach areas like pipelines hazardous zones, or even in hostile environments like war zones. Therefore, the efficient management of IoT networks requires considering both the constraints of low power IoT devices and the deployment complexity of the underlying communication infrastructure. IoT landscape is depicted by an increasing number of connected devices characterized by their heterogeneity and the presence of resources constrained networks. To ensure the correct functioning of those connected devices, they must be remotely accessed to configure, monitoring their status, and so forth. Traditional management solutions cannot be used for low power devices networks given their resources limitation and scalability issues. Therefore, efficient and autonomic management of IoT networks is needed. Developing an IoT network management solution is not an easy task because of the intrinsic constraints of IoT networks (architecture, technologies, physical layer)[10].

Indeed, it is necessary to take into account several elements such as scalability, interoperability, energy efficiency, topology control, Quality of Service (QoS), fault tolerance, and security [4]. The security, context-aware, and the standard model of messages still in an early stage and should be resolved in a new management platform. Therefore, this work proposes a platform for IoT networks and devices management, called M4DN.IoT (Management for Device and Network in the Internet of Things). This solution integrates and controls the individual functionalities of the devices in an IoT network as well as the status and characteristics of this network. M4DN. IoT defines a management structure in two scopes: local management, where the platform runs in the same environment as the devices, and remote management, where the platform controls the devices in different networks[10].

The structure of the platform is expandable, allowing the addition of new types of network devices or applications. In addition, the platform provides standard web services, such as device discovery, data storage, and user authorities, which are basic requirements for creating IoT applications[10].

The detail of Management for Device and Network in the Internet of Things (M4DN.IoT) is out of the scope of this module

4.3 Applications of IoT

There are numerous real-world applications of the internet of things, ranging from consumer IoT and enterprise IoT to manufacturing and industrial IoT (IIoT). IoT applications span numerous verticals, including automotive, telecom and energy[4].

In the consumer segment, for example, smart homes that are equipped with smart thermostats, smart appliances, and connected heating, lighting and electronic devices can be controlled remotely via computers and smartphones[4].

Wearable devices with sensors and software can collect and analyze user data, sending messages to other technologies about users with the aim of making users' lives easier and more comfortable. Wearable devices are also used for public safety -- for example, improving first responders' response times during emergencies by providing optimized routes to a location or by tracking construction workers' or firefighters' vital signs at life-threatening sites[4].

In healthcare, IoT offers many benefits, including the ability to monitor patients more closely to use the data that's generated and analyze it. Hospitals often use IoT systems to complete tasks such as inventory management, for both pharmaceuticals and medical instruments[4].

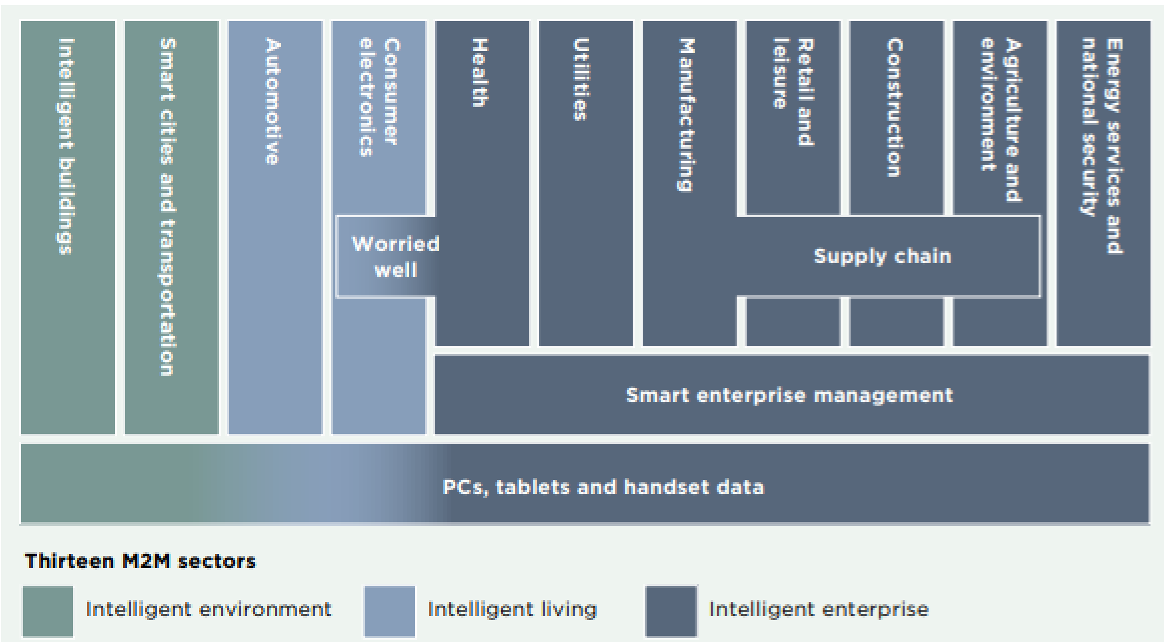
Smart buildings can, for instance, reduce energy costs using sensors that detect how many occupants are in a room. The temperature can adjust automatically -- for example, turning the air conditioner on if sensors detect a conference room is full or turning the heat down if everyone in the office has gone home[4].

In agriculture, IoT-based smart farming systems can help monitor, for instance, light, temperature, humidity and soil moisture of crop fields using connected sensors. IoT is also instrumental in automating irrigation systems[4].

In a smart city, IoT sensors and deployments, such as smart streetlights and smart meters, can help alleviate traffic, conserve energy, monitor and address environmental concerns and improve sanitation[4].

The Internet of Things can enable the next wave of life-enhancing services across several fundamental sectors of the economy[4].

As the Internet of Things evolves, the proliferation of smart connected devices supported by mobile networks, providing pervasive and seamless connectivity, will unlock opportunities to provide life-enhancing services for consumers while boosting productivity for enterprises. As can be seen in Figure below, thirteen industry sectors are likely to show significant adoption of IoT services[11]:



F. Internet of Things industry sector categories[11]

4.3.1 Smart home

Smart Home technology is the future of residential related technology which is designed to deliver and distribute a number of services inside and outside the house via networked devices in which all the different applications & the intelligence behind them are integrated and interconnected. These smart devices have the potential to share information with each other given the permanent availability to access the broadband internet connection. Hence, Smart Home Technology has become part of IoT (Internet of Things)[12].

Smart Home initiative allows subscribers to remotely manage and monitor different home devices from anywhere via smartphones or over the web with no physical distance limitations. With the ongoing development of mass-deployed broadband internet connectivity and wireless technology, the concept of a Smart Home has become a reality where all devices are integrated and interconnected via the wireless network. These “smart” devices have the potential to share information with each other given the permanent availability to access the broadband internet connection. Hence, Smart Home Technology has become part of the Internet of Things (IoT)[12].

Remote Control Appliances: Switching on and off remotely appliances to avoid accidents and save energy, Weather: Displays outdoor weather conditions such as humidity, temperature, pressure, wind speed and rain levels with ability to transmit data over long distances, Smart Home Appliances: Refrigerators with LCD screen telling what’s inside, food that’s about to expire, ingredients you need to buy and with all the information available on a smartphone app. Washing machines allowing you to monitor the laundry remotely, and. Kitchen ranges with interface to a Smartphone app allowing remotely adjustable temperature control and monitoring the oven’s self-cleaning feature, Safety Monitoring: cameras, and home alarm systems making people feel safe in their daily life at home, Intrusion Detection Systems: Detection of window and door openings and violations to prevent intruders, Energy and Water Use: Energy and water supply consumption monitoring to obtain advice on how to save cost and resources, & many more…[6]

For consumers, the connectivity provided by the IoT could enhance their quality of life in multiple ways, such as, but not limited to, energy efficiency and security at home and in the city. In the home, the integration of connected smart devices and cloud-based services will help address the pressing issue of energy efficiency and security. Connected smart devices will enable a reduction in utility bills and outages, while also improving home security via remote monitoring[11].

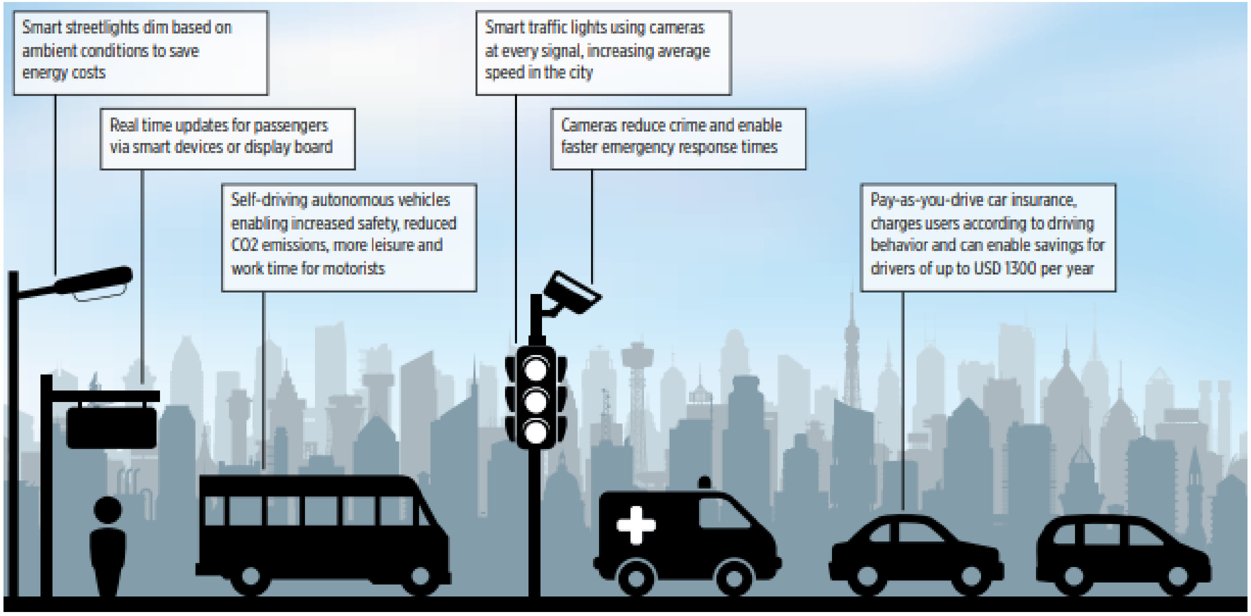
4.3.2 Smart grid

Energy consumption monitoring and management, Wind Turbines/ Powerhouse: Monitoring and analyzing the flow of energy from wind turbines & powerhouse, and two-way communication with consumers’ smart meters to analyze consumption patterns, Power Supply Controllers: Controller for AC-DC power supplies that determines required energy, and improve energy efficiency with less energy waste for power supplies related to computers, telecommunications, and consumer electronics applications, Photovoltaic Installations: Monitoring and optimization of performance in solar energy plants[6].

4.3.3 Smart city

Structural Health: Monitoring of vibrations and material conditions in buildings, bridges and historical monuments, Lightning: intelligent and weather adaptive lighting in street lights, Safety: Digital video monitoring, fire control management, public announcement systems, Transportation: Smart Roads and Intelligent High-ways with warning messages and diversions according to climate conditions and unexpected events like accidents or traffic jams, Smart Parking: Real-time monitoring of parking spaces availability in the city making residents able to identify and reserve the closest available spaces, Waste Management: Detection of rubbish levels in containers to optimize the trash collection routes. Garbage cans and recycle bins with RFID tags allow the sanitation staff to see when garbage has been put out[6].

In cities, the development of smart grids, data analytics, and autonomous vehicles will provide an intelligent platform to deliver innovations in energy management, traffic management, and security, sharing the benefits of this technology throughout society[11].



F. Example IoT smart cities applications[11]

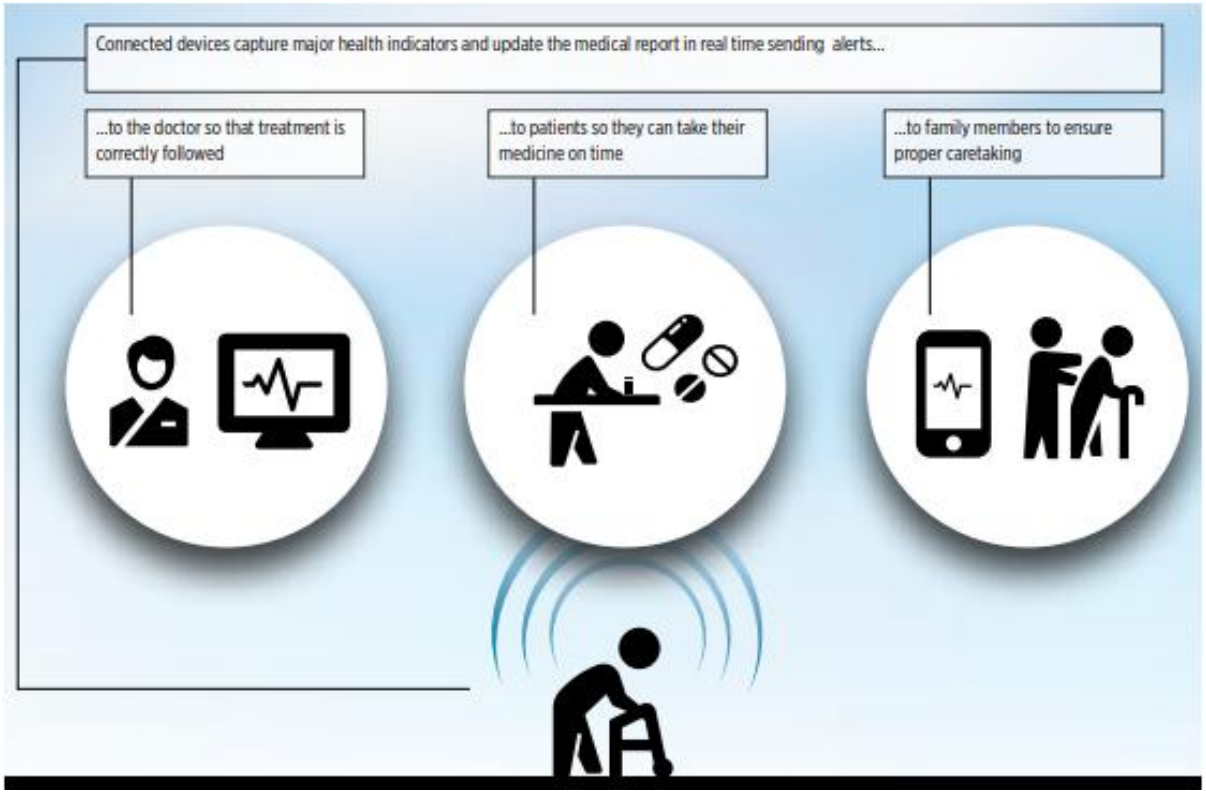
The IoT will also help widen access and improve the quality of education and health. As demand for healthcare doubles8, connected smart devices will help address this challenge by supporting a range of e-health services that improve access and enable monitoring of chronic diseases and age-related conditions in the home. In doing so, they will improve the quality of care and quality of life for patients, while reducing the strain on the wider healthcare system[11].

4.3.4 Wearable devices

Wearable electronic devices are small devices worn on the head, neck, arms, torso, and feet.

Current smart wearable devices include:

- Head – Helmets, glasses
- Neck – Jewelry, collars
- Arm – Watches, wristbands, rings
- Torso – Clothing, backpacks
- Feet – Socks, shoes[5]



F. Example IoT health applications[11]

A wearable sensor network system for the Internet of Things (IoT) connected safety and health applications. Safety and health of workers are important for the industrial workplace; therefore, an IoT network system that can monitor both environmental and physiological can greatly improve safety in the workplace. Multiple wearable sensors can monitor environmental and physiological parameters. The wearable sensors on different subjects can communicate with each other and transmit the data to a gateway via a network that forms a heterogeneous IoT platform with Bluetooth-based medical signal sensing network. Once harmful environments are detected and, the sensor node will provide an effective notification and warning mechanism for the users. A smart IoT gateway is implemented to provide data processing, local web server, and cloud connection. After the gateway receives the data from wearable sensors, it will forward the data to an IoT cloud for further data storage, processing and visualization[13].

4.3.5 Smart farming

Green Houses: Control micro-climate conditions to maximize the production of fruits and vegetables and its quality, Compost: Control of humidity and temperature levels in alfalfa, hay, straw, etc. to prevent fungus and other microbial contaminants, Animal Farming/Tracking: Location and identification of animals grazing in open pastures or location in big stables, Study of ventilation and air quality in farms and detection of harmful gases from excrements, Offspring Care: Control of growing conditions of the offspring in animal farms to ensure its survival and health, field Monitoring: Reducing spoilage and crop waste with better monitoring, accurate ongoing data obtaining, and management of the agriculture fields, including better control of fertilizing, electricity and watering[6].

4.4 IoT platforms and development tools

4.4.1 IoT platforms

IoT platform is an essential component of a huge IoT ecosystem that supports and connects all components within the system. It helps to facilitate device management, handle hardware/software communication protocols, collect/analyze data, enhance data flow and functionality of smart applications[14].
The overall IoT system includes[14]:

- hardware (devices and sensors)
- connectivity through a router, gateway, wi-fi, satellite, Ethernet, etc.
- software
- user interface

Despite a vast variety of articles and tutorials on both commercial and open-source IoT platforms, people still wonder how IoT solution works. To keep it short and simple, an IoT solution has devices or sensors which collect data and transfer it to the cloud using some kind of hardware/software communication protocols. As soon as the data is delivered, the software performs its processing and then carries out an action — adjusts devices or sensors automatically or sends an alert. The user interface is leveraged in those cases when a user needs to check-in or their input is required to continue the work[14].

Types of Internet of Things Platforms[15]**:**

- End to end
- Connectivity
- Cloud
- Data

Cloud hosting has become a wide-spread and generally appreciated method of developing and running various technology solutions, and here IoT, directly depending on Internet, definitely benefits from all the advantages of **cloud computing**. Special cloud-based IoT platforms support the Internet-based functions of the application – running, maintenance, analytics, data storage, and security measures[14].

The criteria for choosing the platform may be as follows[14]:

- **Price and pricing model.** Some platforms use the pay-as-you-go model where you are charged for the resources you actually consume (like AWS IoT Core), while others use the subscription model billing a flat fee per month (like Salesforce). Depending on your project specifics, choose the pricing concept that suits you best.
- **Availability of a free tier.** This is a great option for cases when you need to test your idea and need an opportunity to run a simple project with a minimum investment. AWS offers a free tier option with certain restrictions, while Oracle has no free option, being rather pricey on the top of it.
- **The development team experience.** This is the sure-fire way of choosing the tools and services for development. Ask the development team about their experience and knowledge of available options and make your selection by balancing the project requirements and the team expertise.

Below are some IoT platforms[14]

- Google Cloud IoT
- Microsoft Azure IoT Suite
- SAP
- Salesforce IoT
- Oracle Internet of Things
- Cisco IoT Cloud Connect
- Bosch IoT Suite
- IBM Watson Internet of Things
- ThingWorx IoT Platform

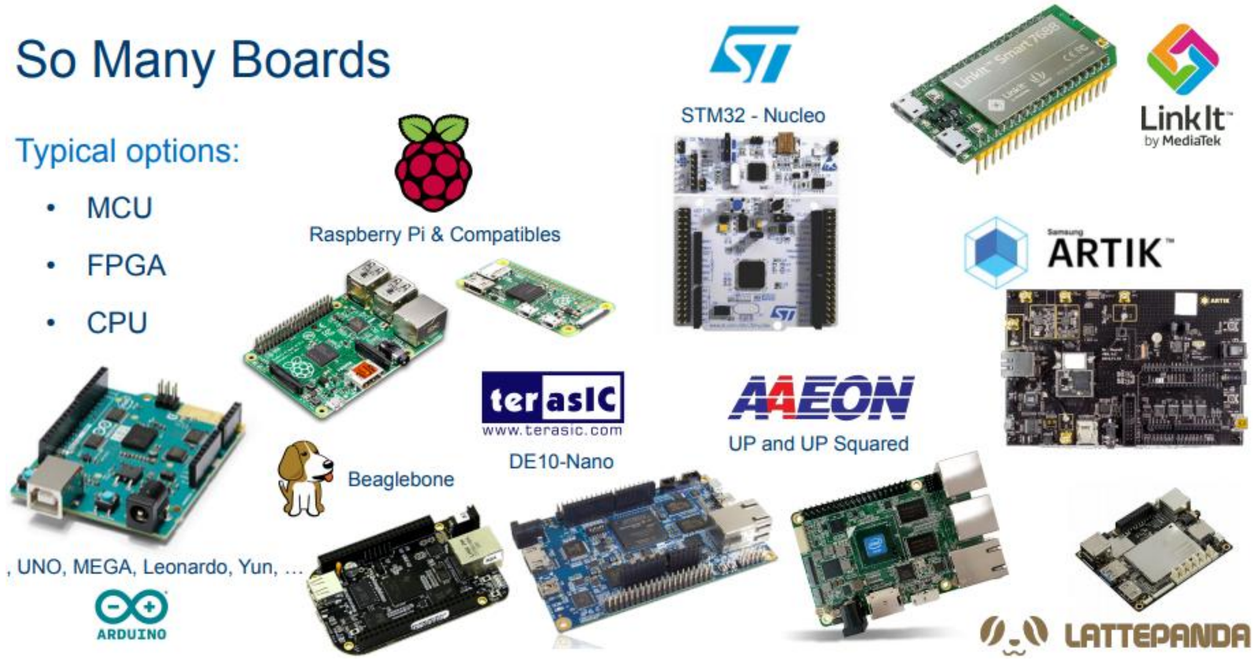
4.4.2 IoT development tools

IoT is the latest buzzword that is doing rounds in the internet-driven space. Going by the numbers, in 2015, there were 15.41 billion IoT connected devices which have now grown to 26.66 billion and it is expected to surpass 75 billion devices by 2025. The majority of these devices are used in the healthcare industry or business/corporates and manufacturing industry[16].

Moreover, to fuel this progressive trend, a host of Internet of Things solution providers are busy creating software and hardware designs that will help developers come up with novel IoT applications and devices[16].

Here are the top-class IoT development tools that can be employed by both developers and for all those who wish to pursue IoT as a DIY hobby[16].

Tessel 2	Raspbian
Eclipse IoT	OpenSCADA
Arduino	Node-RED
PlatformIO	Kimono Create
IBM Watson	Device Hive



F. IoT hardware platforms

5. AUGMENTED REALITY

5.1 Introduction to AR

Augmented Reality (AR) is a general term for a collection of technologies used to blend computer-generated information with the viewer's natural senses[17].

F. AR example with virtual chairs and a virtual lamp[18]

Why is AR (Augmented Reality) an interesting topic? AR is interesting since it allows the user to experience the real world with virtual objects in it. Namely, seeing and handling virtual objects in the real world makes AR attractive and such a concept may offer diverse possibilities for many applications. Despite such attractiveness of AR, the realism of virtual objects has not come close to the user's expectation, which is thought of as a negative aspect of AR. Therefore, AR research has focused on achieving the realism of virtual objects to make the user feel more immersed in the AR world[19].

The realism of a virtual object can be considered from the two different standpoints: appearance and behavior. Using a rendering method such as Photon mapping, an augmented object can be made to have a realistic appearance. On the other hand, using a physical law, the motion of a virtual object can be simulated in a physically correct manner[19].

The goal of Augmented Reality (AR) is to improve and enhance our perception of the surroundings by combining sensing, computing and display technologies[20].

Most AR research addresses human vision, as it is generally considered to be our most important sense. Visual systems are also the focus in this overview, but it is worth noting that other stimuli, such as feedback from auditory, tactile or olfactory displays, may be equally or even more important, depending on the specific scenario and individual[20].

The characteristics of these systems can be further understood from three classical and widely used criteria for AR systems[20]:

1. "Combines virtual and real" AR requires display technology that allows the user to simultaneously see virtual and real information in a combined view. Traditional displays can show only computer-generated images and are thus insufficient for AR.
2. "Registered in 3-D" AR relies on an intimate coupling between the virtual and the real that is based on their geometrical relationship. This makes it possible to render the virtual content with the right placement and 3D perspective with respect to the real.
3. "Interactive in real-time" The AR system must run at interactive frame rates, such that it can superimpose information in real-time and allow user interaction.

The fundamental idea of AR is to combine, or mix, the view of the real environment with additional, virtual content that is presented through computer graphics. Its convincing effect is achieved by ensuring that the virtual content is aligned and registered with the real objects. As a person moves in an environment and their perspective view of real objects changes, the virtual content should also be presented from the same perspective [20].

The Reality-Virtuality Continuum spans the space between reality, where everything is physical, and virtual reality, where virtual and synthesized computer graphics replace the physical surroundings. Mixed reality is located between them, and includes AR and augmented virtuality[20].

AR adds virtual content to a predominantly real environment, whereas augmented virtuality adds real content to a predominantly virtual environment. Although both AR and augmented virtuality are subsets of mixed reality by definition, most of the research in the area focuses on AR, and this term is therefore often used interchangeably with mixed reality[20].

AR techniques exploit the spatial relationships between the user, the digital information, and the real environment, to enable intuitive and interactive presentations of data. An AR system can, for example, achieve the medical see-through vision, by using a special display in which the images displayed by the computer are seen overlaid on the patient, as shown in Figure 1 and Figure 2[20].

F. The Sonic Flashlight uses a see-through display to overlay real-time ultrasound images over a patient's body parts[20]

F. The visualization of a 3D ultrasound scan is registered with a pregnant woman's body, to allow the physician to "look into the body" for a view of the fetus[20]

Such configurations rely on the proper acquisition and registration of internal medical imagery for the relevant perspective, and careful calibration to establish the geometrical relationship between the display, the viewer, and the patient, to ensure that the correct image is accurately presented[20].

5.2 Virtual reality (VR), Augmented Reality (AR) vs mixed reality (MR)

5.2.1 WHAT IS VR, AR, AND MR?

Virtual Reality (VR) encompasses immersive experiences and content via a **VR headset or HMD (head-mounted display)**. The content is 100% digital and computer-generated. The current reality is replaced with a new 3D digital environment in which the **user is isolated from the real world**[21]**.**

- Some VR headsets manufacturers **i**nclude technology giants such as Facebook (through their acquisition of Oculus), Google (with a series of Daydream headsets), HTC (VIVE), Samsung (Gear VR), and Windows (who have named their range of devices Windows Mixed Reality, even though a number is VR-only enabled.)[21]
- There are three types of VR devices available these are tethered, stand-alone, and smartphone VR[21]. **<u>Discuss the technology, pros, and cons of the above headsets. And give some example</u>**

Augmented reality (AR) overlays computer-generated content on top of the real world. This superimposed digital overlay can superficially interact with the environment in real-time**.** AR is primarily experienced via a wearable glass device or through smartphone applications[21].

- Augmented content doesn't recognize or interact with the physical objects within a real-world environment, however, it does enhance the user's experience[21].

- Augmented reality is believed to have some of the biggest potential for mass consumption compared to virtual reality or mixed reality. It can be delivered on hardware that we already own and use (smartphones)[21].
- Some of the categories of AR products are wearable AR glass (smart glass), smartphone AR and other AR headsets[21].

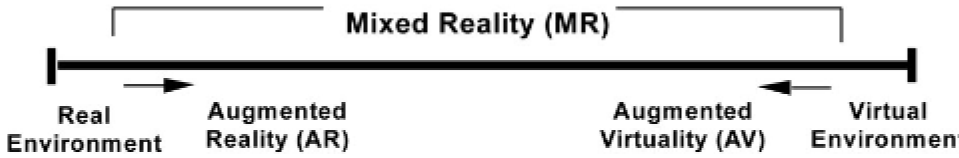
<u>Discuss the technology, pros, and cons of the above headsets. And give some example</u>

Mixed reality (MR) combines several technologies into one wearable device. Immersive media, spatial computing, and hybrid reality intertwine digital content while interacting with a user's real-world environment**.** This allows for digital content to integrate, enrich and interact with the user's real-world environment.MR lenses or headsets present an overlay of digital content that interacts with objects in the real world in real-time. The products are, in most cases, in the research and development phase, but MR is viewed through transparent wearable glasses[21].

- Mixed Reality removes the boundaries between real and virtual worlds using occlusion: the computer-generated objects can be visibly obscured by objects in the physical environment from the user's point of view[21].
- Some of MR products are Microsoft's hololens, magic leaps and other MR devices[21].

5.2.2 WHAT ARE THE DIFFERENCES BETWEEN VR, AR, AND MR?

- **Virtual Reality:** VR is content which is 100% digital and can be enjoyed in a fully immersive environment[21].
- **Augmented Reality:** AR overlays digital content on top of the real-world[21].
- **Mixed Reality:** MR is a digital overlay that allows interactive virtual elements to integrate and interact with the real-world environment[21].



F.Reality-virtuality continuum

AR has an almost infinite number of potential applications and it offers practical daily uses that have the ability to change the way people live and interact. Furthermore, AR is considered less restrictive than VR and doesn't disengage a user from the real world[22].

AR is a variation of the more known concept of Virtual Reality Technology (VR), which is often defined as "the use of real-time digital computers and other special hardware and software to generate a simulation of an alternate world or environment, which is believable as real or true by the users". VR technology creates an environment in which the user feels and seems to be moving inside a computer-created virtual world in the same way people move inside the natural environment; while immersed in the virtual world, the user cannot perceive the real one which still surrounds him. On the contrary, AR allows the user to see the real world, augmenting it with superimposed virtual objects. In other words, while VR replaces reality, AR supplements it, creating an environment in which real and virtual objects harmonically coexist. AR exploits users' perceptual-motor skills in the real world, creating a special type of human-machine interaction[23].

In telepresence, the fundamental purpose is to extend the operator's sensory-motor facilities and problem-solving abilities to a remote environment. In this sense, telepresence can be defined as a human/machine system in which the human operator receives sufficient information about the teleoperator and the task environment, displayed in a sufficiently natural way, that the operator feels physically present at the remote site. Very similar to virtual reality, in which we aim to achieve the illusion of presence within a computer simulation, telepresence aims to achieve the illusion of presence at a remote location[18].

AR can be considered a technology between VR and telepresence. While in VR the environment is completely synthetic and in telepresence it is completely real, in AR the user sees the real world augmented with virtual objects[18].

5.3 The architecture of AR systems.

5.3.1 AR Components

1. Scene Generator

The scene generator is the device or software responsible for rendering the scene. Rendering is not currently one of the major problems in AR, because a few virtual objects need to be drawn, and they often do not necessarily have to be realistically rendered in order to serve the purposes of the application[18].

2. Tracking System

The tracking system is one of the most important problems in AR systems mostly because of the registration problem. The objects in the real and virtual worlds must be properly aligned with respect to each other, or the illusion that the two worlds coexist will be compromised. For the industry, many applications demand accurate registration, especially on medical systems[18].

3. Display

A fundamental characteristic of AR systems is that they allow the user to see a combined view of virtual imagery and real objects[20].

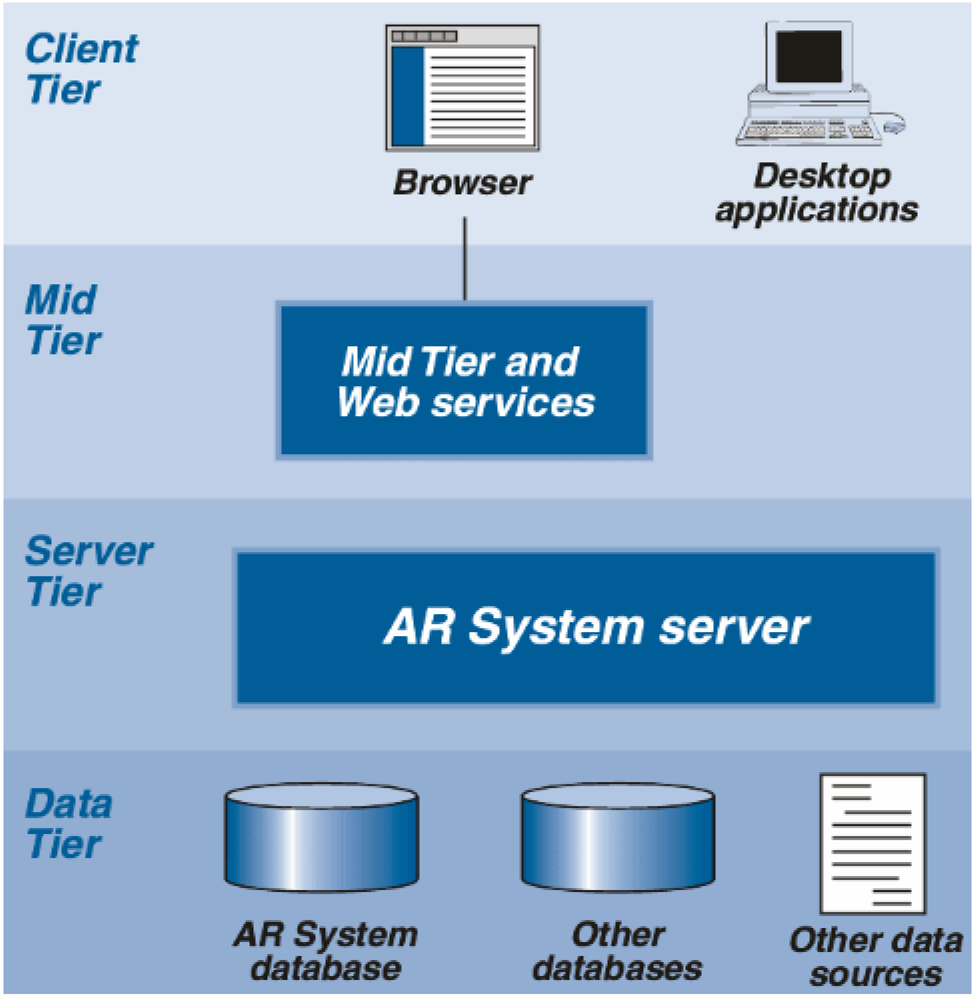
The technology for AR is still in development and solutions depend on design decisions. Most of the Displays devices for AR are HMD (Head Mounted Display), but other solutions can be found (see the next section).

When combining the real and virtual world two basic choices are available: optical and video technology. Each of them has some tradeoffs depending on factors like resolution, flexibility, field-of-view, registration strategies, among others[18].

Display technology continues to be a limiting factor in the development of AR systems. There are still no see-through displays that have sufficient brightness, resolution, field of view, and contrast to seamlessly blend a wide range of real and virtual imagery. Furthermore, many technologies that begin to approach these goals are not yet sufficiently small, lightweight, and low-cost. Nevertheless, the past few years have seen a number of advances in see-through display technology, as we shall see next[18].

5.3.2 AR Architecture

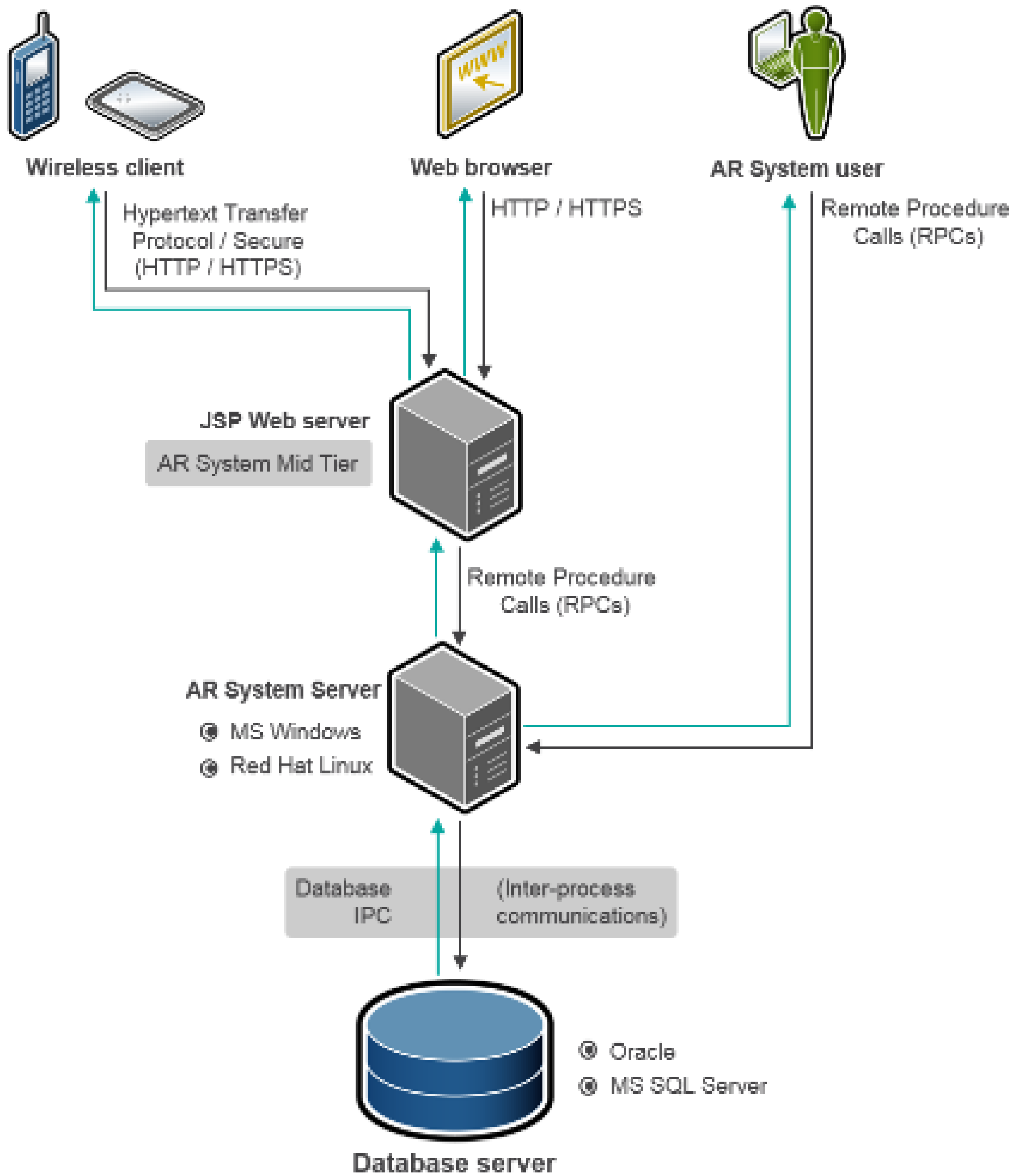
The AR System is built on a multi-tier, client-server architecture. Tiers are characterized by the type of processing that takes place within them, or in the way one-tier communicates with another. The following figure shows the various tiers of the AR System[24].



F._ **AR System architecture**[24]

- **Client tier** — Contains AR System clients. Most clients present information to application users and receive input from them, but the tools for migration and application development are also clients.
- **Mid-tier** — Contains components and add-in services that run on a web server, enabling users to view applications on the web.
- **Server tier** — Contains the AR System server, which controls workflow processes and access to databases and other data sources in the data tier. This tier also contains server-side applications (such as Approval Server, Email Engine, and the Flashboards server) and the C and Oracle Java plug-in servers with plug-ins.
- **Data-tier** — Contains database servers and other data sources that can be accessed by the AR System server. The database server acts as the data storage and retrieval engine.

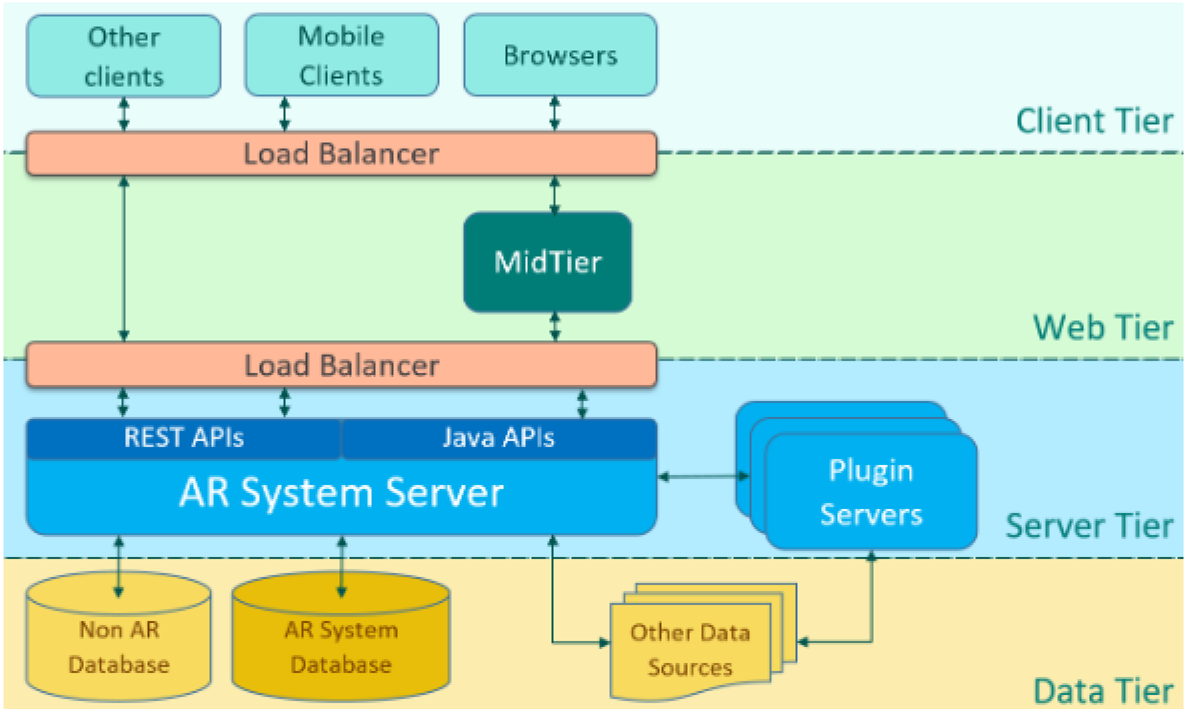
AR System clients provide the user interface. The Mid Tier makes the user interface available in browsers. The AR System server implements the workflow functions, access control, and flow of data into and out of the database. The database server acts as a data storage and retrieval engine[24].



F. **AR System multitier architecture**[24]

To provide scalability and increase reliability, you can connect a group of AR System servers to the same database and manage them as a unit by configuring a server group. Server groups act as a single server to support the applications that they run. Servers in the server group can be configured to spread the load of shared services, and they can provide backup to each other to ensure that those services are always available[24].

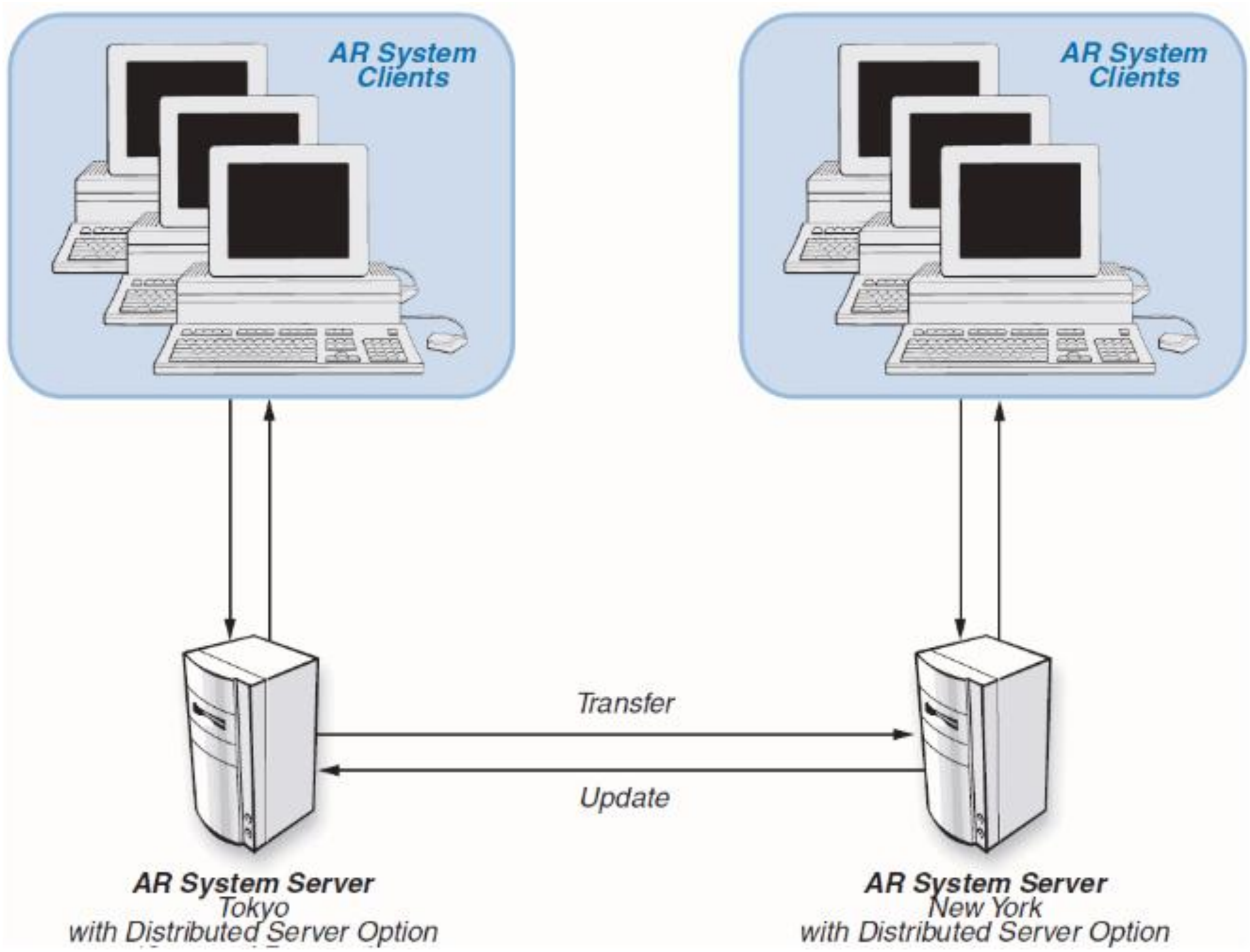
The following figure depicts the high-level architecture of the AR System[24].



F. **High-level architecture of the AR System**

Use Distributed Server Option (DSO) to build large-scale, distributed environments that behave like a single virtual system. DSO enables you to share common information among servers and to keep that information consistent[24].

For example, as illustrated in the following figure, you can transfer copies of a request to other servers and ensure that any changes made to the copies are also made to the original request. The way that you define the processes for transferring information is similar to the way that you define business processes for an application. First, managers at each site must agree on what information to transfer from one application to another, what conditions drive transfers, and which sites control the ability to update a record. An administrator at each site then uses DSO to implement these decisions[24].



F. **AR System in a distributed environment**

Because the multiple layers of AR systems are independent of one another, you can combine operating system platforms to fulfill different functions. The heterogeneous environment enables you to mix and match client and server platforms. For example[24]:

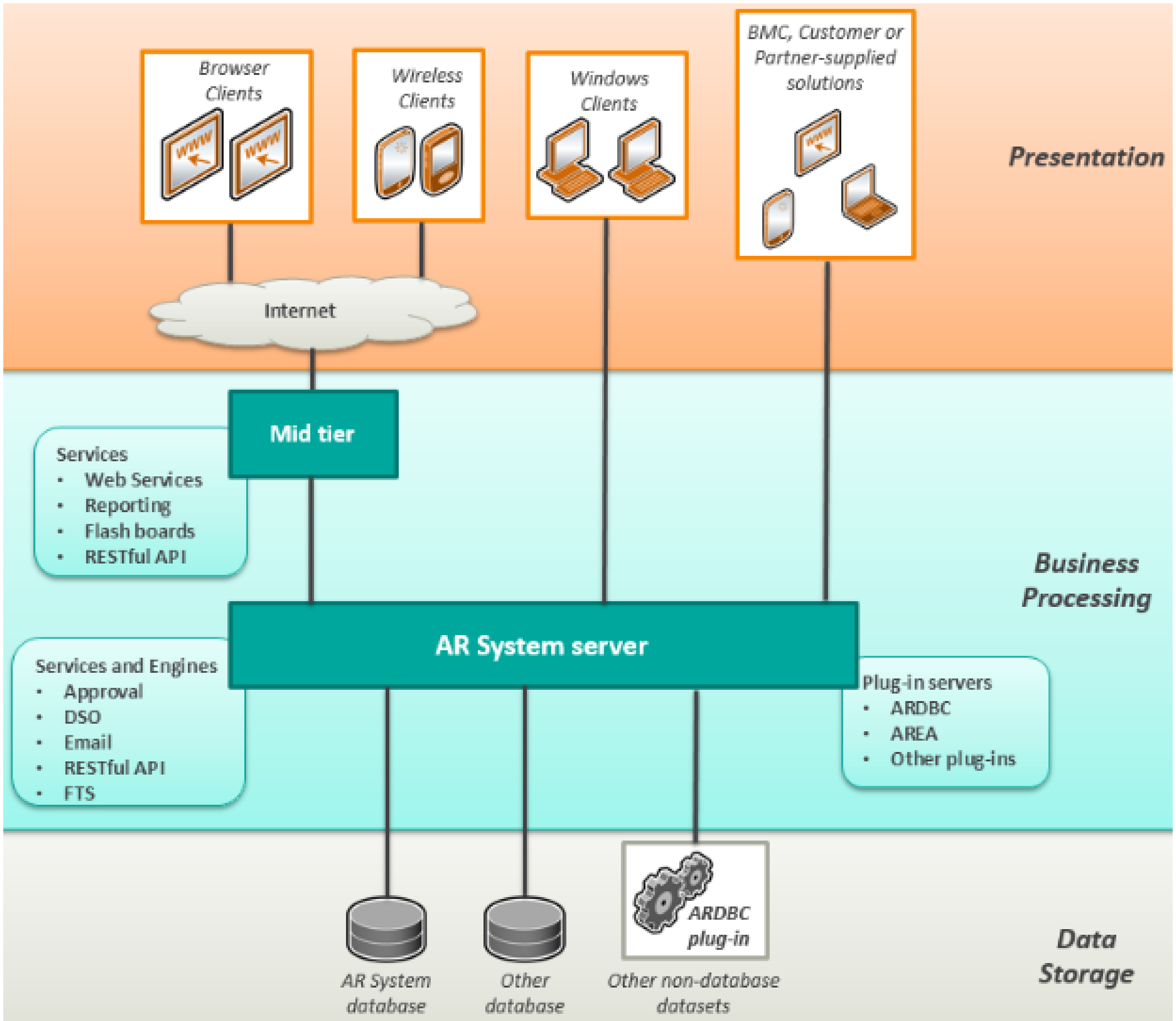
- Developer Studio on a computer running Windows can manage forms on a UNIX or Linux server.
- Browsers can use a Windows-based mid-tier to access forms on a UNIX server.

An AR System server on Windows can interact with a database on UNIX[24].

Functionally the AR System consists of three environments:

- Presentation
- Business Processing
- Data Storage

The following figure depicts the relationship between the components that reside within each of the functional environments of the AR System architecture[24].



F. AR System functional components[24]

1. **Presentation** — The presentation layer is responsible for presenting services and displaying data to clients through various interfaces, which include the following[24]:

   - Browsers
   - Cell phones
   - PCs
   - Personal Digital Assistants (PDAs)

- BMC Developer Studio
- API programs

2. **Business processing** — The following business processing components manage the data entered through clients, perform services based on your business processes, and enforce your business rules. This portion of the architecture includes[24]:

   - Mid Tier
   - AR System server
   - Server functions such as the Distributed Server Option (DSO), and Approval Server
   - Atrium Integrator (AI)
   - Web services

2. **Data storage** — AR System supports Oracle and Microsoft SQL Server databases for storing data. For each of the relational databases, tables owned by other systems can be referenced as if they were owned by AR System[24].

5.3.3 AR System client/server communication

1. Communications between clients and the AR System server

All clients of the AR System server communicate with the server by using remote procedure calls (RPCs) on top of a TCP/IP transport stack. The type of RPC is the Oracle ONC RPC. TCP/IP networks are the de facto standard for corporate and Internet communications. The RPC mechanism is used because it is a "lightweight" transport that uses minimal network bandwidth, yet provides robust communications services. It can function over slower dial-up network links and high-speed internet and intranets and is supported over most of the wireless networking technologies. The AR System web server communicates with the browsers using Hypertext Transfer Protocol (HTTP) or Secure HTTP (HTTPS)[24].

2. Communications between AR System servers and database servers

From the perspective of the database server, the AR System server is a database client. AR System server uses the JDBC to connect to the database. When an AR System server is installed, the installer specifies the type and location of the database server that informs the AR server which JDBC driver to be used. The AR System servers support SQL Server and Oracle databases and communicate with the database servers using type 4 JDBC drivers. The AR server uses the JDBC connection pooling to allow multiple database connections in parallel. The AR server process comprises many threads to support user requests and share the connection pool. This provides tremendous data throughput and system scalability[24].

3. Many-to-many connections

In an AR System environment, one AR System server can theoretically support any number of AR System client connections (limited by network bandwidth and server host and database performance). The clients can be on any mix of platforms. Similarly, an AR System client can be connected to any number of servers at the same time. These servers can be any mix of server hosts and underlying database engines[24].

5.3.4 AR System clients

AR System clients provide user interface facilities available from various platforms, including the Web. AR System clients are available for a number of operating system environments, as listed in AR System client/server architecture. For each operating system, the client is composed of a set of native applications (tools) that use the standard user interface conventions for that environment. Individual users can run these tools as necessary[24].

AR System clients can be broadly divided into user client and developer clients.

1. User clients

Through the Mid Tier, users can access the AR System in a browser. Using the web-based interface, users can submit and modify new requests, search for information about requests, and generate reports[24].

The following table summarizes the main clients used to perform administrative, user, and development tasks[24].

Client	Task
User	Administrator tasks: ➢ Create groups and roles ➢ Create users and assign licenses ➢ Manage AR System server settings and licenses User tasks: ➢ Access AR System forms and applications to create, submit, search, and modify requests

- Receive and respond to AR System notifications
- Chart data
- Generate reports
- Display alerts in the Alert List form, which can be refreshed automatically at specified intervals or manually at any time
- Search records, run or generate reports, and view flashboards

2. Developer clients

The developer clients are used to create, modify, and extend AR System applications[24].

Developer Studio	Developer tasks: ➢ Create and update application, forms, and workflow
Mid Tier Configuration Tool	Administrator tasks: ➢ Modify the Mid Tier settings for AR System servers, passwords, logging, caching, and authenticating web services ➢ Specify home page and preference and catalog servers
Data Import	Administrator tasks: ➢ Import AR System data from one AR System server to another ➢ Load external data into the AR System database ➢ Map between the columns in the external data set and the fields in the AR System form Data Import is available for Windows.

Import/export command-line interface (CLI)	Administrator tasks: ➢ Connect to the AR System server to import and export object definitions without the graphical user interface of Developer Studio ➢ Automate tasks
Data Import Command Line Interface (CLI)	➢ Connect to the AR System server to import data without the graphical user interface of Data Import ➢ Automate tasks
Migrator	➢ Migrate applications, objects, and data between servers, servers, and files, or files ➢ Reduce the difficulty and time required to synchronize AR System servers in development and production environments

3. Integration clients

BMC and its partners also offer the following tools for expanding the capabilities of the core AR System. These tools act as clients of the AR System[24].

- Knowledge Management
- Network management platform integration accessories
- Systems management integration utilities

5.3.5 AR System database server

AR System uses standard relational database engines for the actual storage and retrieval of data. Architecturally, the database server is an independent set of processes that are completely separate from the AR System server processes. Physically, the database server processes can be running on the same server host as the AR System server or on a different host. The database server can be any platform that the database engine supports[24].

A. Support for an external database

AR System can also work with data stored in external databases and other data sources that are not managed by the AR System. AR System accesses these data sources through view forms. In addition, AR System can use AR System database connectivity (ARDBC) to work with data not stored in databases as if the data was locally owned. In other words, ARDBC plug-ins can be created and configured to enable access to data stored outside the database as if it were in tables owned by the AR System[24].

B. Support for multiple database types

Because the AR System server manages all workflow, applications are independent of the database. Therefore, applications created on an AR System server running one type of database can easily be moved to a server running a different type of database. BMC provides a simple export/import utility for this purpose[24].

AR System is not a database application in the typical sense. All of the workflows are managed by the AR System server, so proprietary database features such as triggers and stored procedures are not used. An application created on an AR System server running one type of database engine can easily be moved to a server running a different database engine through a simple export/import process[24].

C. Support for database searches

AR System workflow components can search for records (requests) in the AR System database and act on the results of the search. Clients can use the following types of searches[24]:

- Query-by-example (QBE)
- Advanced search
- Predefined
- Recent

An administrator can create and store searches that are commonly performed by users. A user can define personal searches for forms to which the user has access[24].

5.3.3 AR Devices

Four major classes of AR can be distinguished by their display type: Optical SeeThrough, Virtual Retinal Systems, Video See-Through, Monitor Based AR and Projector Based AR[18].

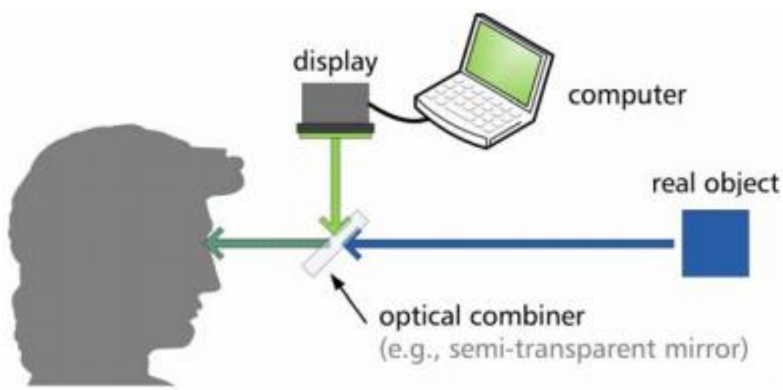
The following sections show the corresponding devices and present their main features.

4. Optical See-Through HMD

Optical See-Through AR uses a transparent Head Mounted Display to show the virtual environment directly over the real world (Figures 2 and 3). It works by placing optical combiners in front of the user's eyes. These combiners are partially transmissive so that the user can look directly through them to see the real world. The combiners are also partially reflective so that the user sees virtual images bounced off the combiners from head-mounted monitors[18].

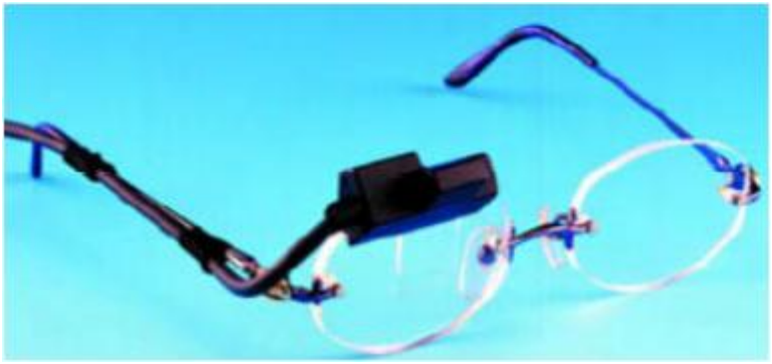
The role of the combiner is to provide an optically direct view of the environment, with a simultaneous presentation of computer-generated imagery. The combiner is typically able to transmit light from the environment, while also reflecting light from a computer display. The combined light reaches the user's eyes[20].

F. Optical See-Through HMD[18]



F. The optical path in an optical see-through display system. The light from the real environment passes through a transparent combiner that simultaneously reflects computer-generated images from a display. The optically combined light reaches the user's eyes. (Other optical elements, such as lenses that control the focal distance, are not shown in this illustration.)[20]

Recent Optical See-Through HMD's are being built for well-known companies like Sony and Olympus and have support for occlusion, varying accommodation (the process of focusing the eyes on objects at a particular distance). There are very small prototypes that can be attached to conventional eyeglasses, see the next picture [18].



F. Eyeglass display with holographic element[18]

Discussion of the advantage and disadvantages of optical see-through displays

5. Video See-Through HMD

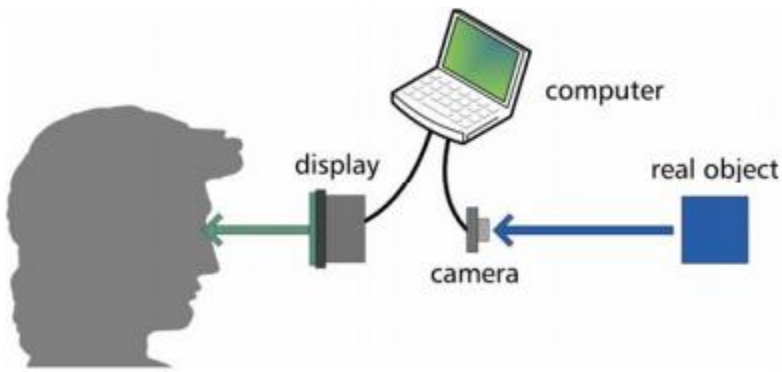
Video See-Through AR uses an opaque HMD to display a merged video of the VE and view from cameras on the HMD (Figure below)[18].

F. Video See-Through HMD[18]

A popular AR technique is based on a camera that acquires the view of the environment, a computer that adds virtual content, and an ordinary video display that presents the combined view to the user[20]. See the figure below.

Head-worn displays can use video see-through techniques by placing cameras close to the eye positions. Ideally, two cameras should be used to acquire a stereo view, with one perspective for each eye, but monoscopic single-camera systems are common and easier to design and implement[20].

This approach is a bit more complex than optical see-through AR, requiring the proper location of the cameras (Figure below). However, the video component of the real and virtual worlds is much easier. There are a variety of solutions available including chroma-key and depth mapping. Mixed Reality Systems Lab (MRSL) of Japan presented a stereo video see-through HMD at ISAR 2000. This device addresses some of the parallax related to the location of the cameras vs eyes[18].



F. The optical path in a video see-through display system. The view of the real environment is acquired by a camera and is combined with virtual imagery by a computer. The combined video is presented to the user on a computer display. (Other optical elements, such as lenses that control the focal distance, are not shown in this illustration.)[20].

Some video see-through displays use a camera to capture the scene, but present the combined view on a regular, typically handheld, computer display. A window-like effect often referred to as a "magic lens," is achieved if the camera is attached on the back of the display, creating the illusion of see-through [20], as shown in Figure below.

F. The NaviCam project illustrates how the camera on a handheld display can be used to recognize features in the environment, such that annotations can be overlaid onto the video feed[20].

It is becoming increasingly popular to directly implement video see-through on mobile devices with built-in cameras, as illustrated in Figure 7. Camera-equipped mobile phones are particularly attractive devices for AR, given their widespread use, connectivity, portable form factor, and rapidly evolving processing and graphics capabilities (e.g.,[20]).

F. Video see-through AR can be achieved using commercial camera phones. The camera on the back of the device captures video of the real environment, which is used by software on the device to recover the phone's pose relative to tracked features in the environment. This makes it possible to render 3D objects that are registered with the real environment, overlaid on the video that is shown on the phone's display[20].

<u>**Discussion of the advantage and disadvantages of video see-through displays**</u>

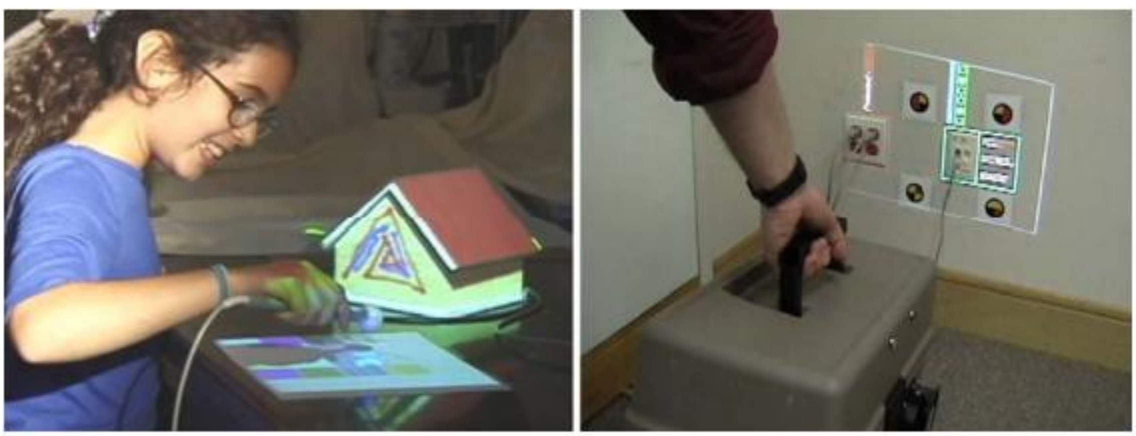
6. Projection Displays

Projector Based AR uses real-world objects as the projection surface for the virtual environment (Figures x y). It has applications in industrial assembly, product visualization, etc. Projector based AR is also well suited to multiple user situations. The alignment of projectors and the projection surfaces is critical for successful applications[18].

F. Projector Based AR[18]

F. Projector Based AR[18]

Augmentation can also be achieved by directly projecting graphics onto the real environment. Figure x and Figure y show examples of how the real world can be modified through controlled light that alters its appearance[20]



F. Left: A child uses a tracked brush to apply virtual paint, which is projected onto physical objects[20]. Right: A handheld projector is combined with a camera that identifies elements of interest in the environment and augments them with projected light. In this example, a network socket is augmented with visualizations of network status and traffic[20].

<u>Discussion of the advantage and disadvantages of video see-through displays</u>

5.4 Application of AR systems (education, medical, assistance, entertainment) workshop-oriented hands demo

Augmented Reality technology has many possible applications in a wide range of fields, including entertainment, education, medicine, engineering, and manufacturing[18].

It is expected that other potential areas of applications will appear with the dissemination of this technology[18].

1. Medical

Because imaging technology is so pervasive throughout the medical field, it is not surprising that this domain is viewed as one of the more important for augmented reality systems. Most of the medical applications deal with image-guided surgery (Figure below)[18].

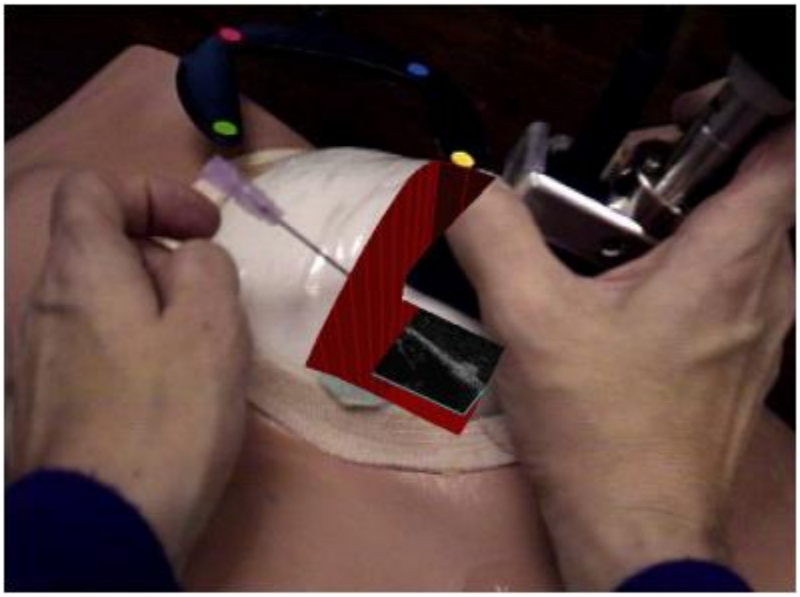
F. Image-Guided surgery[18]

Pre-operative imaging studies of the patient, such as CT (Computed Tomography) or MRI (Magnetic Resonance Imaging) scans, provide the surgeon with the necessary view of the internal anatomy. From these images, the surgery is planned[18].

Visualization of the path through the anatomy of the affected area (where a tumor must be removed, for example) is done by first creating a 3D model from the multiple views and slices in the pre-operative study. The model is then projected over the target surface to help the surgical procedure[18].

Augmented reality can be applied so that the surgical team can see the CT or MRI data correctly registered on the patient in the operating theater while the procedure is progressing. Being able to accurately register the images at this point will enhance the performance of the surgical team and eliminate the need for the painful and cumbersome stereotactic frames that are currently used for registration[18].

Another application for augmented reality in the medical domain is in ultrasound imaging. Using an optical see-through display the ultrasound technician can view a volumetric rendered image of the fetus overlaid on the abdomen of the pregnant woman. The image appears as if it were inside of the abdomen and is correctly rendered as the user moves[18] (Figure below).



F. Ultrasound Imaging[18]

2. Entertainment

A simple form of augmented reality has been in use in the entertainment and news business for quite some time. Whenever you are watching the evening weather report, the speaker remains standing in front of changing weather maps. In the studio, the reporter is actually standing in front of a blue screen. This real image is augmented with computer-generated maps using a technique called chroma-keying. Another entertainment area where AR is being applied is on game development[18] (Figure x y).

F. Games using a virtual table and synthetic objects[18]

F. VR-Border Guards, an AR game[18]

Princeton Electronic Billboard has developed an augmented reality system that allows broadcasters to insert advertisements into specific areas of the broadcast image (Figure below). For example, while broadcasting a baseball game this system would be able to place an advertisement in the image so that it appears on the outfield wall of the stadium[18].

F. Advertisement in a Football game.[18]

The electronic billboard requires calibration to the stadium by taking images from typical camera angles and zoom settings in order to build a map of the stadium including the locations in the images where advertisements will be inserted. By using pre-specified reference points in the stadium, the system automatically determines the camera angle being used and referring to the predefined stadium map inserts the advertisement into the correct place[18].

3. Military Training

The military has been using displays in cockpits that present information to the pilot on the windshield of the cockpit or the visor of the flight helmet (Figure below). This is a form of augmented reality display[18].

F. Military Training.

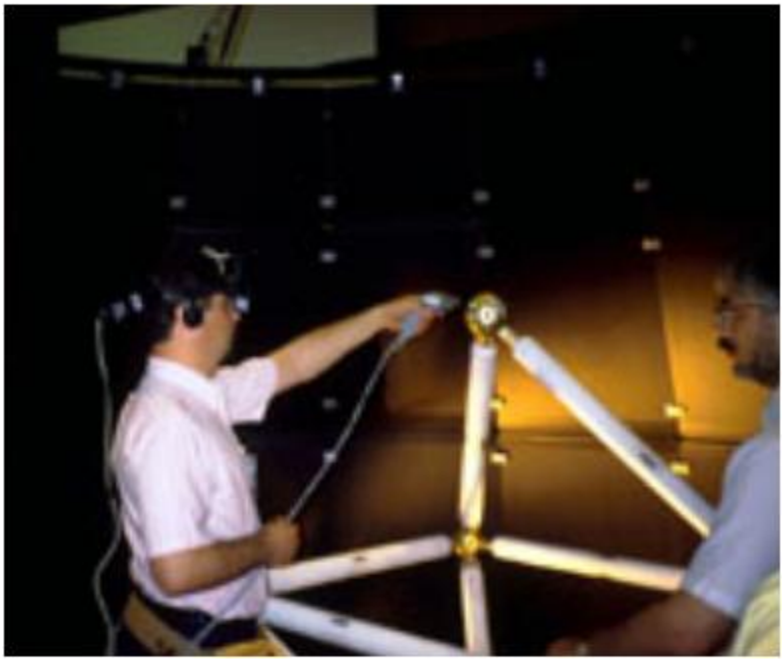
By equipping military personnel with helmet-mounted visor displays or a special purpose rangefinder the activities of other units participating in the exercise can be imaged. While looking at the horizon, during a training section, for example, the display equipped soldier could see a virtual helicopter rising above the tree line. This helicopter could be being flown in simulation by another participant. In wartime, the display of the real battlefield scene could be augmented with annotation information or highlighting to emphasize hidden enemy units[18].

4. Engineering Design

Imagine that a group of designers is working on the model of a complex device for their clients. The designers and clients want to do a joint design review even though they are physically separated. If each of them had a conference room that was equipped with an augmented reality display this could be accomplished[18].

The physical prototype that the designers have mocked up is imaged and displayed in the client's conference room in 3D. The clients can walk around the display looking at different aspects of it. To hold discussions the client can point at the prototype to highlight sections and this will be reflected on the real model in the augmented display that the designers are using. Or perhaps in an earlier stage of the design, before a prototype is built, the view in each conference room is augmented with a computer-generated image of the current design built from the CAD files describing it [18] (Figure below).

AR applied to Engineering Design. This figure shows a real object augmented with virtual tubes.



F. AR applied to Engineering Design. This figure shows a real object augmented with virtual tubes[18].

5. Manufacturing, Maintenance, and Repair

When the maintenance technician approaches a new or unfamiliar piece of equipment instead of opening several repair manuals they could put on an augmented reality display. In this display, the image of the equipment would be augmented with annotations and information pertinent to the repair. For example, the location of fasteners and attachment hardware that must be removed would be highlighted[18] (Figure below).

F. AR used to aid mechanical work[18].

Boing made an experimental system, where the technicians are guided by the augmented display that shows the routing of the cables on a generic frame used for all harnesses (Figure below). The augmented display allows a single fixture to be used for making multiple harnesses[18].

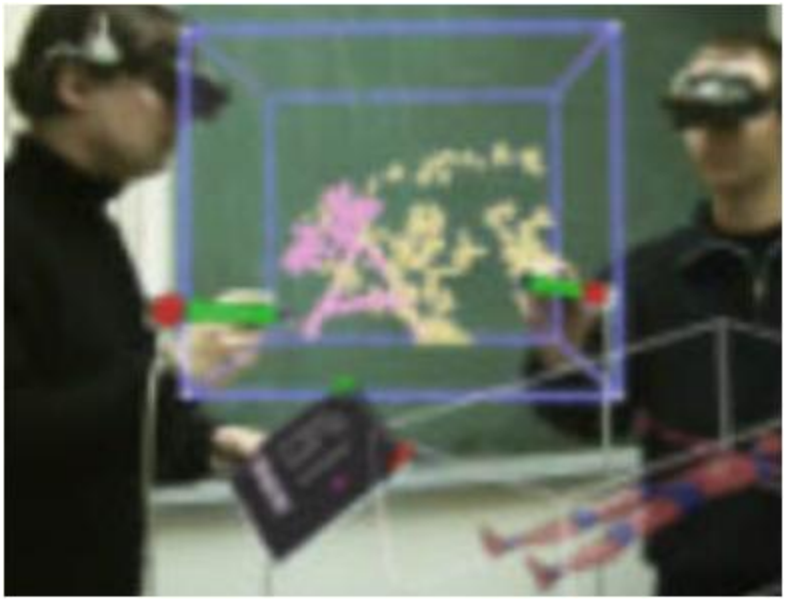
F. AR applied to maintenance work[18].

6. Collaborative AR

AR addresses two major issues with collaboration: seamless integration with existing tools and practices, and enhancing practice by supporting remote and co-located activities that would otherwise be impossible[18].

Collaborative AR systems have been built using projectors, hand-held and head-worn displays. By using projectors to augment the surfaces in a collaborative environment, users are unencumbered, can see each other’s eyes, and are guaranteed to see the same augmentations[18].

Examples of collaborative AR systems using see-through displays include both those that use see-through handheld displays and see-through head-worn displays [18] (figure below).



F. The Studierstube collaborative AR system[18].

6. ETHICS AND PROFESSIONALISM OF EMERGING TECHNOLOGIES

6.1 Technology and ethics

The Internet boom has provided many benefits for society, allowing the creation of new tools and new ways for people to interact. As with many technological advances, however, the Internet has not been without negative aspects. For example, it has created new concerns about privacy, and it has been hampered by spam and viruses. Moreover, even as it serves as a medium for communication across the globe, it threatens to cut off people who lack access to it[25].

New solutions in information and communication technologies (ICTs) are constantly emerging, and, for good or for ill, the changes they bring may open up our societies and our world to a greater extent than did the first phase of the Internet revolution. It is imperative to consider the implications of these new technologies and to encourage positive choices regarding their uses[25].

Technology can serve to promote or restrict human rights. The Information Society should foster the use of emerging technologies in such a way as to maximize the benefits that they provide while minimizing the harms. In many cases, this promotion may be less a matter of technological control than of oversight: establishing the proper legal or regulatory system to ensure that technology capable of abuse is not in fact abused and that the benefits of technology are shared among all[25].

Ethics is particularly important for the accountancy profession, with a code for professional ethics based on five basic principles – integrity, objectivity, competence and due care, confidentiality, and professional behavior. However, the emergence of new technologies raises some new challenges for the profession to address[26]

New ethical questions

The increasing use of big data, algorithmic decision-making, and artificial intelligence can enable more consistent, evidence-based and accurate judgments or decisions, often more quickly and efficiently. However, these strengths can potentially have a darker side too, throwing up questions around the ethical use of these fairly new technologies[26].

For example, outputs can be based on biased data, which could lead to discriminatory outcomes. Indeed, where systems learn from real-world data, there is a significant risk that those systems simply recreate the past and subsequently build in errors or systemic biases. Closely linked to discrimination is personalization, and the impact of tailoring decisions very specifically to individuals, based on preferences, activities and other features. While this can be beneficial for many, others can lose out, and outcomes can again seem unfair or unethical[26].

Additionally, questions are being asked regarding the interaction between computers and humans. How much reliance can we place on data and models, and what is the role of human judgment, as well as how do we ensure that we understand the decision-making process? Whatever the power of the machine, humans will still need to be involved, so that people can be held accountable, or explain the reasons behind a decision[26].

A central problem of the ethics of technology is that it tends to arrive too late. In many cases, ethical issues are only recognized when the technology is already on the market and problems arise during its widespread use. Ethics can then become a tool to clean up a mess that might have been avoidable. It is probably not contentious to say it would be desirable to have ethical input at the earlier stages of technology design and development. Indeed, there are ethical theories and approaches that explicitly aim at an early integration of ethics into the technology life cycle. One central problem of this type of approach is that the future is unknown. By definition, we do not know with certainty what will happen in the future and ethics that relies on future development needs to be able to answer the question of how it decides which technological developments to pursue. Ethics has traditionally not been well equipped to deal with issues of uncertainty and, in particular, future uncertainty[27].

6.1.1 GENERAL ETHICAL PRINCIPLES

1. **Contribute to society and to human well-being, acknowledging that all people are stakeholders in computing.**
2. **Avoid harm.**
3. **Be honest and trustworthy.**
4. **Be fair and take action not to discriminate**
5. **Respect the work required to produce new ideas, inventions, creative works, and computing artifacts.**
6. **Respect privacy.**
7. **Honor confidentiality**[28]

Briefly discuss each of the above common ethical principles

6.1.2 PROFESSIONAL RESPONSIBILITIES.

1. **Strive to achieve high quality in both the processes and products of professional work.**
2. **Maintain high standards of professional competence, conduct, and ethical practice.**
3. **Know and respect existing rules pertaining to professional work.**
4. **Accept and provide appropriate professional review.**
5. **Give comprehensive and thorough evaluations of computer systems and their impacts, including analysis of possible risks.**
6. **Perform work only in areas of competence.**
7. **Foster public awareness and understanding of computing, related technologies, and their consequences.**
8. **Access computing and communication resources only when authorized or when compelled by the public good.**
9. **Design and implement systems that are robustly and usably secure.** [28]

Briefly discuss each of the above professional responsibilities

6.1.3 PROFESSIONAL LEADERSHIP PRINCIPLES.

1. **Ensure that the public good is the central concern during all professional computing work.**
2. **Articulate, encourage acceptance of and evaluate fulfillment of social responsibilities by members of the organization or group.**
3. **Manage personnel and resources to enhance the quality of working life.**
4. **Articulate, apply, and support policies and processes that reflect the principles of the Code.**
5. **Create opportunities for members of the organization or group to grow as professionals.**
6. **Use care when modifying or retiring systems. Interface changes, the removal of features, and even software updates have an impact on the productivity of users and the quality of their work.**
7. **Recognize and take special care of systems that become integrated into the infrastructure of society.**[28]

<u>Briefly discuss each of the above professional leadership principles</u>

6.2 Digital privacy

Digital Privacy is the protection of personally identifiable or business identifiable information that is collected from respondents through information collection activities or from other sources[29].

It is a collective definition that encompasses three sub-related categories; information privacy, communication privacy, and individual privacy It is often used in contexts that promote advocacy on behalf of individual and consumer privacy rights in digital spheres, and is typically used in opposition to the business practices of many e-marketers/businesses/companies to collect and use such information and data[30].

Information Privacy

In the context of digital privacy, information privacy is the notion that individuals should have the freedom, or right, to determine how their digital information, mainly that pertaining to personally identifiable information, is collected and used. The EU has various laws that dictate how information may be collected and used by companies. Some of those laws are written to give agency to the preferences of individuals/consumers in how their data is used. In other places, like in the United States, privacy law is argued by some to be less developed in this regard, For example, some legislation, or lack of, allows companies to self-regulate their collection and dissemination practices of consumer information[30].

Communication Privacy

In the context of digital privacy, communication privacy is the notion that individuals should have the freedom, or right, to communicate information digitally with the expectation that their communications are secure; meaning that messages and communications will only be accessible to the sender's original intended recipient However, communications can be intercepted or delivered to other recipients without the sender's knowledge, in a multitude of ways. Communications can be intercepted directly through various hacking methods, this is expanded upon further below. Communications can also be delivered to recipients unbeknownst to the sender due to false assumptions made regarding the platform or medium which was used to send information. An example of this is a failure to read a company's privacy policy regarding communications on their platform could lead one to assume their communication is protected when it is in fact not. Additionally, companies frequently have been known to lack transparency in how they use information, this can be both intentional and unintentional. Discussion of communication privacy necessarily requires consideration of technological methods of protecting information/communication in digital mediums, the effectiveness, and ineffectiveness of such methods/systems, and the development/advancement of new and current technologies[30].

Individual Privacy

In the context of digital privacy, individual privacy is the notion that individuals have a right to exist freely on the internet, in that they can choose what types of information they are exposed to, and more importantly that unwanted information should not interrupt them An example of a digital breach of individual privacy would be an internet user receiving unwanted ads and emails/spam, or a computer virus that forces the user to take actions they otherwise wouldn't. In such cases the individual, during that moment, doesn't exist digitally without interruption from unwanted information; thus their individual privacy has been infringed upon[30].

Some digital privacy principles[29]:

- Data Minimization: collect the minimal amount of information necessary from individuals and businesses consistent with the Department’s mission and legal requirements.
- Transparency: Notice covering the purpose of the collection and use of identifiable information will be provided in a clear manner. Information collected will not be used for any other purpose unless authorized or mandated by law.
- Accuracy: Information collected will be maintained in a sufficiently accurate, timely, and complete manner to ensure that the interests of the individuals and businesses are protected.
- Security: Adequate physical and IT security measures will be implemented to ensure that the collection, use, and maintenance of identifiable information are properly safeguarded and the information is promptly destroyed in accordance with approved records control schedules.

6.3 Accountability and trust

When emerging technology creates far-reaching and rapid change, it can also bring new risks.
Understanding and mitigating them will help to build confidence.

Often legal and regulatory frameworks haven’t kept pace with digital transformation, and organizations are seeking guidance. This challenge is exacerbated by the speed at which **technological change** is occurring and the breadth of its adoption – which is introducing **new risks that demand new responses**[31].

Emerging technologies can provide improved accuracy, better quality and cost efficiencies for businesses in every sector. They can enhance trust in the organization’s operations and financial processes, which is crucial for sustainable success. But this can produce a paradox: the very solutions that can be used to better manage risk, increase transparency and build confidence are often themselves **the source of new risks**, which may go unnoticed[32].

There’s a danger that the use of technology will degrade people’s willingness to judge and intervene because they feel that they are less personally connected to consumers and consumer outcomes – the logic of the machine has taken over from individual responsibility[31].

The obligation of an individual or organization to account for its activities, accept responsibility for them, and to disclose the results in a transparent manner. It also includes the responsibility for money or other entrusted property[33].

6.4 Treats and challenges

6.4.1 Ethical and regulatory challenges

With Technology moving at a fast pace it is always been a challenge for Security. As security professionals, we need to keep pace with ever-changing technology and be aware of the AI, IoT, Data Mining, Big Data, Machine Learning, etc. It is no more Guards, guns & gates it is more than that & I presume we need to play a major role for a security professional to support business or rather we should be able to understand the language of business and talk to the leaders in their language. Deeper understanding & prioritization of the business side of security, familiarity with the requirement of regulation & compliances and understanding the business risks are part of the value Security professionals are providing to Senior Management. With Growing needs Cyber & Data Security is getting prominence that requires security practitioners to focus on the business need for securing data, understanding security and risk from a business perspective by extensively interacting with the business community in understanding their requirements or what they want[34].

<u>What role can technologies such as AI, IoT, Machine Learning and Big Data play in enhancing the security of an organization?</u>

Emerging technologies are already impacting how we live and work. They're also changing how we approach, plan, and integrate security operations. With the advent of artificial intelligence, robotics, quantum computing, the Internet of Things, augmented reality, materials science, 3-D printing, and data analytics, the security industry is being transformed. Certainly, we are living in an era where innovation, agility, and imagination are all essential in order to keep pace with the exponential technological transformation taking place. For security, both physical and cyber, the equation is the same catalyzing many new potential applications for emerging technologies. I personally see emerging technologies are making an impact include[34]

1. Counter-terrorism and law enforcement informatics via predictive analytics and artificial intelligence.
2. Real-time horizon scanning and data mining for threats and information sharing
3. Automated cybersecurity and information assurance
4. Enhanced Surveillance (chemical and bio-detection sensors, cameras, drones, facial recognition, license plate readers)
5. Simulation and augmented reality technologies for training and modeling
6. Safety and security equipment (including bullet and bomb proof) made with lighter and stronger materials
7. Advanced forensics enabled by enhanced computing capabilities (including future quantum computing)
8. Situational awareness capabilities via GPS for disaster response and crisis response scenarios
9. Biometrics: assured identity security screening solutions by bio-signature: (every aspect of your physiology can be used as a bio-signature. Measure unique heart/pulse rates, electrocardiogram sensor, blood oximetry, skin temperature)
10. Robotic Policing (already happening in Dubai!)

New and emerging technologies could pose some of the biggest opportunities to enterprises in the near future, but they will also present challenges. Technologies that are being developed now and have been taken on by early adopters will become increasingly common and influential over the next couple of years. We cannot yet know all the implications of these innovations but businesses will need to predict and plan for how these technologies will disrupt them and their industry[35].

1. Artificial Intelligence and Machine Learning

Advances in Artificial Intelligence (AI) have been huge over the past few years and the staggering number of possible applications presents a huge opportunity. Machine Learning is an advanced form of AI where the machine can learn as it goes rather than having every action programmed by humans

<u>AI is only as good as the data it is exposed to</u>, which is where certain challenges may present themselves. How a business teaches and develops its AI will be the major factor in its usefulness. Humans could be the weak link here, as people are unlikely to want to input masses of data into a system[35].

Another dilemma that comes along with AI is its potential to replace human workers. As machines become more "intelligent" they could begin to replace experts in higher-level jobs. Alternatively, AI also has the potential to take the burden of laborious and time-consuming tasks from these people, freeing up their time and brainpower for other things e.g. doctors using diagnostic AI to help them diagnose patients will analyze the data presented by the AI and make the ultimate decision. Managing the challenges posed by AI will require careful planning to ensure that the full benefits are realized and risks are mitigated[35].

2. Automation and Robotics

With automation and robotics moving from production lines out into other areas of work and business, the potential for humans losing jobs is great here too. As automation technologies become more advanced, there will be a greater capability for automation to take over more and more complex jobs. As robots learn to teach each other and themselves, there is the potential for much greater productivity but this also raises ethical and cybersecurity concerns[35].

3. Cryptocurrency and Blockchain

Though they have been around for some time, in recent years cryptocurrencies like Bitcoin and Ethereum have become increasingly common and legitimized (as well as valuable). These purely digital currencies that are not backed by any government or institution could pose a destabilizing risk. However, blockchain, the system used to register Bitcoin, could be a real opportunity for established institutions[35].

Blockchain distributed ledger technology creates hacker- and fraud-proof decentralized databases which have already disrupted banking and mortgage systems, but has the potential to be applied to many industries. Everledger uses blockchain technology to register diamonds to prevent counterfeits and track conflict diamonds. The transparency and security of blockchain have the potential to rebuild public trust in institutions[35].

4. Internet of Things

As more and more connected devices (such as smartwatches and fitness trackers) join the Internet of Things (IoT) the amount of data being generated is increasing. Companies will have to plan carefully how this will affect the customer-facing application and how to best utilize the masses of data being produced. There are also severe security implications of mass connectivity that need to be addressed[35].

5. Big Data

Almost all the technologies mentioned above have some relation to Big Data. The huge amount of data being generated on a daily basis has the potential to provide businesses with better insight into their customers as well as their own business operations[35].

Although data can be incredibly useful for spotting trends and analyzing impacts, surfacing all this data to humans in a way that they can understand can be challenging. AI will play a role here, as well as applications like Splunk that surface machine-generated data in a human way[35].

New and emerging technologies pose significant opportunities for businesses if they utilize them well and understand their true value early on. They also pose risks and questions not only to business but to society as a whole. Planning for how to deal with these emerging technologies and where value can be derived while assessing potential risks before they become a fully-fledged reality is essential for businesses that want to thrive in the world of AI, Big Data and IoT[35].

The World Economic Forum's list of top 10 emerging technologies of 2015 includes those that aim to resolve some of the ethical debates posed by an earlier generation of technologies, as well as others that will bring about new ethical and regulatory challenges. The notion of "emerging" technology does not necessarily mean that all such technologies are new or revolutionary by themselves. Some have already been around for years or, in various forms, for decades (e.g. fuel-cell vehicle, artificial intelligence, digital genome, additive manufacturing methods). However, they are now transitioning to a new phase, becoming more widely used or incorporated in consumer goods. In one way or another, all these technologies are bound to gain more ground in the years to come[36].

1. **Precise genetic engineering techniques**, one of the highlighted technologies, will likely solve some of the main controversial elements in the GMO debate, for example, the fact that genetic engineering was neither precise nor predictable. The range of procedures associated with GM crops is precise in the initial process of cutting and splitting genes in the test tubes. But the subsequent steps are uncontrolled and some mutations can occur and alter the functioning of the natural genes in potentially harmful ways[36].

2. Autonomous systems, artificial intelligence (AI) and robotics, while already decades-old technologies, will continue to expand their functionalities and enter new eras of continuous specialization. More intuitive, **emergent AI** could change speech and conversational software with unprecedented precision, helping millions of people and also redefining the way we command and interact with computers[36].

3. **New-generation robotics** will increasingly have more autonomy and capacity to react without pre-programming, which complicates all current debates on robotics: the trust and reliance invested in a robot will have to be greater, bringing us closer to the point of being on a par with robots. **Neuromorphic chip technology** further illustrates this. This is among the most revolutionary developments in AI and a radical step further in computing power. Mimicking the intricacies of the human brain, a neuro-inspired computer would work in a similar fashion to the way neurons and synapses communicate and potentially be able to learn or develop memory. This would imply that, for instance, a drone equipped with a neuromorphic chip would be better at surveillance, remembering or recognizing new elements in the environment[36].

4. Inevitably, the emerging technologies of the future will redefine our understanding of biology, the material world, and manufacturing. The implications will further extend into geopolitics and global balances of power. **Fuel cell vehicles** are finally expected to make their way to the market and reduce dependency on oil or emissions that contribute to climate change. In the long term, this will accentuate the vulnerability of oil-dependent economies and recalibrate geopolitical relations. **Recyclable thermostat polymers**, reportedly discovered by accident, will dramatically

change fabrication and manufacturing, leading to new standards in industries. Globally, the advent of **distributed manufacturing** is bound to lead to a reassessment of the meaning of value chains and infrastructure: rather than ship parts of a given product, some companies will simply trade information, leaving it to the customer to finalize the manufacture of the product. A suite of other technologies, such as 3D printing, informatics, and robotics are enabling a paradigm shift to a dematerialized future with endless possibilities for customization[36].

6.4.2 Treats

1. Ambient intelligence

Ambient intelligence is the most pervasive form of emerging IT. Ambient intelligence is the ultimate goal of the internet of things. In ambient intelligence the user interface merges into the environment, responding to voice and behavior without needing a direct command from the user[37].

Such capabilities require that ambient systems understand each person individually and can respond to their unique behavioral characteristics, necessitating highly detailed user profiling on a level well beyond anything seen today[37].

There is much interest in ambient intelligence in the medical field and for the care of the elderly. However, there is also a concern that this will mean automating tasks currently undertaken by humans and risk isolating the sick and the vulnerable inside digital cocoons, bereft of human contact[37].

Needless to say, the needs of user profiling generate extreme privacy concerns. The issue is who gets access to the data and what it is used for? Today many insurance companies are installing black boxes in customer cars to monitor driver behavior, adjusting premiums accordingly[37].

Similarly, there is the talk of medical insurance companies using ambient intelligence to monitor your eating and exercise patterns and adjusting their premiums accordingly[37].

Google is currently buying many home control systems and has a stated goal to monitor everyone's conversations in the home and interrupt them with useful suggestions of relevant products[37].

Of even greater concern is the potential for surveillance organizations to access such ambient systems, just as they have with all other internet communications. This would potentially allow them to spy on every single aspect of our existence – all the time and in minute detail[37].

The moral of this is to design ambient systems with privacy concerns in mind; don't make it easy to misuse user data; assume others will try to hack the system in order to spy on people and design accordingly[37].

2. Augmented reality

Augmented reality refers to the use of a display of some form to inject digital output into our perception of the physical world. The most popular forms of augmented reality today are found in mobile apps, such as Google Sky and Google Goggles[37].

However, first-generation augmented reality goggles are starting to appear on market, such as Google Glass, Vuzix Smart Glasses, Samsung SmartGlass and Epson Moverio[37].

Many of the concerns regarding augmented reality can be seen in the controversies generated during Google Glass's beta program. One concern is that augmented reality may not augment at all, but detract. US states are in confusion as to whether they should allow driving while wearing smart glasses[37].

The correct use of the right software could significantly increase driver safety, but it is currently impossible to ensure people are using navigation software, for example, and not just watching movies while driving. The lack of visibility of operation also leads to the second concern – other people's privacy. It's impossible to know if you're being recorded by someone wearing smart glasses[37].

As a result, many places have banned them and people have been attacked for refusing to take them o in bars and restaurants. This concern over being spied on by smart glass wearers is so strong some people have been attacked simply for wearing them in the street. Refusal to remove smart glasses when asked has given rise to the new epithet of glasshole[37].

Privacy issues apply to the wearer as well as those around them. Google Glass, for example, routes all commands through its servers, treating the glasses very much as dumb terminals. Google has frequently repeated its intention to process this data[37].

There is nothing in the design of Google Glass that demands such a model. Google Glass has already been deployed to doctors in Beth Israel Deaconess Hospital[37].

The first step its developers, Wearable Intelligence, took was to disable routing of commands through Google servers. The intrusive output is also a concern with augmented reality[37].

Intrusive output occurs when unexpected output interferes with what the user is doing. Error messages are the most benign form of intrusive output. Suddenly dropping an ad for a discount sale in front of someone's eye when they drive past the store is a potentially lethal form of intrusive output[37].

We are about to see an explosion of augmented reality apps as smart glasses hit the market over the next 3-5 years. Augmented reality is, therefore, one of the emerging technologies that IT professionals are most likely to encounter in the near future[37].

Augmented reality will enter enterprise computing just as much as the high street, particularly in factory and warehouse operations and onsite engineering diagnostics[37].

The moral of this is: once again privacy issues are a serious concern, including concern for the user's ability to violate the privacy of others. Design and deployment, especially within the corporate environment, should be sensitive to the heightened privacy concerns augmented reality devices generate for people around the user[37].

Some risks of emerging technology are[38]:

- Driverless car: while a compelling option for future fleer cars, companies could crash and burn from claims related to bodily injury and property damage.
- Wearables: Google glass, Fitbit and other wearables can expose companies to the invasion of privacy claims that may not be covered by general liability or personal injury claims that weren't foreseen.
- Drones: Turbulence is in the offing for manufacturers and organizations that fail to protect themselves for property damage and bodily injury, as well as errors and omissions.

- Internet of things: The proliferation of sensors and cross platform integration creates potential exposure from privacy invasion, bodily injury and property damage that may connect an organization to huge liabilities.
- 3D printing: Use of trade secrets, patents or other protected materials can create intellectual property liability.
- Telemedicine: As a projected lack of primary physicians drives increased adoption, an unhealthy mix of crossover claims may result from medical consultations, software, hardware, facilities, health insurance, and personal data via ISP

7 Other emerging technologies

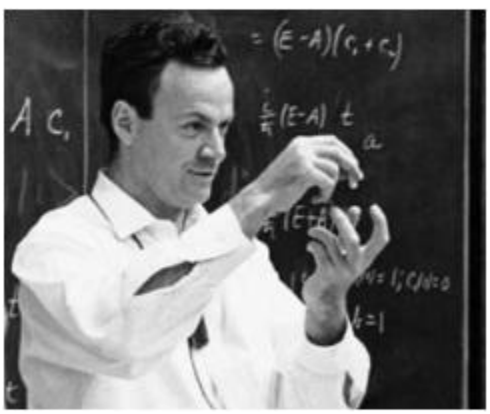
7.1 Nanotechnology

Nanotechnology is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers[39].

Nanoscience and nanotechnology are the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering[39].

7.1.1 How it started

The ideas and concepts behind nanoscience and nanotechnology started with a talk entitled "There's Plenty of Room at the Bottom" by physicist Richard Feynman at an American Physical Society meeting at the California Institute of Technology (CalTech) on December 29, 1959, long before the term nanotechnology was used. In his talk, Feynman described a process in which scientists would be able to manipulate and control individual atoms and molecules. Over a decade later, in his explorations of ultraprecision machining, Professor Norio Taniguchi coined the term nanotechnology. It wasn't until 1981, with the development of the scanning tunneling microscope that could "see" individual atoms, that modern nanotechnology begun[39].



F.Physicist Richard Feynman, the father of nanotechnology[39]

7.1.2 Fundamental concepts in nanoscience and nanotechnology

IT'S HARD TO IMAGINE JUST HOW SMALL NANOTECHNOLOGY IS. ONE NANOMETER IS A BILLIONTH OF A METER OR 10^{-9} OF A METER. HERE ARE A FEW ILLUSTRATIVE EXAMPLES[39]:

- There are 25,400,000 nanometers in an inch
- A sheet of newspaper is about 100,000 nanometers thick
- On a comparative scale, if a marble were a nanometer, then one meter would be the size of the Earth

Nanoscience and nanotechnology involve the ability to see and to control individual atoms and molecules. Everything on Earth is made up of atoms—the food we eat, the clothes we wear, the buildings and houses we live in, and our own bodies[39].

But something as small as an atom is impossible to see with the naked eye. In fact, it's impossible to see with the microscopes typically used in high school science classes. The microscopes needed to see things at the nanoscale were invented relatively recently—about 30 years ago[39].

As small as a nanometer is, it's still large compared to the atomic scale. An atom has a diameter of about 0.1 nm. An atom's nucleus is much smaller -- about 0.00001 nm. Atoms are the building blocks for all matter in our universe. You and everything around you are made of atoms. Nature has perfected the science of manufacturing matter molecularly. For instance, our bodies are assembled in a specific manner from millions of living cells. Cells are nature's nanomachines. At the atomic scale, elements are at their most basic level. On the nanoscale, we can potentially put these atoms together to make almost anything[40].

In a lecture called "Small Wonders:The World of Nanoscience," Nobel Prize winner Dr. Horst Störmer said that the nanoscale is more interesting than the atomic scale because the nanoscale is the first point where we can assemble something -- it's not until we start putting atoms together that we can make anything useful[40].

People are interested in the nanoscale – which we define to be from 100nm down to the size of atoms (approximately 0.2nm) – because it is at this scale that the properties of materials can be very different from those at a larger scale. We define nanoscience as the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale; and nanotechnologies as the design, characterisation, production and application of structures, devices and systems by controlling shape and size at the nanometer scale[41].

The properties of materials can be different at the nanoscale for two main reasons[41]:

- First, nanomaterials have a relatively larger surface area when compared to the same mass of material produced in a larger form. This can make materials more chemically reactive (in some cases materials that are inert in their larger form are reactive when produced in their nanoscale form), and affect their strength or electrical properties.
- Second, quantum effects can begin to dominate the behavior of matter at the nanoscale – particularly at the lower end – affecting the optical, electrical and magnetic behavior of materials. Materials can be produced that are nanoscale in one dimension (for example, nanowires, nanorods, and nanotubes), in two dimensions (plate-like shapes like nanocoatings, nanolayers, and graphene) or in all three dimensions (for example, nanoparticles).

Today's scientists and engineers are finding a wide variety of ways to deliberately make materials at the nanoscale to take advantage of their enhanced properties such as higher strength, lighter weight, increased control of light spectrum, and greater chemical reactivity than their larger-scale counterparts[39].

7.1.3Applications of nanotechnology:

A. Medicine

Researchers are developing customized nanoparticles the size of molecules that can deliver drugs directly to diseased cells in your body. When it's perfected, this method should greatly reduce the damage treatment such as chemotherapy does to a patient's healthy cells[42].

B. Electronics

Nanotechnology holds some answers for how we might increase the capabilities of electronics devices while we reduce their weight and power consumption[42].

C. Food

Nanotechnology is having an impact on several aspects of food science, from how food is grown to how it is packaged. Companies are developing nanomaterials that will make a difference not only in the taste of food but also in food safety and the health benefits that food delivery[42].

D. Space

Nanotechnology may hold the key to making space-flight more practical. Advancements in nanomaterials make lightweight spacecraft and a cable for the space elevator possible. By significantly reducing the amount of rocket fuel required, these advances could lower the cost of reaching orbit and traveling in space[42].

E. Agriculture

Uses of nanotechnology can possibly change the whole agriculture part and nourishment industry anchor from generation to preservation, handling, bundling, transportation, and even waste treatment. NanoScience ideas and Nanotechnology applications can possibly update the generation cycle, rebuild the preparing and protection forms and rethink the nourishment propensities for the individuals[43].

F. Vehicle manufacturers

Much like aviation, lighter and stronger materials will be valuable for making vehicles that are both quicker and more secure. Burning motors will likewise profit from parts that are all the more hardwearing and higher temperature safe[43].

G. Construction

Nanotechnology can possibly make development quicker, less expensive, more secure, and more changed. Computerization of nanotechnology development can take into account the formation of structures from cutting edge homes to enormous high rises substantially more rapidly and at much lower expense[43].

H. Information and communication

Current high-innovation generation techniques are in view of customary top-down procedures, where nanotechnology has as of now been presented noiselessly. The basic length size of incorporated circuits is as of now at the nanoscale (50 nm and underneath) with respect to the entryway length of transistors in CPUs or DRAM gadgets[43].

I. Medicine

The scientific and scientific analysis areas have utilized the exclusive qualities of nanomaterials for various programs (e.g., comparison providers for mobile pictures and therapeutics for the treatment of cancer). Conditions such as biomedical nanotechnology, bionanotechnology, and nanomedicine are used to explain these multiple areas. Features can be included in nanomaterials by interfacing them with scientific elements or components. The size of nanomaterials is just like that of most scientific elements and structures; therefore, nanomaterials can be useful for both in vivo and in vitro biomedical analysis and programs. Thus far, the incorporation of nanomaterials with chemistry has led to the growth of analytic gadgets, comparison providers, systematic resources, actual physical rehabilitation programs, and medication distribution automobiles[43].

7.2 Biotechnology

It is the broad area of biology involving living systems and organisms to develop or make products, or "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use"[44].

At its simplest, biotechnology is technology based on biology - biotechnology harnesses cellular and biomolecular processes to develop technologies and products that help improve our lives and the health of our planet. We have used the biological processes of microorganisms for more than 6,000 years to make useful food products, such as bread and cheese, and to preserve dairy products[45].

Brewing and baking bread are examples of processes that fall within the concept of biotechnology (use of yeast (= living organism) to produce the desired product). Such traditional processes usually utilize the living organisms in their natural form (or further developed by breeding), while the more modern form of biotechnology will generally involve a more advanced modification of the biological system or organism[46].

One example of modern biotechnology is genetic engineering. Genetic engineering is the process of transferring individual genes between organisms or modifying the genes in an organism to remove or add a desired trait or characteristic[47].

Today, biotechnology covers many different disciplines (eg. genetics, biochemistry, molecular biology, etc.). New technologies and products are developed every year within the areas of eg.

medicine (development of new medicines and therapies), agriculture (development of genetically modified plants, biofuels, biological treatment) or industrial biotechnology (production of chemicals, paper, textiles, and food)[46].

7.2.1 History

When Edward Jenner invented vaccines and when Alexander Fleming discovered antibiotics, they were harnessing the power of biotechnology. And, of course, modern civilization would hardly be imaginable without the fermentation processes that gave us beer, wine, and cheese![48]

When he coined the term in 1919, the agriculturalist Karl Ereky described 'biotechnology' as "all lines of work by which products are produced from raw materials with the aid of living things." In modern biotechnology, researchers modify DNA and proteins to shape the capabilities of living cells, plants, and animals into something useful for humans. Biotechnologists do this by sequencing or reading, the DNA found in nature, and then manipulating it in a test tube – or, more recently, inside of living cells[48].

7.2.2 Application of biotechnology

A. Agriculture

The use of **Biotechnology** in **Agriculture** is known as **Green Biotechnology**. Biotechnology had contributed a lot towards the upliftment of agriculture. The organisms formed after manipulation of genes is known as **Genetically Modified Organisms** such as Crops, Animals, Plants, Fungi, Bacteria, etc. Genetically modified crops are formed by the manipulation of **DNA** to introduce a new trait into the crops. These manipulations are done to introduce traits such as pest resistance, insect resistance, weed resistance, etc[49].

B. Medicine

The use of biotechnology in medicine is known as **Medicinal Biotechnology**. This helps in the formation of genetically modified insulin known as humulin. This helps in the treatment of a large number of diabetes patients[49].

Biotechnology has given rise to a technique known as gene therapy. Gene therapy is a technique to remove the genetic defect in an embryo or child. This technique involves the transfer of a normal gene that works over the non-functional gene[49].

C. Aquaculture Fisheries

It helps in improving the quality and quantity of fishes. Through biotechnology, fishes are induced to breed via gonadotropin-releasing hormone[49].

- Growth Enhancement
- Genetic Characterization
- Control of Diseases
- Metabolic Engineering
- Transgenesis

D. Production of Antibiotics

Plants are used to develop antibiotics for **Humans** as well as for **Animal** use. It helps in the production of antibiotics, vaccines and artificial hormones for hormone therapies[49].

E. Environment

Environmental biotechnology is used in waste treatment and pollution prevention. Environmental biotechnology can more efficiently clean up many wastes than conventional methods and greatly reduce our dependence on methods for land-based disposal[47].

Every organism ingests nutrients to live and produces by-products as a result. Different organisms need different types of nutrients. Some bacteria thrive on the chemical components of waste products. Environmental engineers use bioremediation, the broadest application of environmental biotechnology, in two basic ways. They introduce nutrients to stimulate the activity of bacteria already present in the soil at a waste site or add new bacteria to the soil. The 5 bacteria digest the waste at the site and turn it into harmless byproducts. After the bacteria consume the waste materials, they die off or return to their normal population levels in the environment.

7.3 Blockchain technology

7.4 Cloud and quantum computing

7.5 Autonomic computing (AC)

Autonomic computing (AC) is an approach to address the complexity and evolution problems in software systems. A software system that operates on its own or with a minimum of human interference according to a set of rules is called autonomic.1 The term autonomic derives from the human body's autonomic nervous system, which controls key functions without conscious awareness or involvement[50].

It refers to the self-managing characteristics of distributed computing resources, adapting to unpredictable changes while hiding intrinsic complexity to operators and users. Initiated by IBM in 2001, this initiative ultimately aimed to develop computer systems capable of self-management, to overcome the rapidly growing complexity of computing systems management, and to reduce the barrier that complexity poses to further growth[51].

Autonomic computing is a self-managing computing model named after, and patterned on, the human body's autonomic nervous system. An autonomic computing system would control the functioning of computer applications and systems without input from the user, in the same way, that the autonomic nervous system regulates body systems without conscious input from the individual. The goal of autonomic computing is to create systems that run themselves, capable of high-level functioning while keeping the system's complexity invisible to the user[52].

7.5.1 Characteristics of Autonomic Systems

An autonomic system can self-configure at runtime to meet changing operating environments, self-tune to optimize its performance, self-heal when it encounters unexpected obstacles during its operation, and—of particular current interest—protect itself from malicious attacks. An autonomic system can self-manage anything including a single property or multiple properties[50] (see picture below).

F. Autonomic Characteristics

<u>Discuss briefly each of the characteristics of the autonomic system</u>

Autonomic systems/applications exhibit eight defining characteristics[53]:

- Self Awareness: An autonomic application/system "knows itself" and is aware of its state and its behaviors.
- Self Configuring: An autonomic application/system should be able to configure and reconfigure itself under varying and unpredictable conditions.
- Self Optimizing: An autonomic application/system should be able to detect suboptimal behaviors and optimize itself to improve its execution.

- Self-Healing: An autonomic application/system should be able to detect and recover from potential problems and continue to function smoothly.
- Self Protecting: An autonomic application/system should be capable of detecting and protecting its resources from both internal and external attacks and maintaining overall system security and integrity.
- Context-Aware: An autonomic application/system should be aware of its execution environment and be able to react to changes in the environment.
- Open: An autonomic application/system must function in a heterogeneous world and should be portable across multiple hardware and software architectures. Consequently, it must be built on standard and open protocols and interfaces.
- Anticipatory: An autonomic application/system should be able to anticipate to the extent possible, its needs and behaviors and those of its context, and be able to manage itself proactively

7.6 Computer vision

A bit of history

The origins of computer vision go back to an MIT undergraduate summer project in 1966. It was believed at the time that computer vision could be solved in one summer, but we now have a 50-year old scientific field that is still far from being solved[54].

Early experiments in computer vision took place in the 1950s, using some of the first neural networks to detect the edges of an object and to sort simple objects into categories like circles and squares. In the 1970s, the first commercial use of computer vision interpreted typed or handwritten text using optical character recognition. This advancement was used to interpret written text for the blind[55].

As the internet matured in the 1990s, making large sets of images available online for analysis, facial recognition programs flourished. These growing data sets helped make it possible for machines to identify specific people in photos and videos[55].

7.6.1 Definition

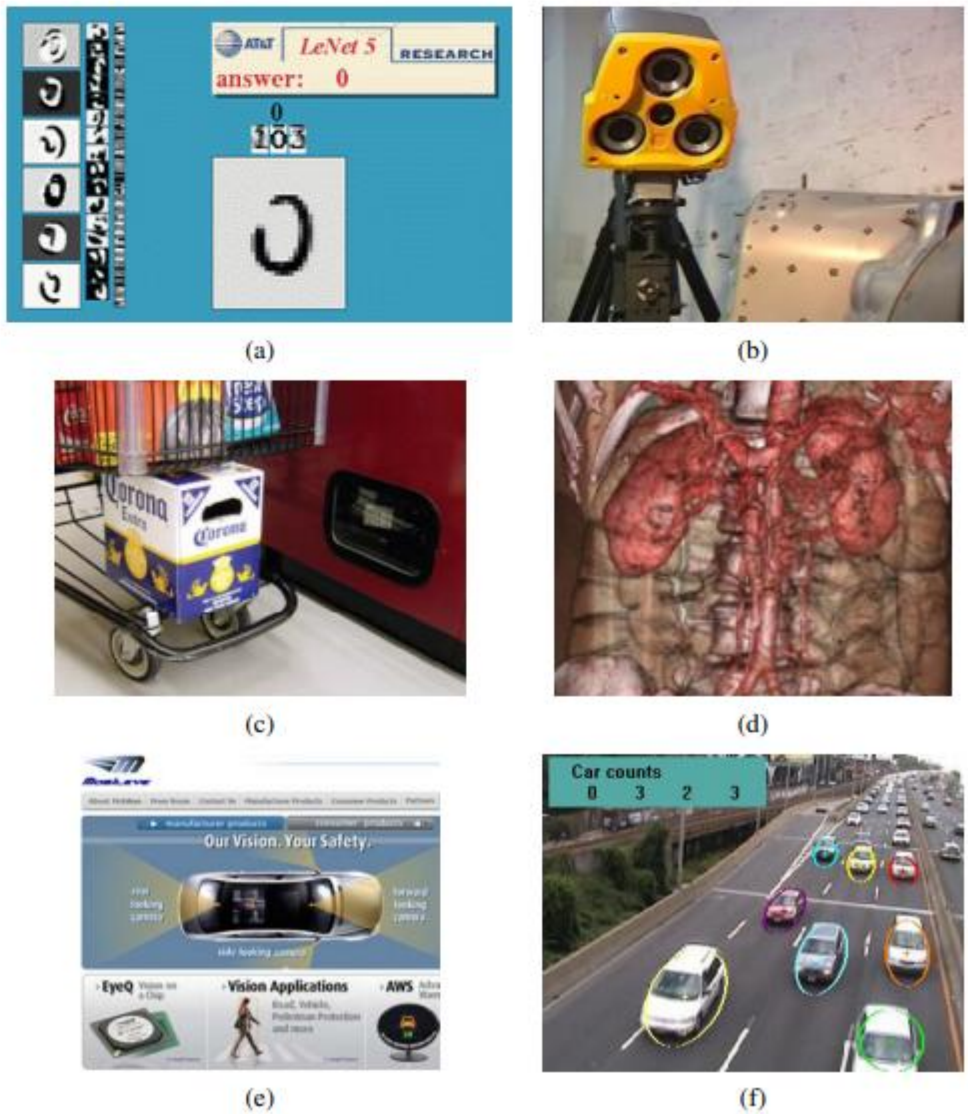
It is an interdisciplinary scientific field that deals with how computers can be made to gain a high-level understanding of digital images or videos. From the perspective of engineering, it seeks to automate tasks that the human visual system can do[56].

Computer vision tasks include methods for acquiring, processing, analyzing and understanding digital images, and extraction of high-dimensional data from the real world in order to produce numerical or symbolic information, e.g. in the forms of decisions. Understanding in this context means the transformation of visual images (the input of the retina) into descriptions of the world that can interface with other thought processes and elicit appropriate action. This image understanding can be seen as the disentangling of symbolic information from image data using models constructed with the aid of geometry, physics, statistics, and learning theory[56].

Another way to define computer vision is through its applications. Computer vision is building algorithms that can understand the content of images and use it for other applications[54].

computer vision is being used today in a wide variety of real-world applications, which include[57]:

- Optical character recognition (OCR): reading handwritten postal codes on letters (Figure 1.4a) and automatic number plate recognition (ANPR);
- Machine inspection: rapid parts inspection for quality assurance using stereo vision with specialized illumination to measure tolerances on aircraft wings or auto body parts (Figure 1.4b) or looking for defects in steel castings using X-ray vision;
- Retail: object recognition for automated checkout lanes (Figure 1.4c);
- Medical imaging: registering pre-operative and intra-operative imagery (Figure 1.4d) or performing long-term studies of people's brain morphology as they age;
- Automotive safety: detecting unexpected obstacles such as pedestrians on the street, under conditions where active vision techniques such as radar or lidar do not work well (Figure 1.4e;
- Surveillance: monitoring for intruders, analyzing highway traffic (Figure 1.4f), and monitoring pools for drowning victims;
- Fingerprint recognition and biometrics: for automatic access authentication as well as forensic applications



F. Some industrial applications of computer vision: (a) optical character recognition (OCR) (b) mechanical inspection (c) retail (d) medical imaging (e) automotive safety (f) surveillance and traffic monitoring [57]

7.6.2 How computer vision works[55]

7.5 Acquiring an image: Images, even large sets, can be acquired in real-time through video, photos or 3D technology for analysis.

7.6 Processing the image: Deep learning models automate much of this process, but the models are often trained by first being fed thousands of labeled or pre-identified images.

7.7 Understanding the image: The final step is the interpretative step, where an object is identified or classified.

There are many types of computer vision that are used in different ways[55]:

- Image segmentation partitions an image into multiple regions or pieces to be examined separately.

- Object detection identifies a specific object in an image. Advanced object detection recognizes many objects in a single image: a football field, an offensive player, a defensive player, a ball and so on. These models use an X, Y coordinate to create a bounding box and identify everything inside the box.

- Facial recognition is an advanced type of object detection that not only recognizes a human face in an image, but identifies a specific individual.

- Edge detection is a technique used to identify the outside edge of an object or landscape to better identify what is in the image.

- Pattern detection is a process of recognizing repeated shapes, colors and other visual indicators in images.

- Image classification groups images into different categories.

- Feature matching is a type of pattern detection that matches similarities in images to help classify them.

Simple applications of computer vision may only use one of these techniques, but more advanced users, like computer vision for self-driving cars, rely on multiple techniques to accomplish their goal[55].

7.7 Embedded systems

It is a controller with a dedicated function within a larger mechanical or electrical system, often with real-time computing constraints. It is *embedded* as part of a complete device often including hardware and mechanical parts. Embedded systems control many devices in common use today. Ninety-eight percent of all microprocessors manufactured are used in embedded systems[58].

Modern embedded systems are often based on microcontrollers (i.e. microprocessors with integrated memory and peripheral interfaces), but ordinary microprocessors (using external chips for memory and peripheral interface circuits) are also common, especially in more complex systems. In either case, the processor(s) used may be types ranging from general-purpose to those specialized in a certain class of computations, or even custom designed for the application at hand. A common standard class of dedicated processors is the digital signal processor (DSP)[58].

Advantages of Embedded [59]

- Easily Customizable
- Low power consumption
- Low cost

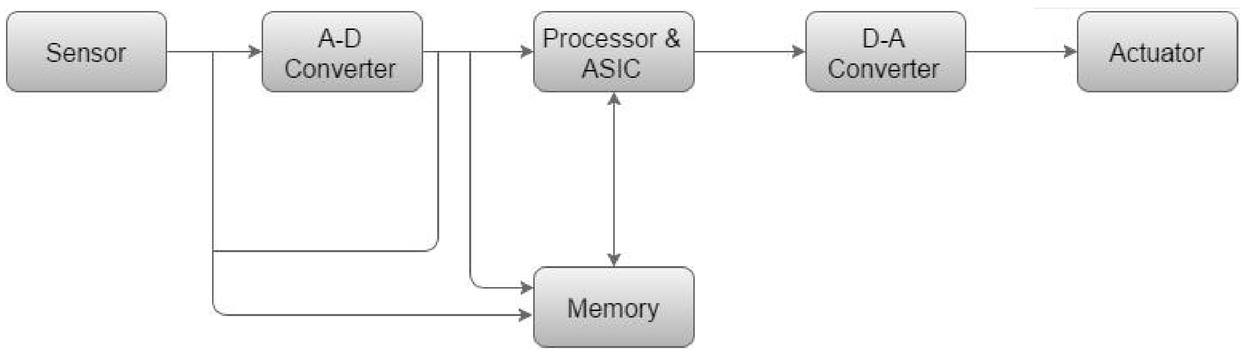
- Enhanced performance

Disadvantages of Embedded systems [59]

- High development effort
- Larger time to market
- Sdfgd

Basic Structure of an Embedded System

The following illustration shows the basic structure of an embedded system.



F. basic structure of an embedded system[59]

- **Sensor** − It measures the physical quantity and converts it to an electrical signal which can be read by an observer or by any electronic instrument like an A2D converter. A sensor stores the measured quantity to the memory[59].
- **A-D Converter** − An analog-to-digital converter converts the analog signal sent by the sensor into a digital signal[59].
- **Processor & ASICs** − Processors process the data to measure the output and store it to the memory[59].
- **D-A Converter** − A digital-to-analog converter converts the digital data fed by the processor to analog data[59].
- **Actuator** − An actuator compares the output given by the D-A Converter to the actual (expected) output stored in it and stores the approved output[59].

7.8 Cybersecurity

7.8.1 Definition

It is the protection of computer systems from the theft of or damage to their hardware, software, or electronic data, as well as from the disruption or misdirection of the services they provide.

The field is becoming more important due to increased reliance on computer systems, the Internet and wireless network standards such as Bluetooth and Wi-Fi, and due to the growth of "smart" devices, including smartphones, televisions, and the various devices that constitute the

"Internet of things". Due to its complexity, both in terms of politics and technology, cybersecurity is also one of the major challenges in the contemporary world[60].

Cybersecurity is often confused with information security but it focuses on protecting computer systems from unauthorized access or being otherwise damaged or made inaccessible. Information security is a broader category that looks to protect all information assets, whether in hard copy or in digital form[61].

The term cybercrime is used to describe an unlawful activity in which computer or computing devices such as smartphones, tablets, Personal Digital Assistants(PDAs), etc. which are stand-alone or a part of a network are used as a tool or/and target of criminal activity. It is often committed by the people of destructive and criminal mindset either for revenge, greed or adventure[62].

Combating this is a multi-disciplinary affair that spans hardware and software through to policy and people – all of it aimed at both preventing cybercrimes occurring in the first place, or minimizing its impact when it does. This is the practice of cybersecurity[63]

7.8.2 Cybersecurity checklist

Boost your cyber defenses with these must-have security measures[61]:

- **Staff awareness training:-** Human error is the leading cause of data breaches, so you need to equip staff with the knowledge to deal with the threats they face. Training courses will show staff how security threats affect them and help them apply best-practice advice to real-world situations.
- **Application security:-** Web application vulnerabilities are a common point of intrusion for cybercriminals. As applications play an increasingly critical role in business, it is vital to focus on web application security.
- **Network security:-** Network security is the process of protecting the usability and integrity of your network and data. This is achieved by conducting a network penetration test, which scans your network for vulnerabilities and security issues.
- **Leadership commitment:-** Leadership commitment is the key to cyber resilience. Without it, it is very difficult to establish or enforce effective processes. Top management must be prepared to invest in appropriate cybersecurity resources, such as awareness training.
- **Password management:-** Almost half of the UK population uses ‘password’, ‘123456’ or ‘qwerty’ as their password. You should implement a password management policy that provides guidance to ensure staff create strong passwords and keep them secure.

7.8.3 Types of cybersecurity threats

- **Ransomware:-** It is a type of malicious software. It is designed to extort money by blocking access to files or the computer system until the ransom is paid. Paying the ransom does not guarantee that the files will be recovered or the system restored[64].
- **Malware:-** itis a type of software designed to gain unauthorized access or to cause damage to a computer[64].
- **Social engineering:-** it is a tactic that adversaries use to trick you into revealing sensitive information. They can solicit a monetary payment or gain access to your confidential data. Social engineering can be combined with any of the threats listed above to make you more likely to click on links, download malware, or trust a malicious source[64].

- **Phishing:-** it is the practice of sending fraudulent emails that resemble emails from reputable sources. The aim is to steal sensitive data like credit card numbers and login information. It's the most common type of cyber attack. You can help protect yourself through education or a technology solution that filters malicious emails[64].

7.8.4 Benefits of cybersecurity

Benefits of utilizing cybersecurity include [65]:

- Business protection against malware, ransomware, phishing, and social engineering.
- Protection for data and networks.
- Prevention of unauthorized users.
- Improves recovery time after a breach.
- Protection for end-users.
- Improved confidence in the product for both developers and customers.

7.8.5 Cybersecurity vendors

Vendors in cybersecurity fields will typically use endpoint, network and advanced threat protection security as well as data loss prevention. Three commonly known cybersecurity vendors include Cisco, McAfee, and Trend Micro[65].

- Cisco tends to focus on networks and allows its customers to utilize firewalls, VPNs and advanced malware protection along with supporting email and endpoint security. Cisco also supports real-time malware blocking[65].
- McAfee makes cybersecurity products for consumers and enterprise users. McAfee supports mobile, enterprise clouds, network, web, and server-based security. Data protection and encryption are also offered[65].
- Trend Micro is an anti-malware vendor which offers threat protection for mobile, hybrid clouds, SaaS and the IoT. Trend Micro provides users with endpoint, email and web security[65].

7.9 Additive manufacturing (3D Printing)

Are “3D printing” and “additive manufacturing” (AM) the same thing? In general, we know that terms stretch over time to include more than just their default meanings. Most of us carry digital entertainment supercomputers around in our pockets and call them “phones”[66].

Whatever the name, new ways of fabricating directly from bytes to stuff are radically changing the what, where, how, and when of making objects. What roles, then, do the two terms “additive manufacturing” and “3D printing” play in describing new ways of making?[66]

Let’s start by considering what the experts have to say[66]:

- The standards organization ASTM International equates the two terms in their definition: “Additive manufacturing, also known as 3D printing, uses computer-aided design to build objects layer by layer.”
- Wikipedia says, “today, the precision, repeatability, and material range has increased to the point that 3D printing is considered as industrial production technology, with the name of additive manufacturing.”
- Author Dave Turbide puts it simply, suggesting that additive manufacturing is “the industrial version of 3D printing”.

7.9.1 3D Printing: It's All About the Printer

When MIT invented binder jet printing in the 1980s, they wrote: “three-dimensional printing is a process under development at MIT for the rapid and flexible production of prototype parts, end-use parts, and tools directly from a CAD model.”[66]

Today our concept of “3D printing” is much broader, but the term is often associated with filament-based plastic printers, which are the pride and joy of many a hobbyist and self-described maker. But there are also binder jet printers, laser metal 3D printers, as well as glass and clay 3D printers[66].

7.9.2 Additive Manufacturing: A Bytes-to-Parts Supply Chain

“Additive manufacturing” (AM) is a big-picture term more at home in the boardroom than the factory floor or garage. Naturally, AM separates itself from older, subtractive technologies like milling. Otherwise, the term is less about the 3D printer itself, and more about the manufacturing process transformed by 3D printing[66].

What is that transformation? AM changes the way we think about inventory and supply chain, taking parts from the point of manufacture to the point of use[66].

AM is flexible in the time it takes to load a file, from anywhere in the world. It enables customized parts, in volume, and involves stocking raw materials like filament and printing spare parts on demand[66].

additive manufacturing (AM) describes types of advanced manufacturing that are used to create threedimensional structures out of plastics, metals, polymers and other materials that can be sprayed through a nozzle or aggregated in a vat.1 These constructs are added layer by layer in real-time based on digital design. The simplicity and low cost of AM machines, combined with the scope of their potential creations, could profoundly alter global and local economies and affect international security[67].

3D printing (also known as additive manufacturing, AM) is a breakthrough technology that has been developing for more than 30 years but has attracted more and more attention in recent years. The American Society for Testing and Materials (ASTM) International defines AM as "A process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies". The seven major additive manufacturing processes as classified per ISO (ASTM F42) are material jetting, binder jetting, material extrusion, vat polymerization, powder bed fusion, direct energy deposition, sheet lamination. With the development of 3D printing (3DP) from rapid prototyping to the end-of-use product manufacturing process, manufacturing constraints have been greatly relieved and design freedom has been significantly expanded, including shape complexity, material complexity, hierarchical complexity, and functional complexity. In particular, 3D printing has the unique capability to control the point-line-area in geometry and material of each layer for an object at full-scale length ranging from micro to macro-scale. The emerging multi-scale and multi-material 3D printing technique possesses great potential to implement the simultaneous and full control of fabricated object which involves the external geometry, internal architecture, functional surface, material composition, and ratio as well as gradient distribution, feature size ranging from nano, micro, to macro-scale, embedded components and electro-circuit, etc. Therefore, it is able to construct the heterogeneous and hierarchical structured object with tailored properties and multiple functionalities that cannot be achieved through the existing technologies. Such technology has been considered as a revolutionary technology and next-generation manufacturing tool which can really fulfill the "creating material" and "creating life", especially subvert traditional product design and manufacturing scheme. 3D printing paves the pathway and will result in a great breakthrough in various applications, for example, functional tissue and organ, functionally graded material/structure, lattice material/structure, metamaterial, smart material, functionally embedded electronic component, bio-inspired material/ structure, multi-functionality product, soft robot, etc. Furthermore, it may promote tremendous progress in many subjects involving material, bio-medical, electronics, mechanics, bionics, aerospace, etc[68].

In the last few years, 3D printing has been utilized to fabricate electronics and structural electronics. More specifically, electronic/electrical components can be deposited and embedded in a 3D structure to form a multi-functionality product by interrupting the 3D printing process. 3D printing promotes the integrated assemblage and embedded other components as results of layer-by-layer or point-by-point characteristics. Functional elements such as sensors, circuits, and embedded components are now being integrated into 3D-printed products or structures, paving the way for exciting new markets, applications, and opportunities. Furthermore, 3D printing can be harnessed to print electronics on stretchable and flexible bio-compatible "skins" with integrated circuitry that can conform to irregularly-shaped mounting surfaces. Therefore, 3D printing electronics can offer great potential and unique capabilities to build a complex object with multiple functionalities. Particularly, it has shown the unique ability to produce embedded electronics, 3D structural electronics, conformal electronics, stretchable electronics, OLED, etc[68].

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