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SCHOOL OF ELECTRICAL AND ELECTRONICS

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

INDUSTRY 5.0 FOR ELECTRONICS ENGINEERS – SECA1406

UNIT – 1

INDUSTRY 4.0

UNIT 1 - INDUSTRY 4.0

Introduction to Industry 4.0, Industry 4.0: The Fourth Industrial Revolution, History of Industry 4.0, Industry 4.0 by definition, Component of Industry 4.0, The opportunities in Industry 4.0, Industrial Internet, Smart Factory, Smart Buildings, Smart Manufacturing, Smart Farming.

1.1 Introduction:

Industry 4.0 has been defined as "a name for the current trend of automation and data exchange in manufacturing technologies, including cyber-physical systems, the Internet of things, cloud computing and cognitive computing and creating the smart factory". Industry 4.0 refers to the rapid pace of digitization in manufacturing today. For generations, manufacturing processes and techniques have evolved and helped businesses improve their production, performance and output.

1.2 Evolution Of Industry 4.0:

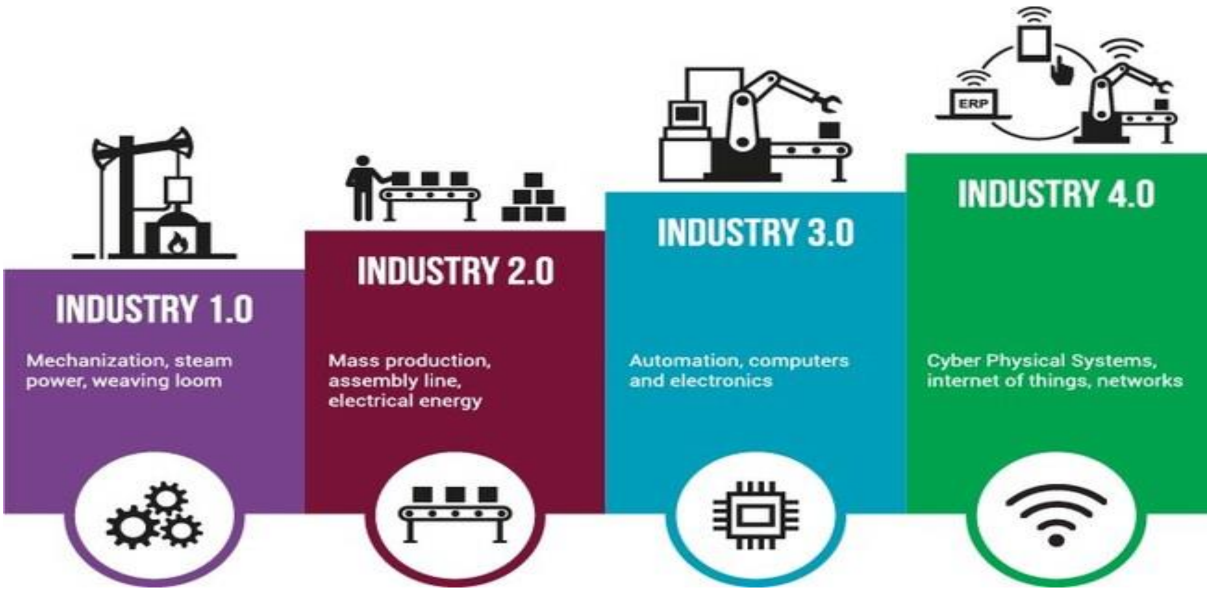

Fig1.1: Evolution of Industry4.0

Evolution of I1.0:

- The First Industrial Revolution was marked by a transition from hand production methods to machines through the use of steam power and water power.

- The implementation of new technologies took a long time, so the period which this refers to it is between 1760 and 1820, or 1840 in Europe and the United States.
- Its effects had consequences on textile manufacturing, which was first to adopt such changes, as well as iron industry, agriculture, and mining although it also had societal effects with an ever stronger middle class.

Evolution of I2.0:

- The Second Industrial Revolution, also known as the Technological Revolution, is the period between 1871 and 1914 that resulted from installations of extensive railroad and telegraph networks, which allowed for faster transfer of people and ideas, as well as electricity.
- Increasing electrification allowed for factories to develop the modern production line

Evolution of I3.0:

- The Third Industrial Revolution, also known as the Digital Revolution, occurred in the late 20th century, after the end of the two world wars, resulting from a slowdown of industrialization and technological advancement compared to previous periods.
- The production of the Z1 computer, which used binary floating-point numbers and Boolean logic, a decade later, was the beginning of more advanced digital developments.
- The next significant development in communication technologies was the supercomputer, with extensive use of computer and communication technologies in the production process; machinery began to abrogate the need for human power.

Evolution to I4.0:

- The term "Industrie 4.0", shortened to I4.0 or simply I4, originated in 2011 from a project in the high-tech strategy of the German government, which promotes the computerization of manufacturing
- The Fourth Industrial Revolution (or Industry 4.0) is the ongoing automation of traditional manufacturing and industrial practices, using modern smart technology.
- Large-scale machine-to-machine communication (M2M) and the internet of things (IoT) are integrated for increased automation, improved communication and self-

monitoring, and production of smart machines that can analyze and diagnose issues without the need for human intervention.

Benefits of Industry4.0:

- Higher Productivity
- Agile Processes
- Rapid Innovation
- Reduced Costs
- Increased Revenues
- Better workplace
- Improved Communication
- Customer Satisfaction

1.2 COMPNENTS OF INDUSTRY 4.O

- IoT
- IIoT
- Big data
- Artificial intelligence (AI)
- M2M
- Digitization
- Smart factory
- Machine learning
- Cloud computing
- Real-time data processing
- Ecosystem
- Cyber-physical systems (CPS)

- There are hundreds of concepts and terms that relate to IIoT and Industry 4.0, but here are 12 foundational words and phrases to know
- Enterprise Resource Planning (ERP): Business process management tools that can be used to manage information across an organization.
- IoT: IoT stands for Internet of Things, a concept that refers to connections between physical objects like sensors or machines and the Internet.
- IIoT: IIoT stands for the Industrial Internet of Things, a concept that refers to the connections between people, data, and machines as they relate to manufacturing.
- Big data: Big data refers to large sets of structured or unstructured data that can be compiled, stored, organized, and analyzed to reveal patterns, trends, associations, and opportunities.
- Artificial intelligence (AI): Artificial intelligence is a concept that refers to a computer's ability to perform tasks and make decisions that would historically require some level of human intelligence.
- M2M: This stands for machine-to-machine, and refers to the communication that happens between two separate machines through wireless or wired networks
- Digitization: Digitization refers to the process of collecting and converting different types of information into a digital format.
- Smart factory: A smart factory is one that invests in and leverages Industry 4.0 technology, solutions, and approaches.
- Machine learning: Machine learning refers to the ability that computers have to learn and improve on their own through artificial intelligence—without being explicitly told or programmed to do so.
- Cloud computing: Cloud computing refers to the practice of using interconnected remote servers hosted on the Internet to store, manage, and process information.
- Real-time data processing: Real-time data processing refers to the abilities of computer systems and machines to continuously and automatically process data and provide real-time or near-time outputs and insights.

- Ecosystem: An ecosystem, in terms of manufacturing, refers to the potential connectedness of your entire operation—inventory and planning, financials, customer relationships, supply chain management, and manufacturing execution.
- Cyber-physical systems (CPS): Cyber-physical systems, also sometimes known as cyber manufacturing, refers to an Industry 4.0-enabled manufacturing environment that offers real-time data collection, analysis, and transparency across every aspect of a manufacturing operation.

1.3 Smart Manufacturing Use Cases:

1. Supply chain management and optimization
2. Predictive maintenance/analytics
3. Asset tracking and optimization

1. Supply chain management and optimization—Industry 4.0 solutions give businesses greater insight, control, and data visibility across their entire supply chain. By leveraging supply chain management capabilities, companies can deliver products and services to market faster, cheaper, and with better quality to gain an advantage over less-efficient competitors
2. Predictive maintenance/analytics—Industry 4.0 solutions give manufacturers the ability to predict when potential problems are going to arise before they actually happen. Without IoT systems in place at your factory, preventive maintenance happens based on routine or time. In other words, it's a manual task. With IoT systems in place, preventive maintenance is much more automated and streamlined. Systems can sense when problems are arising or machinery needs to be fixed, and can empower you to solve potential issues before they become bigger problems. Predictive analytics allow companies to not just ask reactive questions like, "what has happened?," or "why did it happen?," but also proactive questions like, "what is going to happen," and, "what can we do to prevent it from happening?" These type of analytics can enable manufacturers to pivot from preventive maintenance to predictive maintenance.

3. Asset tracking and optimization—Industry 4.0 solutions help manufacturers become more efficient with assets at each stage of the supply chain, allowing them to keep a better pulse on inventory, quality, and optimization opportunities relating to logistics. With IoT in place at a factory, employees can get better visibility into their assets worldwide. Standard asset management tasks such as asset transfers, disposals, reclassifications, and adjustments can be streamlined and managed centrally and in real time.The point of reviewing these use cases is to help you imagine and start thinking about how smart manufacturing could be integrated into your own organization. How do you actually decide if Industry 4.0 is right for you

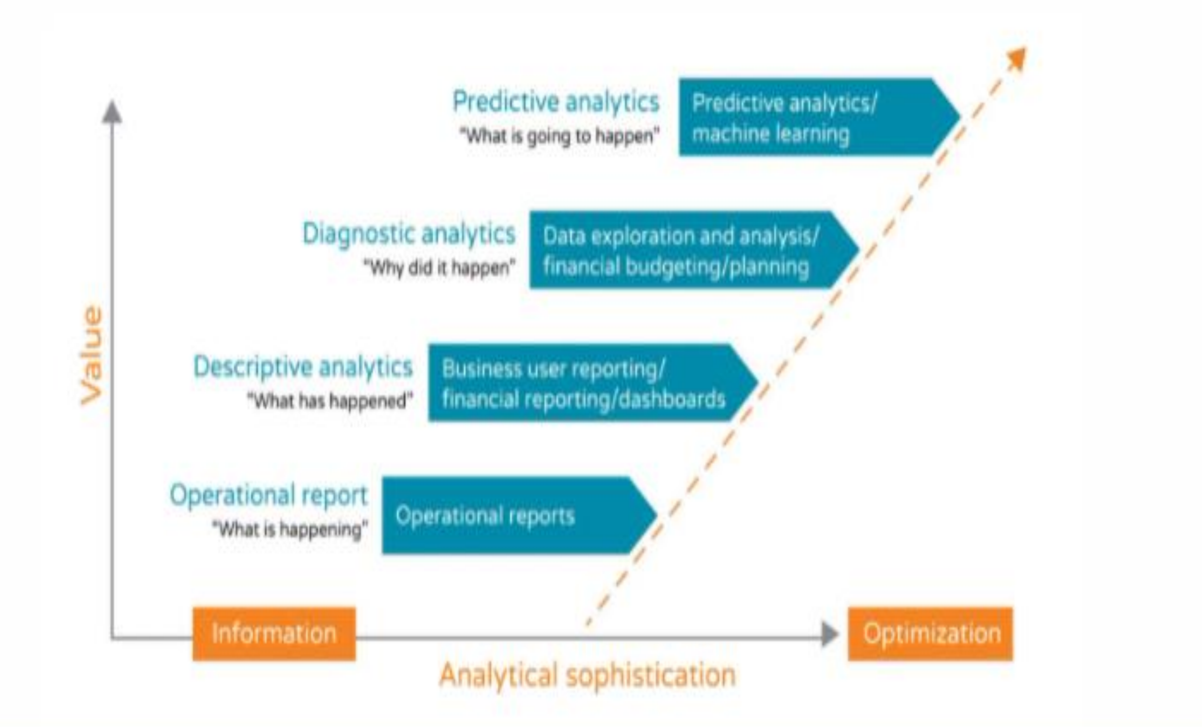

Fig 1.2: Smart Manufacturing

1.4 Benefits of Adopting an Industry 4.0 Model:

Industry 4.0 spans the entire product life cycle and supply chain— design, sales, inventory, scheduling, quality, engineering, and customer and field service. Everyone shares informed, up-to-date, relevant views of production and business processes—and much richer and more timely analytics.

1.It makes you more competitive, especially against disruptors like Amazon: As companies like Amazon continue to optimize logistics and supply chain management, you need to be investing in technology and solutions that help you improve and optimize your own operation. To stay competitive, you have to have the systems and processes in place to allow you to provide the same level of service (or better) to your customers and clients that they could be getting from a company like Amazon.

2.It makes you more attractive to the younger workforce: Companies that invest in modern, innovative Industry 4.0 technologies are better positioned to attract and retain new workers.

3.It makes your team stronger and more collaborative: Companies that invest in Industry 4.0 solutions can increase efficiency, boost collaboration between departments, enable predictive and prescriptive analytics, and allow people including operators, managers, and executives to more fully leverage real-time data and intelligence to make better decisions while managing their day-to-day responsibilities.

4.It allows you to address potential issues before they become big problems: Predictive analytics, real-time data, internet-connected machinery, and automation can all help you be more proactive when it comes to addressing and solving potential maintenance and supply chain management issues.

5.It allows you to trim costs, boost profits, and fuel growth:

Industry 4.0 technology helps you manage and optimize all aspects of your manufacturing processes and supply chain. It gives you access to the real-time data and insights you need to make smarter, faster decisions about your business, which can ultimately boost the efficiency and profitability of your entire operation.

1.5. SMART FARMING

There are many ways to refer to modern agriculture. For example, AgriTech refers to the application of technology in agriculture in general. Smart agriculture, on the other hand, is mostly used to denote the application of IoT solutions in agriculture. So what is smart agriculture using IoT? By using IoT sensors to collect environmental and machine metrics, farmers can make informed decisions, and improve just about every aspect of their work – from livestock to crop farming.For example, by using smart agriculture sensors to monitor the state of crops, farmers can define exactly how many pesticides and fertilizers they have to use to reach optimal efficiency. The same applies to the smart farming definition.

Although smart agriculture IoT, as well as industrial IoT in general, aren’t as popular as consumer connected devices; yet the market is still very dynamic. The adoption of IoT solutions for agriculture is constantly growing. Namely, COVID-19 has had a positive impact on IoT in the agriculture market share.

In fact, as per recent reports, the smart framing market share is set to reach $6.2 billion by 2021. At the same time, the global smart agriculture market size is expected to triple by 2025, reaching $15.3 billion (compared to being slightly over $5 billion back in 2016). Because the market is still developing, there is still ample opportunity for businesses willing to join in. Building IoT products for agriculture within the coming years can set you apart as an early adopter, and as such, help you pave the way to success.

The Benefits of smart farming: How’s IoT shaping agriculture:

Technologies and IoT have the potential to transform agriculture in many aspects. Namely, there are 5 ways IoT can improve agriculture:

1)Data, tons of data, collected by smart agriculture sensors, e.g. weather conditions, soil quality, crop’s growth progress or cattle’s health. This data can be used to track the state of your business in general as well as staff performance, equipment efficiency, etc.

2)Better control over the internal processes and, as a result, lower production risks. The ability to foresee the output of your production allows you to plan for better product distribution. If you know exactly how much crops you are going to harvest, you can make sure your product won’t lie around unsold.

3)Cost management and waste reduction thanks to the increased control over the production. Being able to see any anomalies in the crop growth or livestock health, you will be able to mitigate the risks of losing your yield.

4)Increased business efficiency through process automation. By using smart devices, you can automate multiple processes across your production cycle, e.g. irrigation, fertilizing, or pest control.

5)Enhanced product quality and volumes. Achieve better control over the production process and maintain higher standards of crop quality and growth capacity through automation.

As a result, all of these factors can eventually lead to higher revenue.

Things to consider before developing your smart farming:

1. The hardware

2. The brain

3. The maintenance

4. The mobility

5. The infrastructure

6. Connectivity

7. Data collection frequency

8. Data security in the agriculture industry

1.6 SMART CITIES:

A smart city is the one that uses information and communication technologies (ICT) to increase operational efficiency, share information with the public and improve both the quality of government services and citizen welfare. Smart cities use intelligent solutions to optimize infrastructure and smart and responsive governance to engage citizens in the management of their city. A system of sensors, networks, and applications collect useful data, like traffic congestion, energy use, and CO_2 levels.

What is the aim of Smart Cities?

- The purpose of the Smart Cities Mission is to drive economic growth and improve the quality of life of people by enabling local area development and harnessing technology, especially technology that leads to Smart outcomes.
- Smart cities use Internet of Things (IoT) devices such as connected sensors, lights, and meters to collect and analyze data. The cities then use this data to improve infrastructure, public utilities and services, and more.
- The four pillars of comprehensive development-institutional, physical, social and economic infrastructure.

Features of Smart Cities:

- adequate water supply
- assured electricity supply
- sanitation, including solid waste management
- efficient urban mobility and public transport
- affordable housing, especially for the poor
- robust IT connectivity and digitalization
- good governance, especially e-Governance and citizen participation

Fig 1.3: Smart Cities

1.7 .Smart Buildings

- Smart buildings use Internet of Things (IoT) devices—sensors, software, online connectivity—to monitor various building characteristics, analyze the data, and generate insights around usage patterns and trends that can be used to optimize the building's environment and operations. Smart buildings use information technology during operation to connect a variety of subsystems, which typically operate independently, so that these systems can share information to optimize total building performance.

- Smart buildings look beyond the building equipment within their four walls.

Semiconductor Solutions for IoT-Enabled Smart Buildings

- Climate control, including temperature, humidity, vibration, etc.
- CO monitoring.
- Electrical usage.
- Fire detection.
- Heating, ventilation and air conditioning systems (HVAC)
- Lighting control.
- Occupancy.

Fig1.4: SMART BUILDING

1.8 SMART MANUFACTURING:

Smart Manufacturing, often abbreviated SM in reference works and referred to as “intelligent manufacturing”, refers to a new global industrial method that relies heavily on the evolutions of the latest technologies in terms of connected means of production during the manufacturing process. In other words, it is a question of setting up systems in factories in which the machines are connected to each other, but also and above all to the Internet in order to ensure optimal and scalable control of production processes. It merges physical system and virtual system In a work environment that applies the principles of Smart Manufacturing, we seek to automate as many operations as possible so that they are carried out with maximum efficiency. The objective is to have them carried out more quickly, guaranteeing quality and profitability at a lower cost.

To do this, the central element of the type of organization is data analysis; collected directly from the equipment, it is digitally analyzed to enable the right decisions to be made and readjustments made to improve and optimize manufacturing performance. Intelligent manufacturing is one of the applications of the IoT, or more specifically of the IIOT, which is the Industrial Internet of Things.

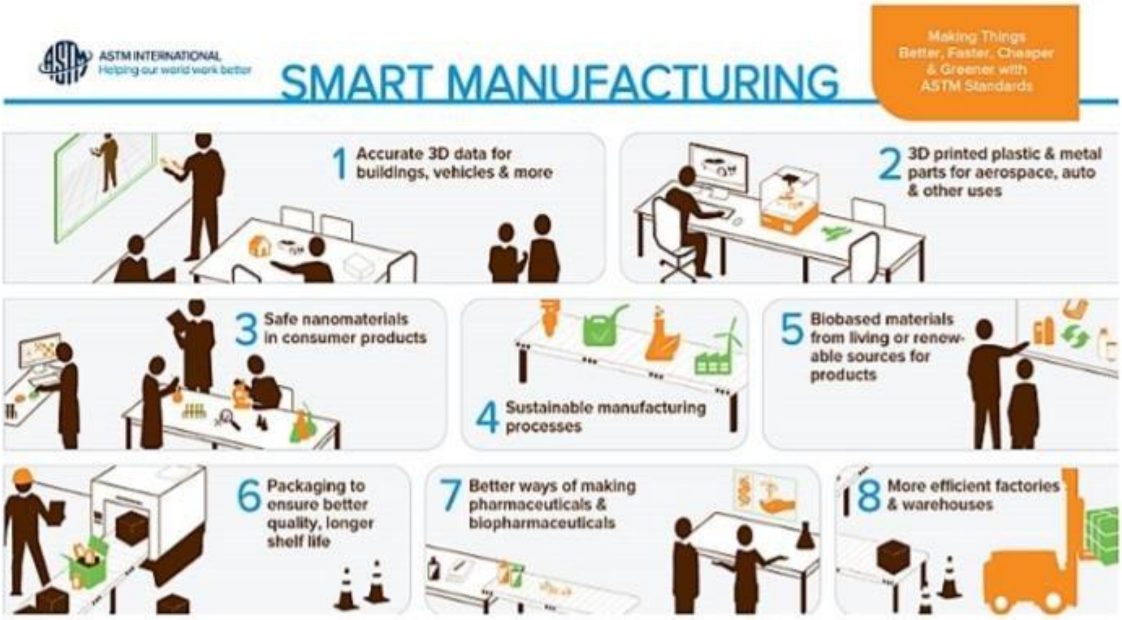

Fig 1.5: Smart Manufacturing

Smart Manufacturing: tools to support projection and improvement:

In a plant structured according to the possibilities offered by Smart Manufacturing, production benefits, on the one hand, from better data acquisition and interpretation, and on the other hand, from improvements made possible by increasingly powerful simulation and projection digital tools

The information (temperatures, speeds, fluid levels, volumes of raw materials used, etc.) collected by the sensors fitted to the machines are screened by specialists and digital officers such as data scientists. The latter analyses them using software specific to production process and planning.

This not only makes it easier and faster to detect sources of error, disruption, poor quality or slowness but also allows them to use this information to simulate processes and improve work instructions with any necessary modifications.

Which data is increasingly voluminous, and therefore hosted on often external media technologies such as the cloud. It is also one of the major characteristics of Smart Manufacturing, as is the interoperability between software. Indeed, it is essential that in such a system, the software solutions accompanying the machines can work together without there being any compatibility problems, for example. They can integrate common functionalities, collaborate and participate in ensuring communication between the means of production.

In recent years, with the emerging technologies, we have also seen the deployment of machines equipped with artificial intelligence that literally allow them to learn. They are thus able to learn from past operations themselves to readjust their behaviour. This is called machine learning.

This intelligent manufacturing is only possible if there are people such as technicians, behind to control this automation. To do this, they need digital and connected work instructions that can be accessed via high –tech tools such as tablets or connected glasses

1.9. INDUSTRIAL INTERNET OF THINGS

The industrial internet of things (IIoT) refers to the extension and use of the internet of things (IoT) in industrial sectors and applications. The industrial internet of things (IIoT) is the use of smart sensors and actuators to enhance manufacturing and industrial processes. Also known as the industrial internet or Industry 4.0, IIoT uses the power of smart machines and real-time analytics to take advantage of the data that "dumb machines" have produced in industrial settings for years. The driving philosophy behind IIoT is that smart machines are not only better than humans at capturing and analyzing data in real time, but they're also better at communicating important information that can be used to drive business decisions faster and more accurately.The IIoT encompasses industrial applications, including robotics, medical devices, and software-defined production processes.

How does IIoT work?

IIoT is a network of intelligent devices connected to form systems that monitor, collect, exchange and analyze data. Each industrial IoT ecosystem consists of:connected devices that can sense, communicate and store information about themselves;public and/or private data communications infrastructure;analytics and applications that generate business information from raw data;storage for the data that is generated by the IIoT devices; and people

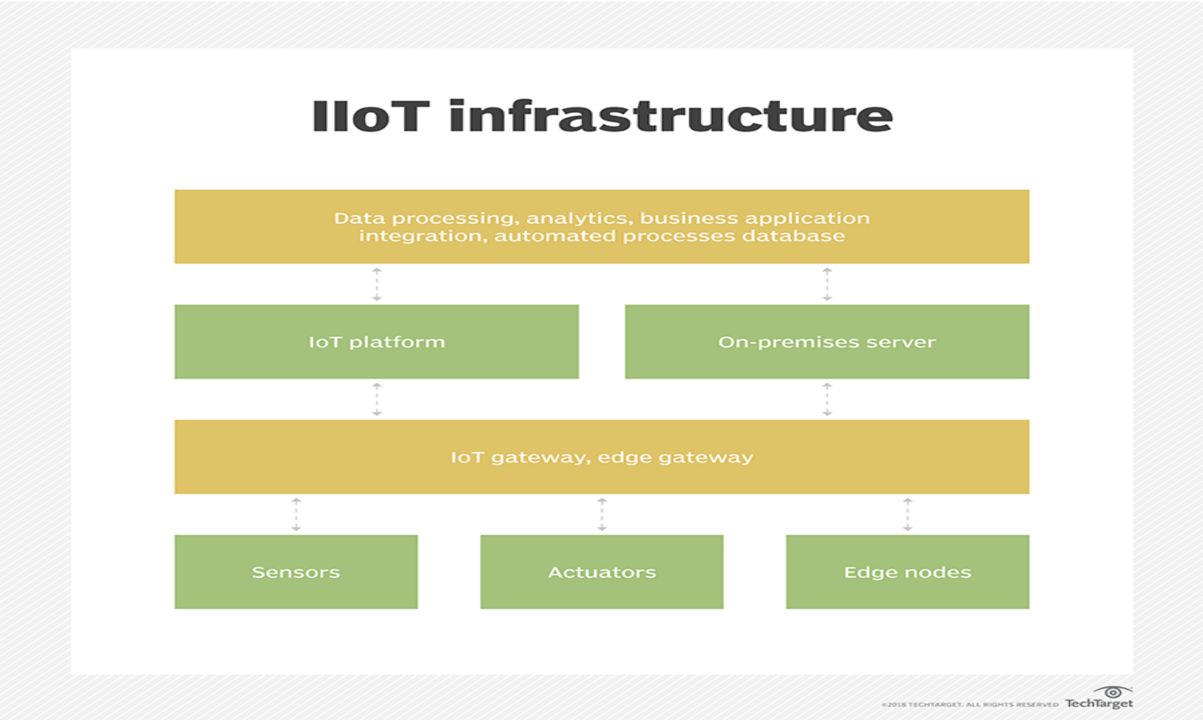

Fig.1.6: IIOT Infrastructure

The convergence of IT and OT provides industries with greater system integration in terms of automation and optimization, as well as better visibility of the supply chain and logistics. The monitoring and control of physical infrastructures in industrial operations, such as in agriculture, healthcare, manufacturing, transportation, and utilities, are made easier through the use of smart sensors and actuators as well as remote access and control.

Real-time data from sensors and other information sources helps industrial devices and infrastructures in their “decision-making,”

Machines are further enabled to take on and automate tasks that previous industrial revolutions could not handle. In a broader context, the IIoT is crucial to use cases related to connected ecosystems or environments, such as how cities become smart cities and factories become smart factories.

The consistent capturing and transmitting of data among smart devices and machines provide industries and enterprises with many growth opportunities. The data allows industries and enterprises to pick up on errors or inefficiencies in the supply chain, for example, and immediately address them, thus pushing for day-to-day efficiency in operations and finance. Proper integration of the IIoT can also optimize the use of assets, predict points of failure, and even trigger maintenance processes autonomously.

What are the security considerations and challenges in adopting the IIoT?

With IIoT implementations, three areas need to be focused on:

availability,

scalability,

security.

Availability and scalability may already be second nature to industrial operations, since they could already have been established or in the business for quite some time. Security, however, is where many can stumble when integrating the IIoT into their operations. For one thing, many businesses still use legacy systems and processes

Also, the proliferation of smart devices has given rise to security vulnerabilities and the concern of security accountability. IIoT adopters have the de facto responsibility of securing the setup and use of their connected devices, but device manufacturers have the obligation of protecting their consumers when they roll out their products.

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What are the risks to IIoT systems?

Software vulnerabilities that can be exploited to attack systems.

Publicly searchable internet-connected devices and systems.

Malicious activities like hacking, targeted attacks, and data breaches.

System manipulation that can cause operational disruption (e.g., product recalls) or sabotage processes (e.g., production line stoppage).

System malfunction that can result in damage of devices and physical facilities or injury to operators or people nearby.

OT systems held for extortion, as compromised through the IT environment.

Securing IIoT systems therefore requires connected threat defense and end-to-end protection, from the gateway to the endpoint, that are able to provide:

Regular monitoring and detection in case of malware infection.

Better threat visibility and early detection of anomalies.

Proactive prevention of threats and attacks between IT and OT.

Secure data transfer.

A next-generation IPS to prevent attacks from exploiting vulnerabilities.

Server and application protection across the data center and the cloud

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Question Bank

PART-A

1.Define Industry4.0

2. List the benefits of Industry4.0

3. Define AgriTech and Smart agriculture

4. Explain the working principle of PIR sensor

5.Explain the components of Industry4.0

6. What is a smart building

7. What are the things to be considered before starting a smart farming

8. Differentiate between IoT and IIoT

9.Define smart Cities and give some examples of smart cities in the world

10.Define smart Parking

PART-B

1. Explain the evolution of Industry4.0

2. Explain Smart Farming

3. Explain IoT based smart Irrigation

4. Explain IIoT in detail

5.Explain the benefits of adapting industry4.0

6.Explain Smart building

7.Expain Smart Manufacturing

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UNIT – 2

INDUSTRY 5.0

2. INDUSTRY 5.0

Evolution from Industry 1.0 to 5.0, Introduction to Industry 5.0, Globalization and Emerging Issues, LEAN Production Systems, Smart and Connected Business Perspective, Smart Factories, Healthcare and Human computer interactions, Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Big Data and Advanced Analysis.

2.1 Evolution from Industry 1.0 to 5.0

Industry 5.0 is transformation of the manufacturing sector to a modern manufacturing so that man and machine can perform work hand in hand to achieve more and faster outcomes. This industry revolution improves customer satisfaction by making personalized products. Industry 5.0 with digital technologies creates a new paradigm in manufacturing and supply chain management. Machin learning and artificial intelligent analyze big data in manufacturing to solve complex problems. In the modern business with a rapid technological advancements and globalizations IoT and Industry 5.0 phenomenon are major requirement of competitive advantage and economic growth. Robots used in this revolutions help human to provide higher accuracy in computing and forecasting in industrial automation systems. In the era of technology, mass personalization and smart manufacturing is experiencing a rapid transformation and robots play an important role with the help of human mind.

The modern industry has seen great advances since its earliest iteration at the beginning of the industrial revolution in the 18th century. For centuries, most of the goods including weapons, tools, food, clothing and housing, were manufactured by hand or by using work animals. This changed in the end of the 18th century with the introduction of manufacturing processes. The progress from Industry 1.0 was then rapid uphill climb leading up to the upcoming industrial era – Industry 4.0. Here we discuss the overview of this evolution.

2.1.1 Industry 1.0

The late 18th century introduced mechanical production facilities to the world. Water and steam powered machines were developed to help workers in the mass production of goods. The first weaving loom was introduced in 1784. With the increase in production efficiency and scale, small businesses grew from serving a limited number of customers to large organizations with owners, manager and employees serving a larger number. Industry 1.0 can also be deemed as the beginning of the industry culture which focused equally on quality, efficiency and scale.

2.1.2 Industry 2.0

The beginning of 20th century marked the start of the second industrial revolution – Industry 2.0. The main contributor to this revolution was the development of machines running on electrical energy. Electrical energy was already being used as a primary source of power. Electrical ma- chines were more efficient to operate and maintain, both in terms of cost and effort unlike the water and steam based machines which were comparatively inefficient and resource hungry. The first assembly line was also built during this era, further streamlining the process of mass production. Mass production of goods using assembly line became a standard practice.

This era also saw the evolution of the industry culture introduced in Industry 1.0 into management program to enhance the efficiency of manufacturing facilities. Various production management techniques such as division of labor, just-in-time manufacturing and lean manufacturing principles refined the underlying processes leading to improved quality and output. American mechanical engineer Fredrick Taylor introduced the study of approached to optimize worker, workplace techniques and optimal allocation of resources.

2.1.3 Industry 3.0

The next industrial revolution resulting in Industry 3.0 was brought about and spurred by the advances in the electronics industry in the last few decades of the 20th century. The invention and manufacturing of a variety electronic devices including transistor and integrated circuits auto- mated the machines substantially which resulted in reduced effort, increased speed, greater accuracy and even complete replacement of the human agent in some cases. Programmable Logic Controller (PLC), which was first built in 1960s was one of the landmark invention that signified automation using electronics. The integration of electronics hardware into the manufacturing systems also created a requirement of software systems to enable these electronic devices, consequentially fueling the software development market as well. Apart from controlling the hardware, the software systems also enabled many management processes such as enterprise resource planning, inventory management, shipping logistics, product flow scheduling and tracking throughout the factory. The entire industry was further automated using electronics and IT. The automation processes and software systems have continuously evolved with the advances in the electronics and IT industry since then. The pressure to further reduce costs forced many manufacturers to move to low-cost countries. The dispersion of geographical location of manufacturing led to the formation of the concept of Supply Chain Management.

2.1.4 Industry 4.0

The boom in the Internet and telecommunication industry in the 1990's revolutionized the way we connected and exchanged information. It also resulted in paradigm changes in the manufacturing industry and traditional production operations merging the boundaries of the physical and the virtual world. Cyber Physical Systems (CPSs) have further blurred this boundary resulting in numerous rapid technological disruptions in the industry. CPSs allow the machines to communicate more intelligently with each other with almost no physical or geographical barriers.

The Industry 4.0 using Cyber Physical Systems to share, analyze and guide intelligent actions for various processes in the industry to make the machines smarter. These smart machines can continuously monitor, detect and predict faults to suggest preventive measures and remedial action. This allows better preparedness and lower downtime for industries. The same dynamic approach can be translated to other aspects in the industry such as logistics, production scheduling, optimization of throughput times, quality control, capacity utilization and efficiency boosting. CPPs also allow an industry to be completely virtually visualized, monitored and managed from a remote location and thus adding a new dimension to the manufacturing process. It puts machines,people, processes and infrastructure into a single networked loop making the overall management highly efficient.

2.1.5 Industry 5.0

Industry 5.0 is a new production model where the focus lies on the interaction between humans and machines. Industry 5.0 takes the next step, which involves leveraging the collaboration between increasingly powerful and accurate machinery and the unique creative potential of the human being. The changes set in motion by Industry 5.0 are already irreversible. This process offers companies the abilities of increasingly powerful machines in combination with better-trained experts to foster an effective, sustainable and safe production.

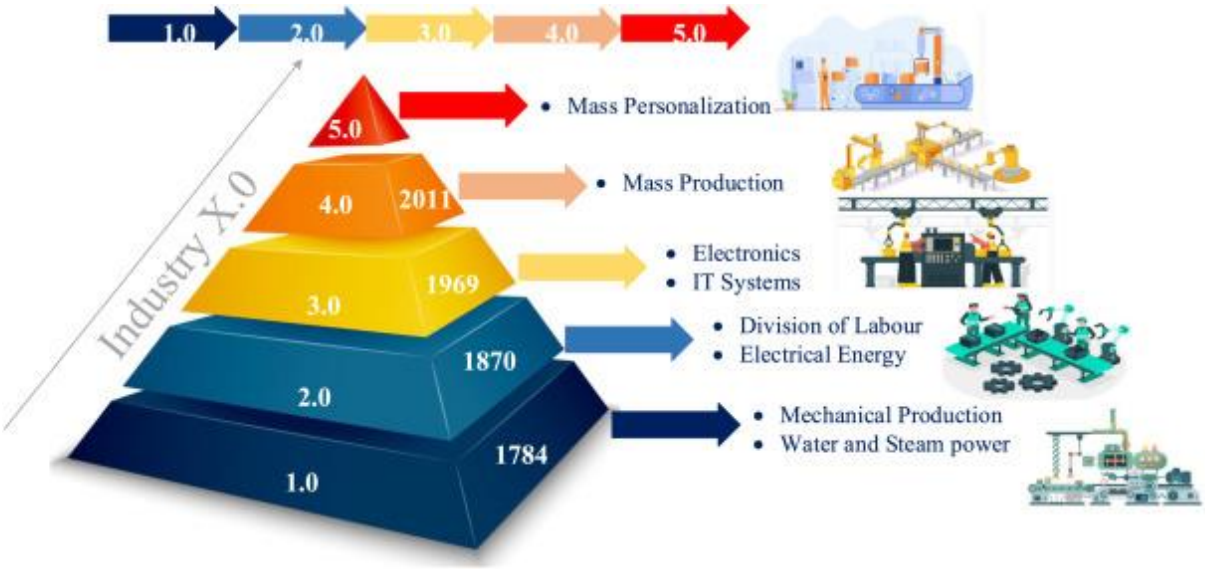

Figure 2.1 Evolution from I 1.0 to I 5.0

Industry 5.0 is not a fad, but rather a new way of understanding manufacturing that has productive, economic and commercial consequences. Therefore, companies that do not tailor their production to the factory 5.0 model will soon become obsolete, being unable to benefit from the competitive advantages that it has to offer.

Not only that: the rate of technological acceleration is increasingly faster and shows that the emergence of new paradigms never stops. For this reason, adjusting the processes of each company and transforming them into the concept of digital industry will be vital in guaranteeing that an organization remains competitive.

2.2 Introduction to Industry 5.0

Currently in the midst of the fourth industrial revolution. A new technological and economic vision that propels us forward. But one thing still needs to be examined – how is this revolution affecting human lives and jobs. With more and more automation, workers are asking themselves if they will be replaced by machines completely. While Industry 4.0 was an initiative introduced by the German government in 2011 to promote smart manufacturing for the future, Industry 5.0 is an idea and a vision promoted by the European Union that aims to go beyond efficiency and productivity as the main goal. Industry 4.0 is the revolution of connectivity. A digital transformation that connects us through "smart" technologies like cyber-physical systems, the cloud, artificial intelligence, and the internet of things. Much less effort and focus have been given to issues of sustainability, and the effect of this revolution on people's lives.

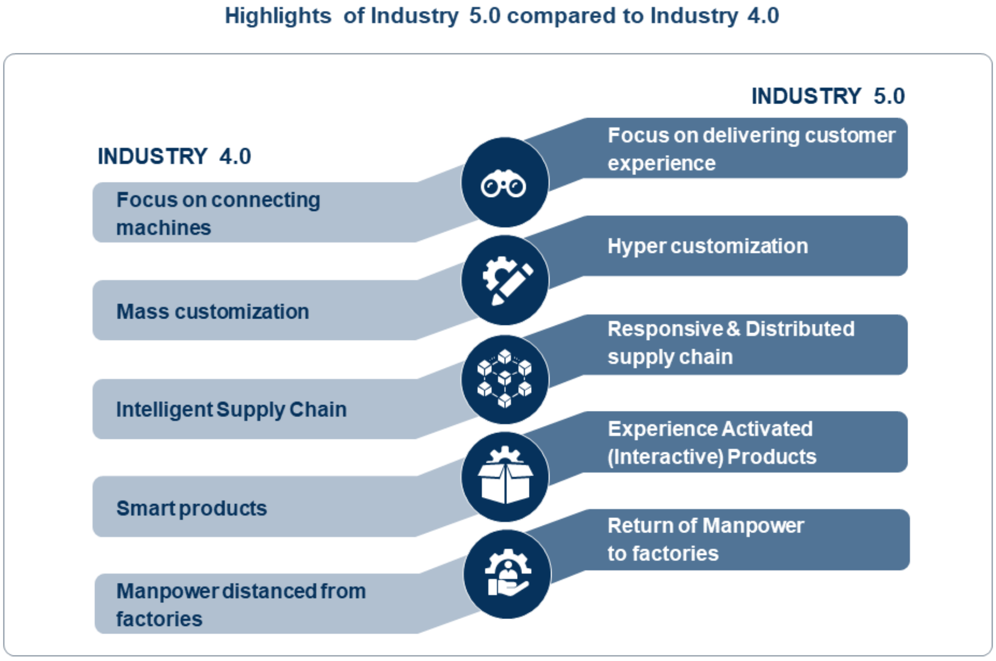

Figure 2.2 Highlights of Industry 5.0 compared to Industry 4.0

Industry 5.0 describes a new outlook on how the industry can add value to society, and how it can be used to better our lives. It is an extension of Industry 4.0. It is a vision of human-robot cooperation, co-working, and sustainability A way of using smart manufacturing, automation, and robotics, not only to benefit the industry, but also the workers, and society as a whole. But, in order to reach this vision, many companies still need to join Industry 4.0 and connect their industrial machines. A human-centered approach to manufacturing and selling products and produce is the proposition here. A reciprocal relationship between a human and a computer is at the heart of this kind of humanistic intelligence – the computer is not totally separate from the human, but it is rather a "second brain". The same goes in reverse – the human is viewed as a peripheral for the computer.

2.3 Globalization and Emerging Issues

The problems that Industry 5.0 can address are pollution, health care, sustainable manufacturing, power consumption and management, and more. Just imagine, with the current technology, and the infrastructure of cities in place, we can successfully manage traffic flow better, enable efficient recycling programs, produce food locally, and add more energy sustainable power sources. The quality of life for everyone within this improved Industry 5.0 environment would grow to new heights.

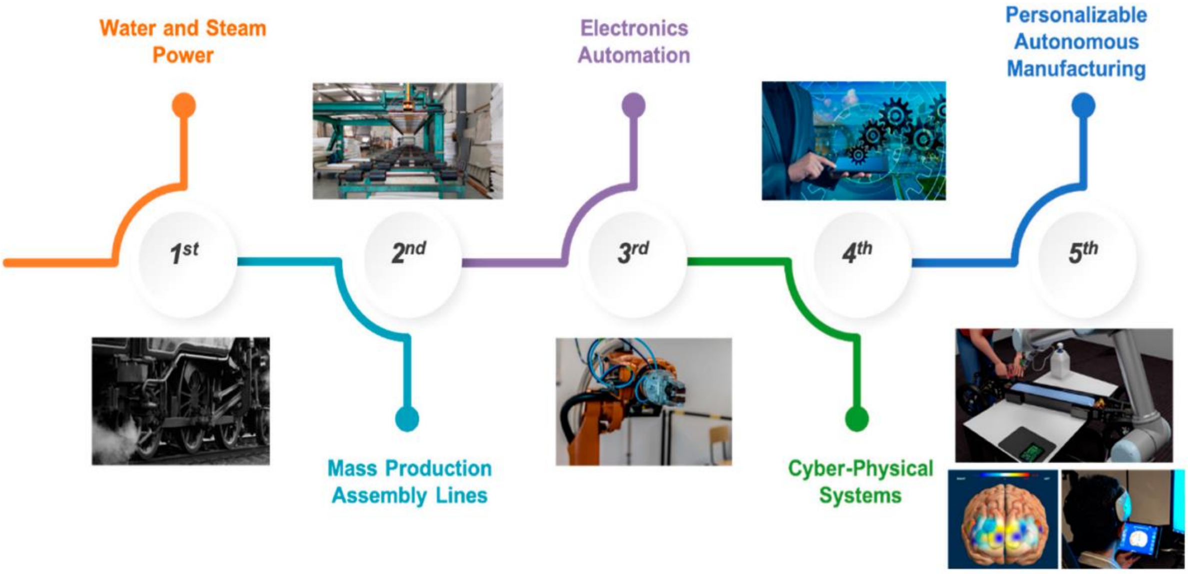

Figure 2.3 Industry 5.0

Some key challenges in manufacturing after realization of Industry 4.0 potential are lack of a clear digital vision, fostering a strong digital culture, data security, Level of digitization, a lack of data analytical capabilities, lack of standardization, prevalence of proprietary standards is going to be a key.

2.3.1 High Rate of Failure:

The difficulty in launching Industry 5.0 initiatives is that there is often a lack of direction when it comes to establishing objectives. They are often cross-functional projects with many stakeholders, which can mean projects can become mired in conflicting goals, and may simply sputter out.

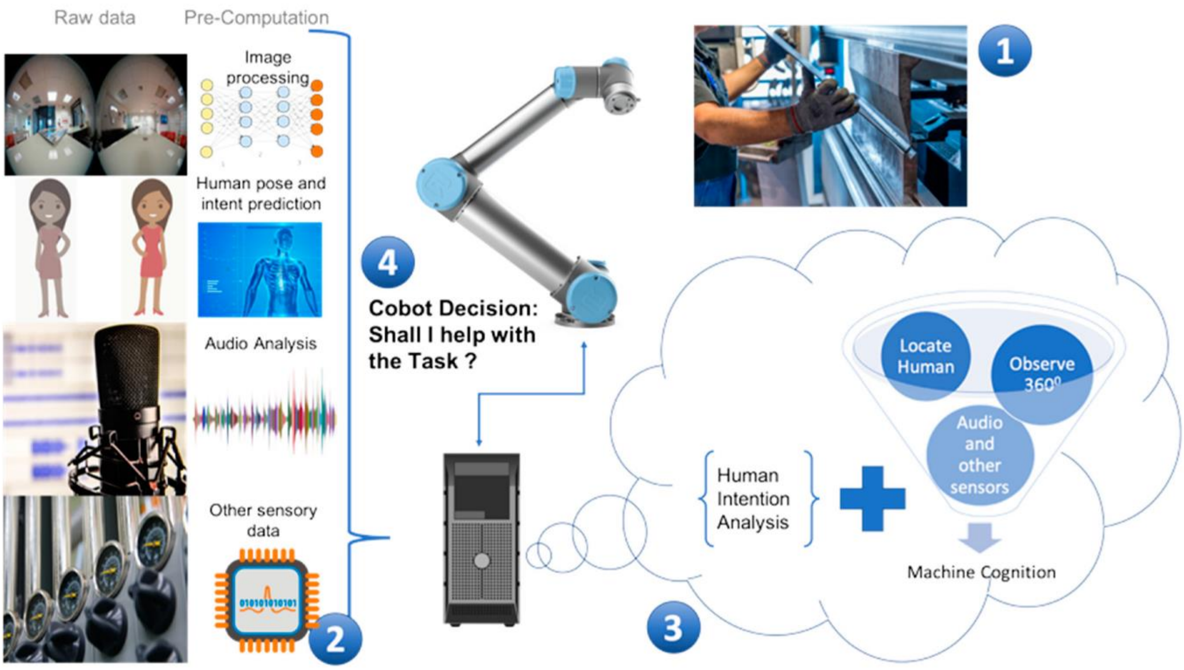

Figure 2.4 Challenges in Industry 5.0

Figure 2.5 Why Industry 5.0?

2.3.2 Barriers to digital transformation

- lack of skills or talent to manage complex Industry 4.0 structures
- concerns regarding cyber security
- other priorities for capital expenditure
- lack of appropriate digital infrastructure
- lack of knowledge of digitalisation and how it can help the business

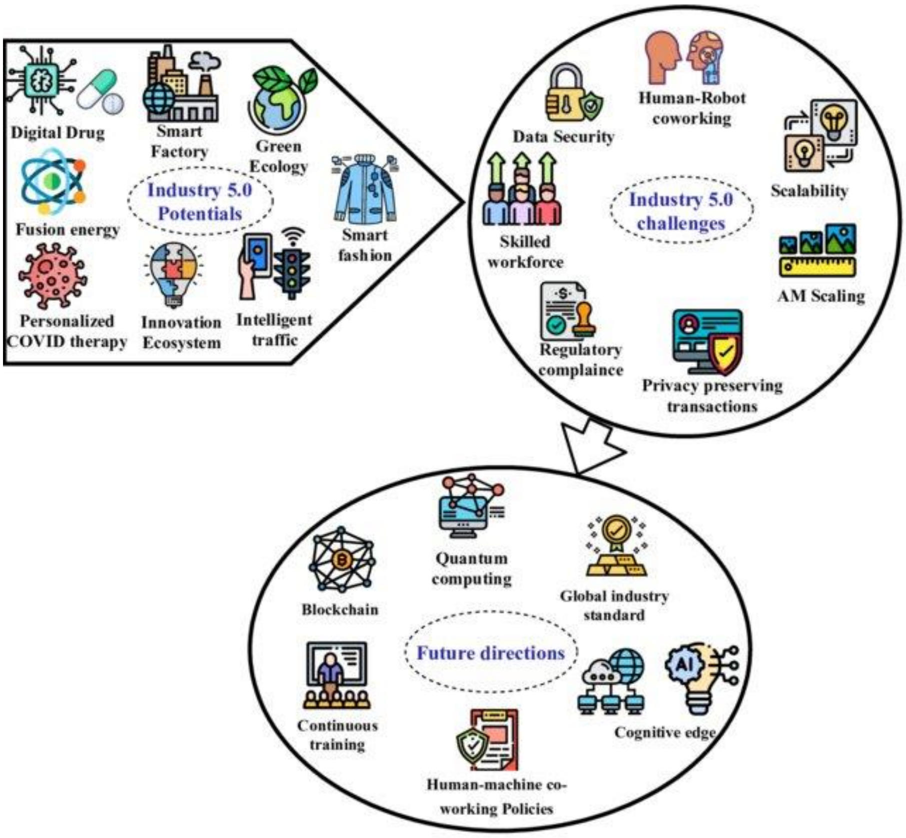

Figure 2.6 Challenges in Industry 5.0

2.3.3 Emerging Challenges and Issues

Outdated processes:

With everything connected digitally, it is challenging to rely on traditional paper-based processes and operate in silos; there is no longer a place for manual, time-consuming processes. To be efficient and provide front-line industrial workers the necessary information at the right time and at the right place, companies need to reimagine and reinvent their outdated processes with modern, "mobile-first" digital solutions that replace outdated and error-prone paper-based processes.

Organizational resistance to change:

Where does your organization sit on change? Most employees are so entrenched in traditional processes of daily duties that, when the time comes to improve processes and incorporate new technology, they resist. They see change management as a challenge to their roles/responsibilities, at best, and a threat to their job security, at worst. To deal with this, organizations should partner with technology companies that don’t merely focus on a software implementation and disappear. Software vendors that understand the correlation between user adoption and ROI will bring Organizational Change Management (OCM) best practices either through their implementation competencies or within their productized solutions via gamification, leader boards and in build end-user training and certifications.

Legacy business model:

Organizations have become very comfortable with their legacy systems. They need to leave this comfort zone, revamp their business model, and proceed ahead for more efficient and faster time-to-market digital solutions that use cloud, mobile, smart wearables and APIs to connect to anything and everything. To achieve this, organizations should consider best in class connected worker platforms that have a long term vision of the world where they focus on productivity, safety, compliance, analytics, autonomous models and powered by a unique code-free platform to support rapid scaling of their strategy and software.

Upskilling employees:

Most of the front-line workers in asset-intensive industries are baby-boomers who are non-tech-savvy. They need a well-designed, intuitive digital solution that will increase productivity and engagement while minimizing training time. Mobile solutions encourage employees to perform business transactions on the fly. This mobility enables real-time transaction processing, improves data accuracy, and increases convenience.

Lack of automation:

The value of automation lies in eliminating redundancies and time-consuming tasks. By embracing the right digital solution, organizations can automate and say goodbye to manual tasks, allowing for faster product updates and response times.

To achieve digital transformation and connected worker strategy goals, organizations need to define their digital strategy and methodically transform their business functions, including front-line operations. Forward-looking companies are turning to mobile technologies, smart glasses, AI/ML with superior user experience to increase employee productivity, sales revenues, and digitize redundant paper-based processes.

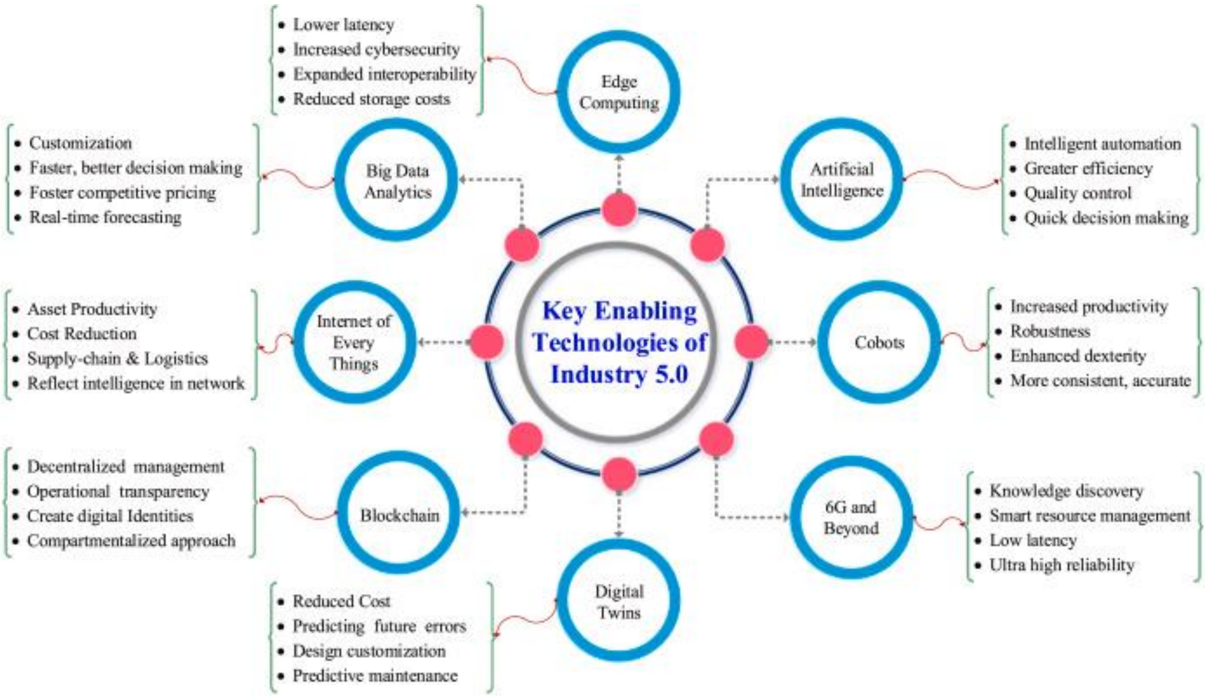

Figure 2.7 Key Enabling technologies of Industry 5.0

2.4 LEAN Production Systems

Lean manufacturing is a production process based on an ideology of maximising productivity while simultaneously minimising waste within a manufacturing operation. The lean principle sees waste is anything that doesn't add value that the customers are willing to pay for. Some examples of this Lean manufacturing principle include: Pair programming: Avoiding quality issues by combining the skills and experience of two developers instead of one. Test-driven development: Writing criteria for a product/feature/part before creating it to ensure it meets business requirements. Lean operations is a means of running an organization by focusing on providing greater customer satisfaction while using as few resources as possible. The objective of lean operations is twofold: Creating value for customers and eliminating waste. Companies that use lean operations are highly concerned with efficiency.

Lean production focuses on stripping waste out of business processes and flowing product or information through faster with less waiting and holds ups. By removing this waste, you can get more done with no or little extra people and resource, thus improving efficiency. Three categories of loss are tracked: down time, slow cycles and rejects. This lean technique establishes a baseline and gives you a means to track progress in eliminating waste from a manufacturing process.

Lean manufacturing improves efficiency, reduces waste, and increases productivity. The benefits, therefore, are manifold: Increased product quality: Improved efficiency frees up employees and resources for innovation and quality control that would have previously been wasted.

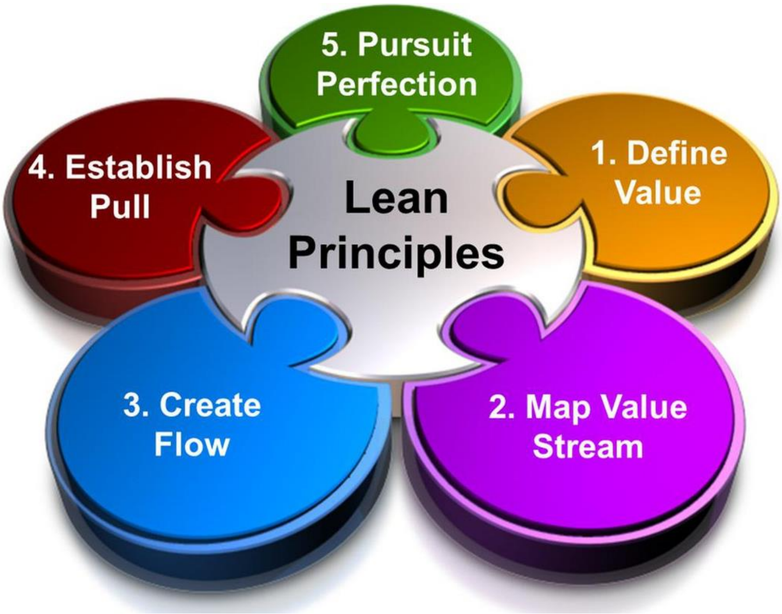

Figure 2.8 Lean Principles

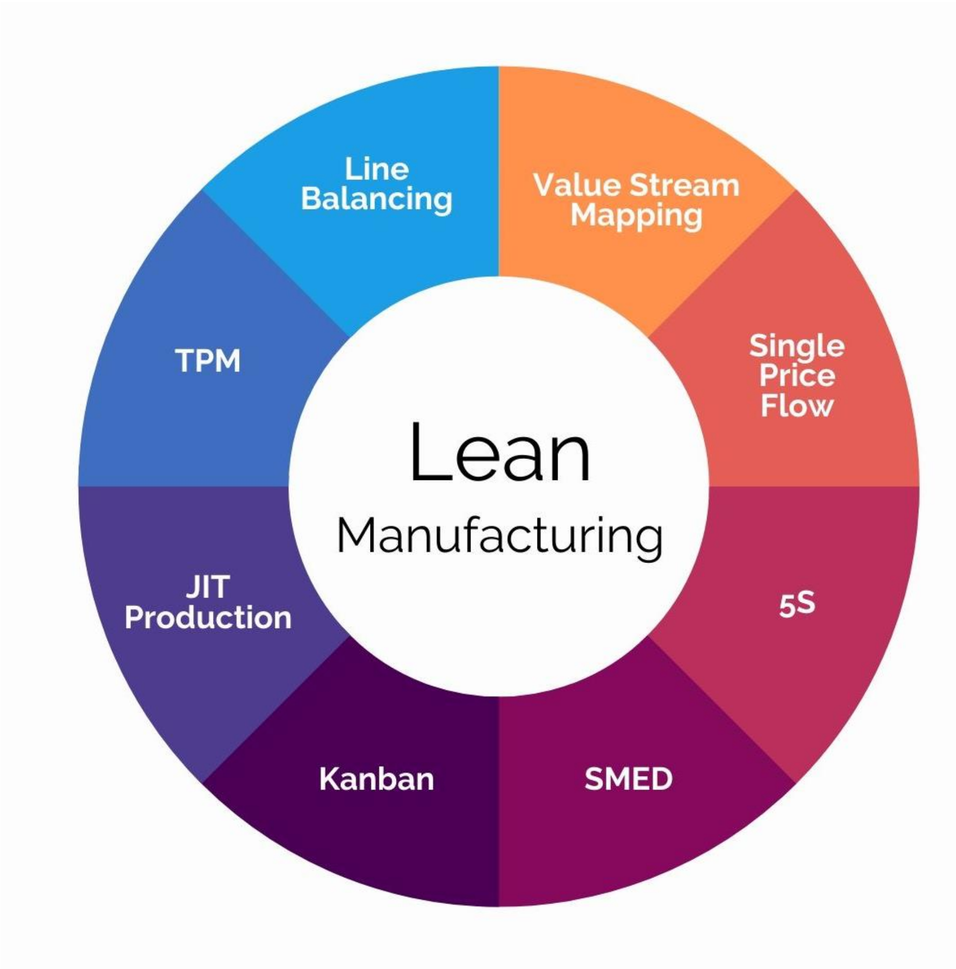

Figure 2.9 LEAN Manufacturing

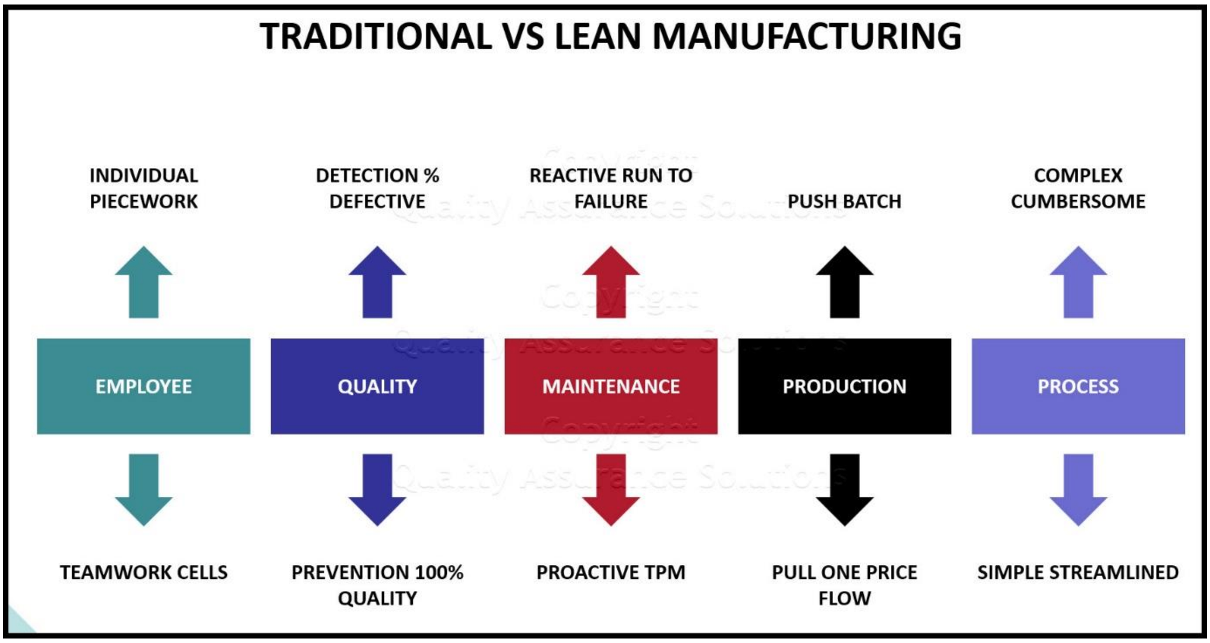

Figure 2.10 Traditional vs LEAN

Figure 2.11 5S Explanation

Wasting Waste

The first goal is to take all the unnecessary and costly parts in a company. The waste needs to be taken out and shed.

For Lean Manufacturing, waste is something that takes away resources, costs, and time without adding anything of value.

Quality Improvement

Quality is another top priority.

The idea is that customers have ever changing wants and needs.

Thus, a company should not rest on their laurels.

They should continuously strive to improve in order to keep up with the demands of the client.

One way to do so is to always strive to improve the quality of a product or service being offered.

Save on Time = Save on Cost

Time is one of the most important resources.

It applies to all people and even businesses. The Lean Manufacturing methodology acknowledges this.

Any wasted time is a wasted opportunity for making any money.

People who run and operate businesses should always strive to speed up how long it takes to finish projects.

The five principles are considered a recipe for improving workplace efficiency and include:

1) defining value
2) mapping the value stream
3) creating flow
4) using a pull system
5) pursuing perfection

2.5 Smart and Connected Business Perspective

Smart, connected products enable the comprehensive monitoring of a product's condition, operation, and external environment through sensors and external data sources. Using data, a product can alert users or others to changes in circumstances or performance. Connectivity type could be Bluetooth, LTE, Wifi or wired. Smart and connected are used together. A smart and connected refrigerator can notify you on your smart phone that milk is over, some can even order online all by itself. They can also play music and movies, you can also use Facebook and twitter. Faster, more effective product updates and development. Cheaper, more efficient maintenance and repair. A connected, or “smart,” product is a device that is linked to the Internet so it can share information about itself, its environment and its users. While the terms “smart” and “connected” are often used synonymously, they're not quite the same thing. Connected devices are connected to the Internet in order to exchange information, while smart devices aim to make users' lives easier in some way. A smart device is an electronic device, generally connected to other devices or networks via different wireless protocols such as Bluetooth, Zigbee, NFC, Wi-Fi, LiFi, 5G, etc., that can operate to some extent interactively and autonomously.

2.4.1 Smart Factories

The smart factory is a concept used to describe the application of different combinations of modern technologies to create a hyperflexible, self-adapting manufacturing capability. ... Smart factory initiatives might also be referred to as "digital factory" or "intelligent factory."

Concept deriving from IIoT that envisages a production environment as a fully automatized and intelligent network of systems that enables facilities, machines and logistics chains within the manufacturing plant to be managed without human intervention.

A smart factory is a highly digitalized and networked manufacturing plant. It is based on smart manufacturing with the aim of creating production facilities that are completely self-organizing and optimized. They include manufacturing plants as well as logistics systems, planning environments, and product development. The defining characteristics of the smart factory are visibility, connectivity and autonomy. Factories have long relied on automation, but smart factories take this concept much further and are able to run without much human intervention. A smart factory is a digitised manufacturing facility that uses connected devices, machinery and production systems to continuously collect and share data. This data is then used to inform decisions to improve processes as well as address any issues that may arise.

Smart factories optimize efficiency and productivity by extending the capabilities of both manufacturing devices and people. ... By continuously improving the productivity of manufacturing processes, smart factories can lower costs, reduce downtime and minimize waste. While terms such as smart factory and smart manufacturing are globally used, smart industry is more used in specific countries and essentially is a synonym of Industry 5.0, which in turn is also known as Industrial Internet or Industrial Internet of Things.

The Smart Factory is a concept for expressing the end goal of digitization in manufacturing. The way the term is most commonly used, a Smart Factory is a highly digitized shop floor that continuously collects and shares data through connected machines, devices, and production systems. The data can then be used by self-optimizing devices or across the organization to proactively address issues, improve manufacturing processes and respond to new demands. Various technologies such as AI, Big Data Analytics, Cloud Computing, and Industrial IoT (Internet of Things) have made smart manufacturing practices fully comprehensive. By connecting the physical and digital world, smart factories can monitor the entire production process, from manufacturing tools and the supply chain to individual operators on the shop floor.

When fully realized, Smart factories use fully integrated, collaborative manufacturing systems to make operations flexible, adaptable, and optimizable.

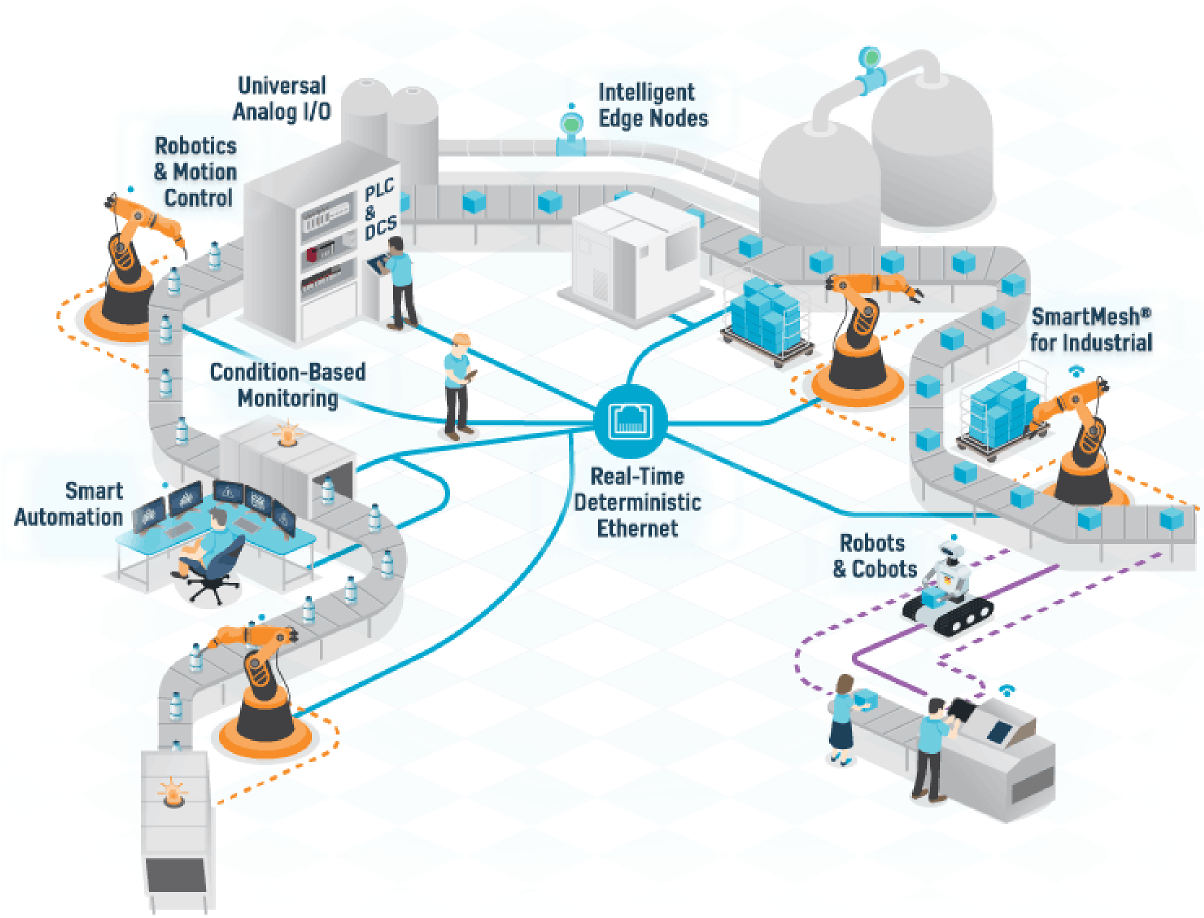

Figure 2.12 Smart factory

Wireless sensor networks is connecting the machines, tooling, materials or any production surfaces, like conveyor belts all the assets involved in the manufacturing processes can be traced in real time granting their full visibility to the operators throughout the whole production chain.

Figure 2.13 Industrial 5G

Figure 2.14 Smart factory solution

2.5.1 Industrial IoT (IIoT)

Industrial IoT refers to interconnected devices, machines, and/or processes that are linked by data communication systems to facilitate the exchange and the use of data between people and machines. Typically, these instruments have sensors that collect meaningful data points on a cloud or off-line database for tracking and identifying ways to improve the manufacturing process. Industrial IoT enables operational efficiency, control, and visibility into actionable key metrics.

Industry 5.0 Technology in Smart Factories

- Robotics and automation
- Additive manufacturing (AM) and 3D printing
- The Internet of Things

2.5.2 Robotics and automation

besides the famous Amazon warehouse robot, robotics also include collaborative robots.

"Cobots" are designed to work alongside their human operators, who "teach" them what to do and in what order

Cobots then optimize the steps to improve outcomes

Automation is constantly improving as well, in every sector from the auto industry and plastics, to food and consumer goods

2.5.3 The Internet of Things

The IoT is the potentially giant network of computers, machines and systems that "talk" to each other through exchange of data over the Internet

One example of the IoT at work is the smart home, with appliances, HVAC systems and security systems all connected to each other and controlled remotely from your device

2.6 Healthcare and Human computer interactions

Health care is the maintenance or improvement of health via the prevention, diagnosis, treatment, amelioration, or cure of disease, illness, injury, and other physical and mental impairments in people. Concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them multidisciplinary field of study focusing on the design of computer technology and, in particular, the interaction between humans (the users) and computers. computer science and software engineering as well as ergonomics, graphic and industrial design, sociology, anthropology and educational sciences.

Human-Computer Interaction (HCI) has four main components:

- the user
- Task
- tools / interface
- the context

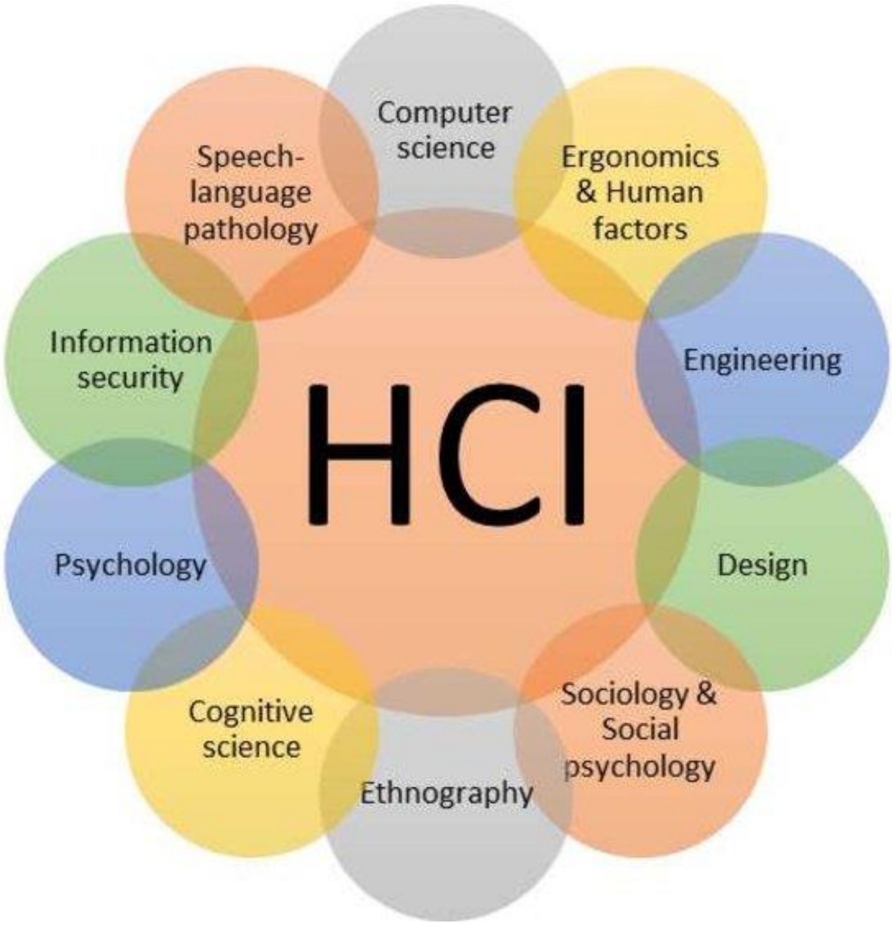

Figure 2.15 Human Computer Interaction

Humans interact with computers through a user interface. This includes software, such as what is displayed on the computer monitor, and hardware, such as the mouse, keyboard and other peripheral devices. In a corporate or factory setting, a poor user interface could have more severe consequences.

2.7 Next Generation Sensors

A sensor is a device that detects the change in the environment and responds to some output on the other system. A sensor converts a physical phenomenon into a measurable analog voltage (or sometimes a digital signal) converted into a human-readable display or transmitted for reading or further processing. Sensors are used to measure temperature, gauge distance, detect smoke, regulate pressure and a myriad of other uses. Because analog signals are continuous, they can account for the slightest change in the physical variable (such as temperature or pressure).

We live in a World of Sensors. You can find different types of Sensors in our homes, offices, cars etc. working to make our lives easier by turning on the lights by detecting our presence, adjusting the room temperature, detect smoke or fire, make us delicious coffee, open garage doors as soon as our car is near the door and many other tasks. All these and many other automation tasks are possible because of Sensors.

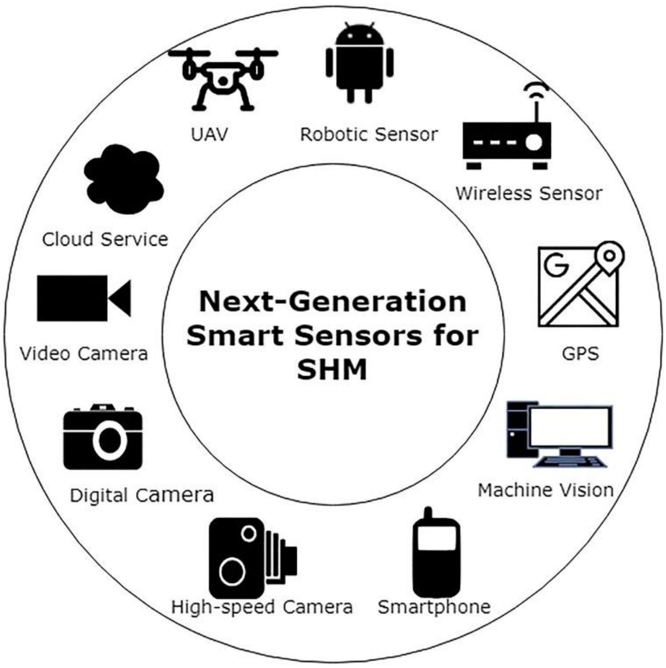

Figure 2.16 Next Generation Sensors

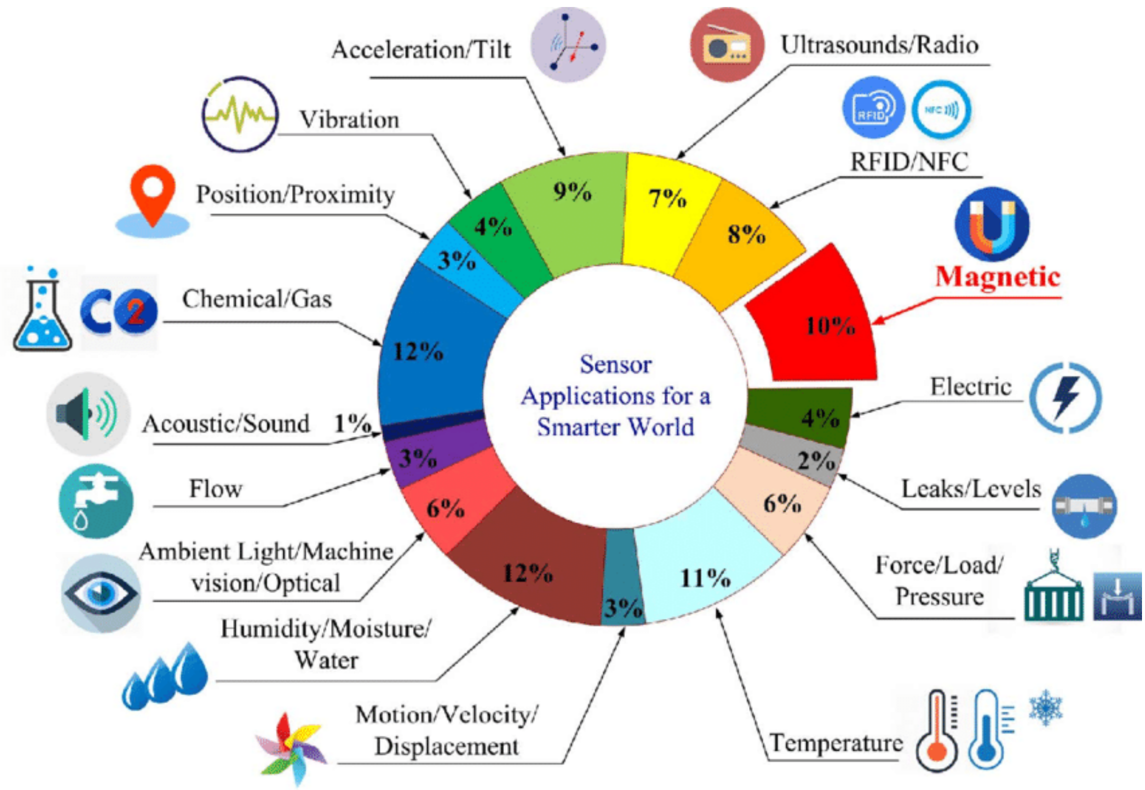

Figure 2.17 Applications of sensors in smart world

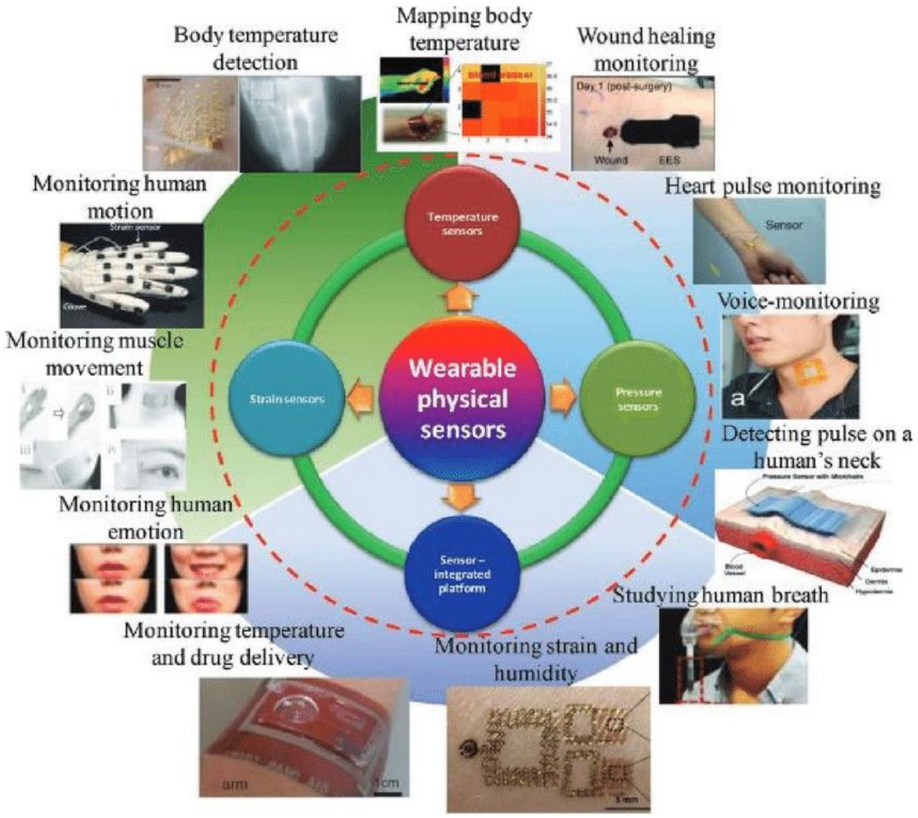

Figure 2.17 Wearable sensors

2.8 Collaborative Platform and Product Lifecycle Management

Product lifecycle management (PLM) refers to the management of data and processes used in the design, engineering, manufacturing, sales, and service of a product across its entire lifecycle and across the supply chain. It refers to a software solution. A broader use case beyond just the manufacturing process.

Product lifecycle management (PLM)

- mitigates those issues
- helps align and integrate key resources
- quickly making product information accessible to teams across the organization

The Product Lifecycle and the PLM Process

Introduction: Costly and risky, new products that are introduced to the market can mean low sales, as well as costs from research and development, consumer reaction, and marketing.

Growth: The product gains popularity and sales and profits grow. Marketing increases to maximize benefit.Maturity: Product popularity dictates more focused marketing as well as future predictions for product improvements or changes to the production process.

Decline: An inevitable end, decline in product popularity happens with increased competition, or lack of customer return. Companies focus on reducing production costs and introduction to less popular markets.

Figure 2.18 Product Life Cycle

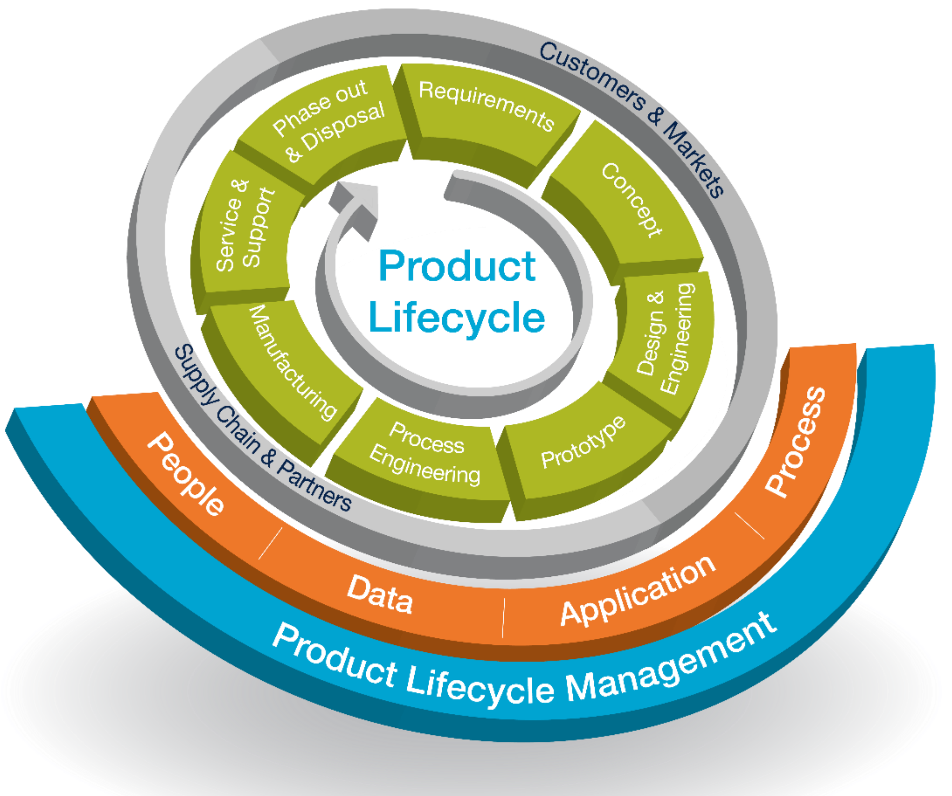

Figure 2.19 PLM process

2.9 Big Data and Advanced Analysis

Big data analytics is the use of advanced analytic techniques against very large, diverse data sets that include structured, semi-structured and unstructured data, from different sources, and in different sizes from terabytes to zettabytes.

There are various types of tools that may fall under the umbrella of Big Data Analytics or serve to improve the process of analyzing data: data storage and management, data cleaning, data mining, data analysis, data visualization, data integration, and data collection.

The Five Key Types of Big Data Analytics Every Business Analyst Should Know

- Prescriptive Analytics
- Diagnostic Analytics
- Descriptive Analytics
- Predictive Analytics
- Cyber Analytics

Big data analytics is the often complex process of examining big data to uncover information -- such as hidden patterns, correlations, market trends and customer preferences -- that can help organizations make informed business decisions.

On a broad scale, data analytics technologies and techniques give organizations a way to analyze data sets and gather new information. Business intelligence (BI) queries answer basic questions about business operations and performance.

Big data analytics is a form of advanced analytics, which involve complex applications with elements such as predictive models, statistical algorithms and what-if analysis powered by analytics systems.

2.9.1 Overview of the four steps of the big data analytics process:

Data professionals collect data from a variety of different sources. Often, it is a mix of semi structured and unstructured data. While each organization will use different data streams, some common sources include:

- internet clickstream data
- web server logs
- cloud applications
- mobile applications
- social media content
- text from customer emails and survey responses
- mobile phone records
- machine data captured by sensors connected to the internet of things (IoT)

Data is prepared and processed. After data is collected and stored in a data warehouse or data lake, data professionals must organize, configure and partition the data properly for analytical queries. Thorough data preparation and processing makes for higher performance from analytical queries.

Data is cleansed to improve its quality. Data professionals scrub the data using scripting tools or data quality software. They look for any errors or inconsistencies, such as duplications or formatting mistakes, and organize and tidy up the data.

The collected, processed and cleaned data is analyzed with analytics software. This includes tools for:

- data mining, which sifts through data sets in search of patterns and relationships
- predictive analytics, which builds models to forecast customer behavior and other future actions, scenarios and trends
- machine learning, which taps various algorithms to analyze large data sets
- deep learning, which is a more advanced offshoot of machine learning
- text mining and statistical analysis software
- artificial intelligence (AI)
- mainstream business intelligence software
- data visualization tools

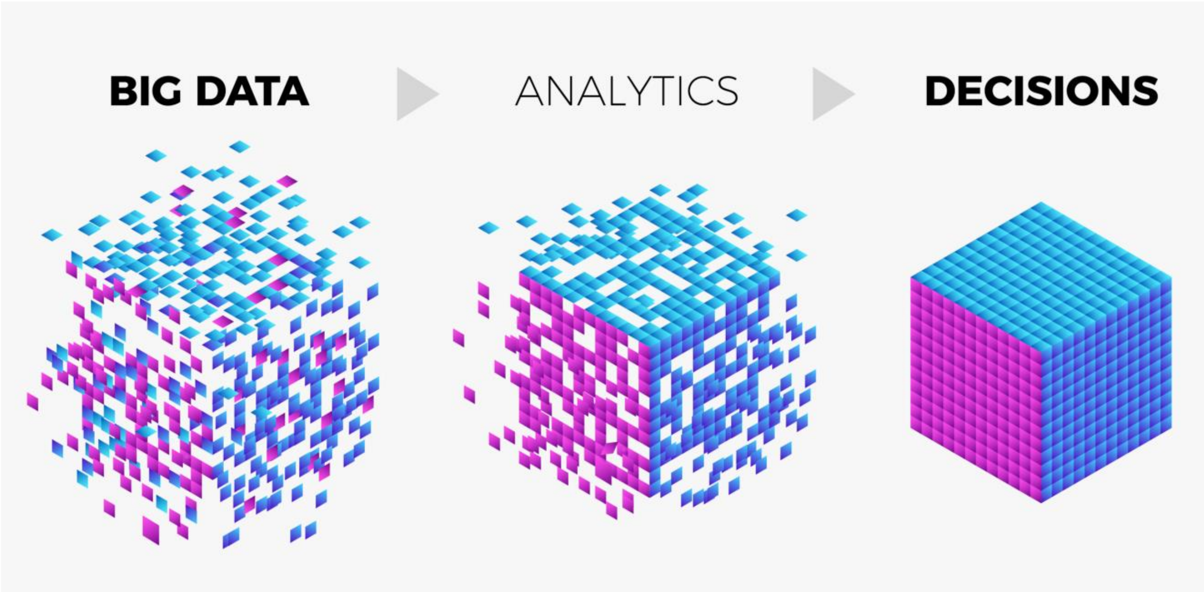

Figure 2.20 Big Data Analytics

Figure 2.21 Big Data and advanced analysis

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Question Bank

Part A: Two Marks:

1. What are the differences between Industry 4.0 and Industry 5.0?
2. What is Industry 5.0 / Smart Manufacturing?
3. What is the difference between Industry 5.0 and Lean manufacturing?
4. What is the difference between Industry 5.0 and the Internet of Things (IoT)?
5. What is the difference between IoT and IIoT?
6. What is a smart factory?
7. What is Big Data?
8. What is advanced industrial analytics?
9. Why is lean manufacturing important?
10. What is human-computer interaction in healthcare?
11. What are next generation sensors?

Part B:

1. How can Industry 5.0 help company to achieve value innovation?
2. Describe the procedures to implement Industry 5.0?
3. Explain in detail about Lean production systems.
4. Discuss about Industry 5.0: Smart and Connected Business Perspective.
5. Describe about Human Computer Interaction Trends in Healthcare.
6. Interpret the implementation of next generation sensors for various smart applications with examples.
7. Explain in detail about the stages of Product life cycle management.
8. Elaborate the necessity of Big data and analytics in the implementation of Industry 5.0 .

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UNIT – 3

DIGITAL TRANSFORMATION TO SOCIETY 5.0

UNIT-3

Digital transformation

Digital Transformation, Introduction to Digital Transformation, Digital business transformation, Causes of disruption and transformation, Digital transformation myths and realities, Digital transformation across various industries, Retail industry, Urban Development, e-Governance and the public sector, Insurance industry, Healthcare, Food, Manufacturing, Disaster Control, Elements of Society 5.0, Data Driven to Society, Humanity Vs Society 5.0

3.1 Digital transformation

Digital transformation (DX) is the adoption of digital technology by a company. Common goals for its implementation are to improve efficiency, value or innovation. Digital transformation is more than just a buzzword; it is a crucial strategy for businesses and their growth. As evolving technologies equip businesses with new and exciting ways to serve customers, owners, founders, and CEOs of mid-sized and family businesses are feeling the pressure to fulfill the high expectations their prospects have of them.

According to estimates, businesses who've implemented effective digital transformation strategies will contribute more than 50% of the global GDP by 2023 and worldwide spending on digital transformation reached 1.3 trillion US dollars in 2020, with a 10.4% YoY growth – despite the economic depression caused by a raging pandemic. This clearly shows that savvy businesses of all sizes need to invest in upgrading their systems and processes, transforming the way they work.

However, 48% of leaders in mid-sized businesses are still only planning their transformation for a digital future. How do we go from planning to doing?

3.2 What Is Digital Transformation?

It can be broadly defined as the integration of the latest, tried-and-tested digital tech to improve all areas of the business as well as the inherent operational processes, all in an effort to provide greater value to prospective customers. This includes using the best digital practices and employing new skills and talents to optimize business for the digital future. However, digital transformation also mandates a cultural shift of sorts as businesses become more agile and deploy intelligent ways to getting things done, usually powered by automation and powerful analytics to guide the way

3.3 Digital Business Transformation

As digital transformation has touched every aspect of a business, there are several reasons why it is vital for an organization. This is why 89% of companies have already adopted a digital business strategy or plan to do so.

(a) Innovation Gives A Competitive Advantage

Even though digital transformation is gaining ground among small and mid-sized businesses, there's only a small number of companies investing in it effectively. This shows that many companies are struggling to evolve and are operating their businesses through outdated systems.But what they fail to realize is that their potential customers have access to advanced tech that they can wield to find better digital opportunities. Moreover, B2B businesses are also using digital channels to their advantage.Adapting a digital setup can help your business get a competitive advantage that drives growth and empowers you to come up to par with your customer's expectations.

(b) Reduced Risks And Higher Security

Digital technology can introduce your business to robust and reliable software that reduces risk and chances of failure. Additionally, digital transformation ensures maximum security for your business, which means protecting your company's valuable data and important customer information.

(c)Improved Decision Making

Businesses these days are only as good as the data they use to make decisions. Giving yourself and your teams access to the data collected through tools like a customer management system or a content management system means you can leverage it to guide your strategy. With the right digital tools it has become easier than ever to gather data, analyze it, and find valuable insights.

(d)Data-Driven Insights

Data analysis has become a specialized field for many businesses that hire experts to help them find meaning in statistics and numbers. Through these insights, companies can optimize their strategies and streamline their processes for better results. These data-driven insights help businesses better understand their customers to execute personalized strategies while enabling real-time feedback and business agility. Thus, the role of digital business processes in offering data-driven insights must not be underestimated, as this can lead to a higher ROI.

(e)Enhanced Collaboration Across Departments

The thought of digital transformation and changing business processes is a daunting prospect for the majority of the employees. This can be assessed from the fact that according to the SMB group study, 27% of leaders observed their team's resistance towards a transformation, a significant challenge. This is because digital transformation demands major changes in all the business processes and strategies right down to the company culture's core. But this presents a perfect opportunity for ensuring unity among the employees as the entire transformation process requires seamless communication.

3.4 .Digital Transformation: Challenges For Businesses And Solutions

If you have decided to take your small or mid-sized business on the journey of digital transformation, you need to assess the challenges you might face and the strategies that you can employ to remain firm in the face of these challenges.

(a)Lack of Digital Skill-Sets

One of the biggest challenges of driving digital transformation for your business is the lack of skill sets that can help you embrace the technological shift. Since digital transformation involves introducing emerging technologies and significant changes in business processes, your employees might not have the skill sets to adapt to these changes.

A Deloitte's analysis shows that almost half of the small and mid-sized businesses have reported at least one challenge related to the lack of skills or employee training. To drive digital transformation, small and mid-sized businesses need to adopt employee training and skilling programs that introduce the employees to the latest digital tools.

(b).Ignorance Of Digital Security

The technologies associated with digital transformation offer several advantages, but they come with their security risks. This is why small and mid-sized businesses need to secure their network's endpoints through strict security measures. Another target in ensuring the security of your digital processes is training and educating the users about security practices that reduce the chances of malware risks.

(c) Misunderstanding Agile Transformation

Another challenge includes keeping your business up to speed with the constant digital landscape transformations. Also, many small businesses fail to realize the need to change their company culture to support agile transformation.

To counter this challenge, you need to instill a transformative vision in the core of your company culture. Moreover, it also means standing firm in the face of failures and leveraging digital tools to experiment in profitable avenues to drive business value.

(d)Compromised Customer Experience

Customer experiences have been termed as the key differentiator between your business and your competitors'. Companies do not get the time to provide the ultimate customer experience, especially if they do not use digital tools in this technology age.

Thus, the key to eliminating this challenge is to wield technology that assists in offering the best customer experiences that keep your customers around for long.

(e)Legacy Architecture

Some businesses rely on their age-old business processes and digital tools until now, but these legacy systems prove to be a burden rather than an asset.

To embrace digital transformation, small and mid-sized businesses need to shun their legacy systems at the right time to make their name in the digital world.

3.5. Digital transformation myths and realities:

As is the case with every concept and trend, a number of myths have risen around the idea of digital transformation. Below we tell you how much truth there is to those myths.

(a) Digital transformation is a bubble

There is much skepticism in relation to this concept among many. These people compare it to yet another technological bubble, such as the dotcom bubble of the year 2000.

In reality, digital transformation is a trend that is here to stay, and only in Spain it will imply a gross increase of 120 billion Euros in the Spanish economy by the year 2025, according to the "Spain 4.0" report by Roland Berger.

(b)Digital transformation is the responsibility of the CTO

It is often believed that the person that must take charge of an organization's digitalization process is the Chief Technical Officer (CTO) – this is not completely try.

It is true that within the process, the opinion of this person carries a lot of weight, but the CTO should not be the top authority in regard to its implementation, since digitalization is a cross-cutting process that encompasses every department in a company. It isn't just reserved to a few tech enthusiasts.

(c)The main benefit of digitalization is the improvement of the user experience

While it is true that digitalization in companies helps improve the user experience, this is not the main advantage when compared to other operational approaches.

The Mckinsey consulting firm measured the benefits that digital transformation offers companies. According to this firm, companies that start implementing this process manage to increase their turnover by 20% and reduce costs by 36%. As we can see, the greatest benefit for companies is a higher efficiency.

(d)Only major corporations should concern themselves with digital transformation

Far from what some people think, digitalization has nothing to do with a company's balance. It is related to a shift in culture and a new way of doing business.

Digitalization allows companies both large and small to streamline and simplify their processes. Two benefits that any type of organization can enjoy.

(e)Digitalization is only worthwhile for B2C companies

This myth has become widespread because one of the advantages of digital transformation is putting the end customer at the core of the business. In this belief, it is common for some to claim that this process is not valid for B2B businesses.

However, this is not completely true, since digitalization also benefits the company by optimizing processes and increasing efficiency – two facts that are completely compatible with B2B and B2C businesses.

(f)A company's digital transformation can only involve a single path

This phrase is another very popular myth nowadays among skeptics of this concept. There is no single way to get the process going. Each company is different and must address the change differently.

In order to be successful in this path, it is recommended to seek the advice of expert companies who are specialized on the matter.

(g) Digitalization is an expensive process

Digital transformation is not only within reach of major IBEX 35 companies. This shift is not necessarily linked to a higher expenditure.

The process does not have to be seen as an expense, but rather as a key investment with sights on attaining higher returns. In fact, according to data by the IDC Research consulting firm, 34% of small-caps who have allocated resources to digital transformation have experienced immediate benefits.

Digitalization is a process that can begin with a technological change, but that has a direct effect across the entire company with a significant change in the way in which it is organized and in its culture.It is a market trend that offers increasing benefits to companies, and that everyone is talking about. Which is why the number of skeptics who disseminate unfounded myths is constantly growing. Transformation is here to stay, since it is a shift in the paradigm of today's world – and it is not only a process aimed at a few elite corporations, around the world are already enjoying. . They only need to find the way to dive into digitalization and start reaping the fruits that millions of companies

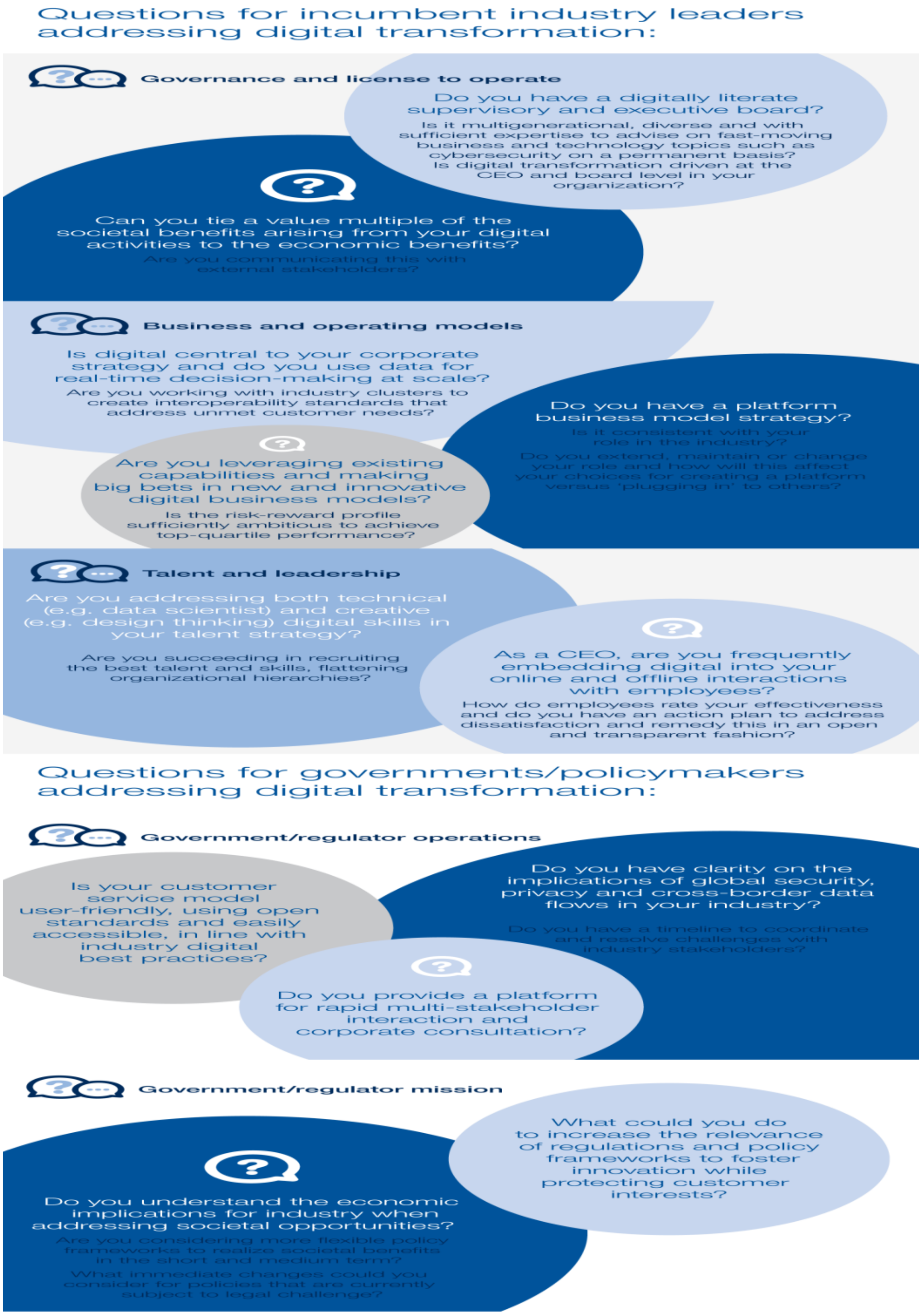

Fig 3.1: Digital Transformation

3.6: Digital transformation across various industries

3.7 Retail Industry

It’s no secret that the retail landscape is more competitive than ever. The customer is in total control, and only a personalized, unique retail experience will capture their attention (and open their wallets).

But despite this, many retailers are slower to adopt new technologies that enable them to change – they must evolve with the customer, because the customer will not change for them. If they don’t, they will soon be seen as irrelevant or “boring” – which can become a mitigating factor for retailers.

So how can you engage a technologically-savvy and selective customer? How can a retailer differentiate themselves from the competition, and deliver the extraordinary experiences that customers seek?

Answer: Digital Transformation.

Consider all the ways digital transformation manifests in the retail industry:

- Retailers provide omnichannel shopping and delivery options for customers
- Customers can access stores from anywhere in the world in just a matter of moments via a mobile device;
- Social media has become a primary form of advertisement;
- Cutting edge technologies such as AI, augmented reality, and virtual reality have become an active part of the shopping experience;
- Retailers use data analytics and machine learning to inform major business decisions

Tools for Digital Transformation in Retail

(i)Machine Learning and Predictive Analytics

Machine learning is key to cementing a bond between retailer and customer by helping the retailer better understand and predict what the customer wants. Machine learning is a data science that collects data from one (or several) sources, and then feeds that data into machine learning models that in turn help predict future outcomes.

Machine learning data enables retailers to identify shopping patterns, understand buying behaviors, adjust promotions and special offers, personalize product recommendations, tweak pricing on the fly, and create forecasts based on historical trends and customer preferences.

(ii)Artificial Intelligence

Customers expect answers and assistance any day, at any time – and the easier, more convenient it is, the better. Artificial intelligence (AI) is an important new way to deliver the attentive 24/7 service that shoppers now expect.

For instance, AI-driven chatbots can act as a digital store associate, instantly responding to customer queries through texts or Chatbot messages. Chatbots can also upsell or cross-sell products, pointing customers toward merchandise they may be interested in, based on the customer's engagement. Chatbots are a cost-effective and rapid response service tool that can help seal conversions and create new sales. In addition, chatbots deliver messages that are consistent with the brand's voice – the chatbot says what it is programmed to say. There's no worry that a chatbot will share something it's not supposed to, or that it will be rude and impatient with a customer's questions.

(iii). Unified Commerce

Shoppers are using multiple channels – web, mobile, social, etc. media – and they expect you to be ready and waiting across channels at all times. To achieve that, many retailers implement a unified commerce strategy, a single, fully integrated software platform that manages all the different systems that a retailer uses to conduct business, from one interface. Before the unified commerce concept, retailers used different systems for managing components of their business. Trying to reconcile data pulled from multiple systems is a time-consuming, resource-draining process. To best keep data integrity intact and secure, data siloes must be broken down, and data from disparate sources integrated into one unified commerce system.

3.8 Urban Development

When people imagine the cities of the future, they typically envision the urban landscapes of science fiction: gleaming metropolises with flying cars and technology powering everything. In fact, however, the city of the future will rely far more on strategic planning and governance than it will on technology. To be clear, technology can indeed help solve some of the large and growing challenges of urbanization. By 2030, more than 5 billion people—60% of the 2010 global population—will live in cities. Meeting the needs of these urban residents will put a tremendous strain on municipal governments, and many are rushing to invest in technology, hoping that it will provide a fast and easy solution. The impulse is understandable: technology is advancing rapidly and has transformed many industries. But under the current approach to implementation—a series of short-term decisions—technology is unlikely to achieve its full potential.

To solve the problems of urbanization and to design livable, sustainable cities of the future, governments need to adopt a far more strategic approach, of which technology is only one part. They need clear upfront analysis to identify the biggest issues that their cities and constituents face, and they need to design collaborative and citizen-centric solutions that use technology to address various functional clusters: energy, mobility, environmental sustainability, public services, and buildings. This is potentially harder and more time-consuming than simply buying software from a vendor. But it is the only way to generate sustainable results.

Urbanization will present challenges on a massive scale. About 55% of the world's population currently lives in cities, according to the UN, and projections call for this number to increase as rural populations shrink. Not all cities are growing at the same pace, however. By 2030, roughly one-sixth of the world's population will live in just 41 very large cities—each with a population of more than 10 million people. That kind of concentration among populations can create conflicts—and greater urgency for city governments—in three specific areas:

Economic Competition Among Cities: Large cities often siphon capital and business activity away from smaller cities nearby. And because concentrated populations lead to increased economic opportunities—an effect that becomes self-reinforcing—large cities win and smaller cities nearby lose. New development and infrastructure can sometimes intensify the problem.

In 2008, for example, the Chinese government built a high-speed rail line between Wuhan and Guangzhou, cutting the travel time between the two cities (roughly 600 miles apart) from 11 hours to about 3. Slower trains used to stop at those cities, but the high-speed line did not. As a result, the populations of many of the smaller cities along the route experienced a net decline from 2008 to 2016, while the populations in the cities at either end of the line increased significantly, accruing economic benefits.

Concentrated Opportunities: According to one estimate, 5% of the world's cities in 2030 will contribute more than one-fifth of the world's GDP. This concentration of economic activity can lead to greater income disparities between the populations of large cities and small cities. Even within the limits of any individual city, wealth accumulates at the top, leading to a growing split between the rich and the poor and, in some cases, social instability. In the US, among the five cities with the highest per-capita GDP, four of them— Boston, New York, San Francisco, and Washington, DC—also show the highest gap in incomes. Only Seattle has managed to keep the income disparity down.

Environmental Challenges: A concentrated population allows for the delivery of more efficient public services, but as cities grow bigger, governments often struggle to meet the needs of larger populations. Currently, about 35% of the world's urban population faces either inadequate or unaffordable housing. Residents in the 25 largest cities lose an estimated 66 hours per year sitting in traffic jams—and increased traffic leads to increased pollution. Only 10% of the global urban population lives in areas that currently meet World Health Organization standards. The environmental challenges grow as cities expand in size, and the effect is most pronounced in developing economies, where the majority of megacities are located.

TECHNOLOGY OFFERS POSSIBLE SOLUTIONS

To address these challenges, many cities are investing in digital technology, which holds considerable potential to help leaders improve urban planning, foster equitable economic growth, deliver services more efficiently, and use more sustainable resources.

To improve planning, for example, governments can use data infrastructure and analytical tools. A government agency tasked with designing and building a city center cannot do so effectively unless it has accurate information about the projected uses for the site, the number of people who will use it, the types of services those citizens will need, and other critical information.

Technology can also help cities foster more equitable growth. The market for "smart city" technology is growing at 21% per year, to a projected $1.5 trillion by 2022. China is the leading country in absolute terms, spending up to $250 billion in 2017, though growth rates in the US and Western Europe are higher. A cloud-based data center in Busan, South Korea, will create 30,000 jobs alone.

What’s more, technology can help cities use resources more effectively and create healthier urban environments. Digital solutions are helping cities generate reductions of 15% to 30% in CO2 emissions, energy and water consumption, traffic congestion, and crime. They also help cities deliver services far more efficiently. In Australia, for example, approximately 80% of the population is expected to access government services through digital channels by 2020.

For these reasons, city governments are spending significantly on technology. In India, the government plans to invest more than $1.5 billion in technology initiatives across 100 cities. China launched pilot projects in more than 500 cities in 2017 alone. Canada plans to build 100 smart buildings in the next three years and reduce energy consumption in existing buildings by 17%.

3.9 e-Governance and the public sector

The 21st century is the Information Technology era. It has brought the revolution a change in the working of varies fields. The latest impact of technology is that the government offices and services are governed through information technology. The adoption of new technology in government sector has caused new phenomenon called E-Governance. The E-Governance is referred to services provided by government to the citizens, business and local government through information technology. E-Governance makes working of government more efficient, responsive and transparent. Many developed countries like UK, USA, and Brazil etc. have adopted the E-Governance and India is one of them. E-Governance is a web based service for local, state and national governments. Government uses these web based services by internet to serve their citizens online. Government give many online services like payment of bills, taxes etc. and citizens use the services according to their need. Indian government recognized the importance of technology and established the Department of Electronics in 1970. India took first step towards the E-Governance Shown strong inclination a nd establishment of the National Informatics centre (NIC) in 1977.

India launched NICNET (National Satellite – Based Computer Network) in 1987 with the aim of computerizing all the district offices of the country. E-Governance provides innumerable and infinite services to the citizens and government also

Different Services through E-Governance

E-Governance is designed in such a way as to provide the services to different sectors and its role is multi-dimensional. The e- governance may provide services [5-8] in different dimensions which are analyzed and discussed below

E-Governence Services From Government To Citizens (G2c)

This model incorporates the services provided by the government to the citizens. This model strong interaction between government and citizens. Citizens use respective services provided by the government. Citizens can interact with the government any time, any place and with suitable mediums like internet, fax, telephone, email etc.. The main object is to enable the citizens to take benefits from efficient delivery public services and to make government, citizens friendly.

The following are the services provided by the G2Cmodel:

E-Citizen

E-Citizen establish many service centers to offer the various customer services like issue of Ration Cards, Certificates, Passports, Online filling of FIR and Payment of online bills such as electricity, taxes, water, telephone bills etc. These centers like government run shops for providing governmental services.

E-Medicine

It facilities the online availability of various hospitals and better medical services in different parts of country.

E-Education

With E-Education, government embarks upon many initiatives to educate the citizens and upgrade their knowledge with various information technologies.

E-Transport

E-Transport provides many facilities like online registration of vehicles, online issue of driving licenses, online payment of challans and taxes, control of pollution.

E-registration

E-Registration reduces the paper work for registration and transfer of properties and stamp duty. It reduces the duplication of entries and increases the transparency in work. The main object of the G2C model is to deliver all the services of government to its citizens. The G2C model will become successful provided all the citizens have knowledge of all the government activities. Usually journalists, civil servants, oppositions keep closely watching the expenditure of government. Government takes feedback from public to improve the relations between government and citizens.

E-Governence Services from Government to Government (G2g)

It is also known as E-Administration. In this model, services are shared between governments. Information is shared among various government agencies, organizations and

departments. The following are the services in the G2G model:

E-Secretariat

E-Secretariat provides huge, valuable and functional information of the state. In ESecretariat, multiple departments are closely linked together on internet and exchange the information of various components. It also binds all the governmental departments with their headquarters and state capitals.

E-Police

E-Police helps citizens to feel safe and secure. E-Police maintains two databases. First database provide records current and previous posting etc. of persons working in police. These databases prop up citizens to find the specialization of policemen in geographical regions and skills. Second database is of criminal records. These database full details of a criminal at fingertips on typing his name. Also previous the produces activities and area of his operation.

E-Court

E-Court shell makes a revolution in the Indian pending court cases. In India, there are numerous pending cases frustrationing people consumers and the system need the change. In ECourt, Judges with component raised data bases can peruse the appeals from intranet and pronounce their decisions online considering recorded facts of case and reduce the backlog cases. The success of G2G model is based on some important aspects like expenditure, establishment of network, planning, monitoring and controlling the performance in human and financial.

3.10. Insurance industry

The insurance industry of India has 57 insurance companies 24 are in the life insurance business, while 34 are non-life insurers. Among the life insurers, Life Insurance Corporation (LIC) is the sole public sector company. There are six public sector insurers in the non-life insurance segment. In addition to these, there is a sole national re-insurer, namely General Insurance Corporation of India (GIC Re). Other stakeholders in the Indian Insurance market include agents (individual and corporate), brokers, surveyors and third-party administrators servicing health insurance claims.

n India, the overall market size of the insurance sector is expected to US$ 280 billion in 2020. The life insurance industry is expected to increase at a CAGR of 5.3% between 2019 and 2023. India’s insurance penetration was pegged at 4.2% in FY21, with life insurance penetration at 3.2% and non-life insurance penetration at 1.0%. In terms of insurance density, India’s overall density stood at US$ 78 in FY21. In the first half of FY22, the life insurance industry recorded growth rate of 5.8% compared with 0.8% in the same period last year. In September 2021, new premiums of life insurers registered 22.2% growth in September 2021, up from 2.9% in September 2020.

Between April 2021 and September 2021, gross premiums written off by non-life insurers reached Rs. 108,705.3 crore (US$ 14.47 billion), an increase of 12.8% over the same period in FY21. In October 2021, total premium earned by the non-life insurance segment stood at Rs. 17,679.98 crore (US$ 2.38 billion), as compared to the Rs. 15,906.71 crore (US$ 2.14 billion) recorded in October 2020.

The market share of private sector companies in the general and health insurance market increased from 47.97% in FY19 to 48.03% in FY20. In the life insurance segment, private players held a market share of 33.78% in premium underwritten services in FY20. In FY22*, premiums from new businesses of life insurance companies in India stood at US$ 20.7 billion and renewable premium stood at US$ 53.7 billion.

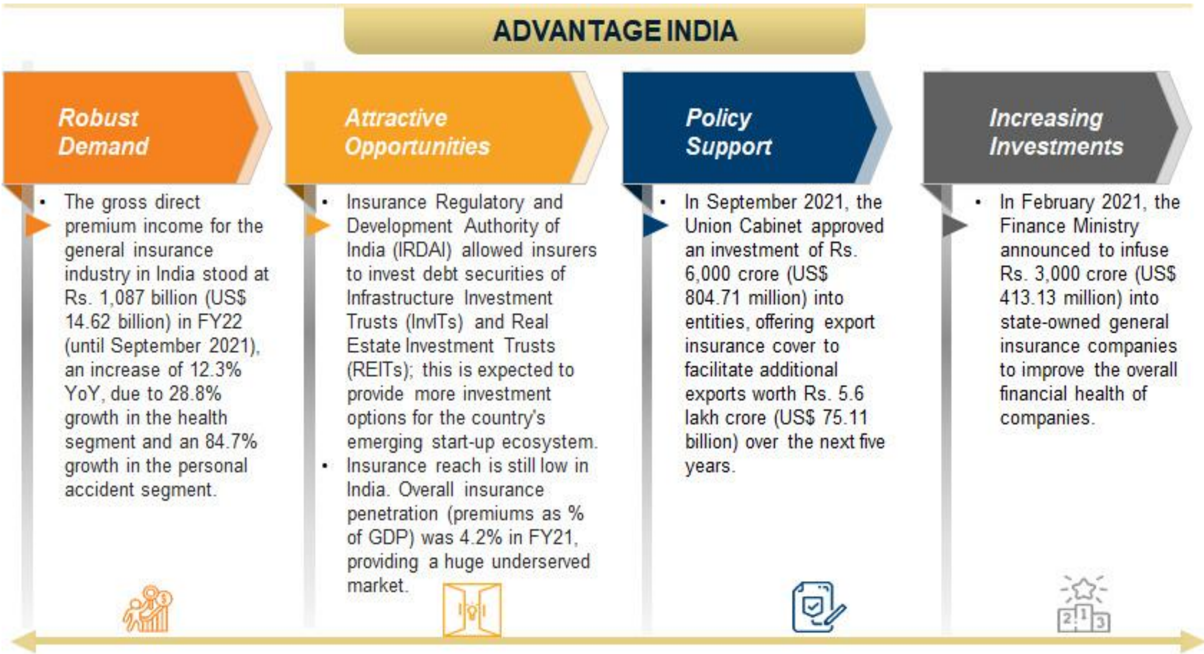

Fig3.2: Advantages of Insurance Industry in India

3.11 Healthcare

Over the past two decades, many hospitals and health systems adopted digital technologies in their various functional areas. In many cases, however, they took a piecemeal approach to numerous initiatives—from installing electronic health record (EHR) systems to building apps to trying disruptive technologies such as artificial intelligence (AI)—while remaining largely focused on the same business and customer models.2

The COVID-19 pandemic significantly altered this status quo for the health care industry. Virtual health and care delivered in the home became the model of not only necessity but also preference. But this change was not as sudden as it might look. The pandemic was an accelerator of several trends, including shifting consumer preferences, rapidly evolving technologies, newer talent models, and clinical innovation. In the face of these trends, as hospitals and health systems work toward adapting their businesses, a well-defined approach toward digital technologies will likely be at the core of this transformation strategy.

The Deloitte Center for Health Solutions collaborated with the Scottsdale Institute to better understand how health systems are using digital to transform health care. To understand the digital transformation journey of health systems, Scottsdale Institute members were engaged in multipronged research: A survey was conducted with executives of 25 health systems, interviewed five health system technology leaders, and facilitated a moderated panel discussion of technology leaders from three health systems. It was found that

Health systems consider digital capabilities a path to fundamentally transform their relationship with consumers. Most survey respondents are hoping to achieve better patient experience (92%) as the top desired outcome from digital transformation. Health system interviewees and panelists discussed taking a consumer-centered, outside-in approach—designing processes and experiences from a consumer's perspective as a way to build their trust and loyalty—to improve patient experience and build on newer forms of care delivery using digital technology.

While the digital transformation journey is long, health systems are focusing on interim milestones to show value. When asked how far they are from an ideal digital state, most survey respondents (60%) rated their organizations as midway through their journeys. Health system interviewees and panelists acknowledged that the transformation journey is longer than they had initially expected as the opportunities and definition of digital transformation expand. They also discussed a need to create frequent checkpoints to measure the value of the initiatives, rather than waiting until the completion of the initiatives to measure returns on investments (ROIs).

Talent, data, and setting key performance indicators (KPIs) are challenges to overcome, in addition to budget. Survey respondents, interviewees, and panelists alike discussed how the quality and quantity of talent to support digital transformation initiatives was one of the biggest barriers to overcome. And, one-third of respondents said talent is their top investment priority in the next 3 years. To address challenges with data, survey respondents and interviewees reported investments in data interoperability and creation of the right KPIs as top priorities in the next 3 years. Despite budget being a top reported constraint, two in three respondents expect investments in digital transformation initiatives as a percentage of total information technology (IT) budget to increase in the next 3 years.

An executive champion is key to digital transformation success. Survey respondents consider leadership (80%) and management of implementation (68%) to be the key accelerators of digital transformation, and culture (60%), communication ownership, and transparency (48%) the key barriers. Health system interviewees and panelists recognized organizational leadership as a crucial factor for the success of their digital transformation efforts.

3.12 FOOD INDUSTRY

Those plants that swiftly adopted IIoT and the above-mentioned industry 4.0 applications saw the benefits in terms of streamlined plant operations, reduced unplanned downtime, and faster root cause analysis and equipment repairs, both during remote work conditions and once employees were able to return to work in person. The food and beverage (F&B) industry isn't at the head of the pack when it comes to digital transformation, but the last few years saw F&B companies pick up the pace of digitalization even before the impact of COVID-19

Consumer trends towards healthier, more sustainable food, a rise in regulations around food safety, and a rise in smaller, more personalized production have all contributed to pushing F&B manufacturing plants to embrace the benefits of industry 4.0 over the last 2-3 years.

However, like other industries, the F&B industry was deeply affected by the global pandemic. Supply chains fractured and broke, employees were unable to come in to work in person in crowded plants, and customer demands swung even more wildly. The overall level of demand varied greatly from plant to plant, as the need for restaurant products plummeted but the market for staples for domestic use, such as flour, milk, and pasta, soared.

In many ways, the food and beverage industry was further along digitally than a number of other manufacturing verticals before COVID-19 arrived. A significant number of plants already use automated equipment items such as ovens, processors, and cold chain storage units equipped with sensors. But when the pandemic began, few of them had smart devices that share data with each other and a broader integrated data analytics system, or the connectivity that enables remote operations.

According to one study, 73% of F&B companies have continued or increased their investment in digital technologies, with supply chain operations (51%), data collection (38%), and improved business analytics (37%) standing out as the primary use cases. 64% say that their progress towards digitalization has been good or advanced.

3.13 Disaster Management:

With the increasing social and economic devastation caused by disasters around the world, the international community and country-level National Disaster Management (NDM) authorities have placed improving their ways to mitigate, prepare for, respond to, and recover from disasters as a top priority. Technological advancements and the 4th Industrial Revolution are critical tools to help achieve this. However, they also present many challenges to traditional NDM systems by altering the fundamental operational, organizational, and social dynamics of conventional disaster management. Currently, there is a lack of research that studies these aspects beyond technology and examines the impact of digital transformation on the full life cycle of disaster management on the national level. Therefore, this research fills this gap by integrating interdisciplinary concepts from different research fields including Disaster Management, Information Systems, and Business Management to understand the impact and determinants of digital transformation in NDM systems. To achieve this, the research uses the Technology-Organization-Environment (TOE) framework and conducts semi-structured interviews with UK NDM experts. The results show that the impact of digital transformation on NDM is profound, paradoxical, multi-directional, and driven by a multitude of driving forces. This research makes many significant contributions to research and practice. Theoretically, this research expands the TOE framework beyond its original underpinnings by uncovering a new set of disaster-context determinants. It also presents an innovative Layered Cake FAST (Foundations-Approach-Strategy-Technology) Model that offers a unique roadmap for NDM on how to handle its digital transformation journey. Practically, the research presents several sets of useful expert-recommended actions.

3.14 SOCIETY 5.0:

One definition: "A human-centered society that balances economic advancement with the resolution of social problems by a system that highly integrates cyberspace and physical space."Society 5.0 was proposed in the 5th Science and Technology Basic Plan as a future society that Japan should aspire to. It follows the hunting society (Society 1.0), agricultural society (Society 2.0), industrial society (Society 3.0), and information society (Society 4.0).

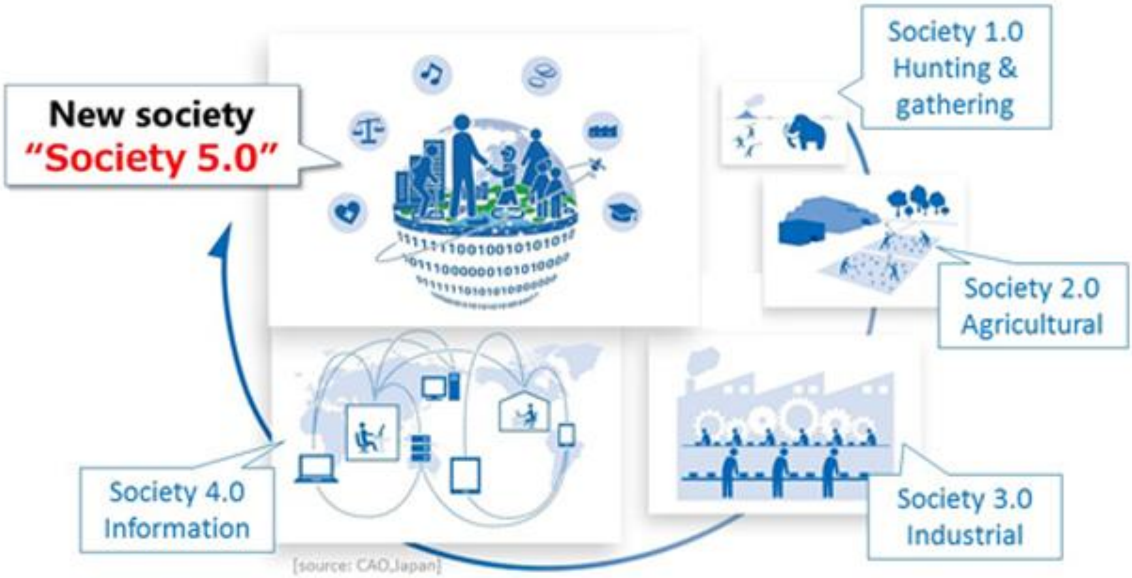

Fig 3.3: Society5.0

In the information society (Society 4.0), cross-sectional sharing of knowledge and information was not enough, and cooperation was difficult. Because there is a limit to what people can do, the task of finding the necessary information from overflowing information and analyzing it was a burden, and the labor and scope of action were restricted due to age and varying degrees of ability. Also, due to various restrictions on issues such as a decreasing birthrate and aging population and local depopulation, it was difficult to respond adequately.

Social reform (innovation) in Society 5.0 will achieve a forward-looking society that breaks down the existing sense of stagnation, a society whose members have mutual respect for each other, transcending the generations, and a society in which each and every person can lead an active and enjoyable life.

How Society 5.0 works:

Society 5.0 achieves a high degree of convergence between cyberspace (virtual space) and physical space (real space). In the past information society (Society 4.0), people would access a cloud service (databases) in cyberspace via the Internet and search for, retrieve, and analyze information or data.In Society 5.0, a huge amount of information from sensors in physical space is accumulated in cyberspace. In cyberspace, this big data is analyzed by artificial intelligence (AI), and the analysis results are fed back to humans in physical space in various forms.In the past information society, the common practice was to collect information via the network and have it analyzed by humans. In Society 5.0, however, people, things, and systems are all connected in cyberspace and optimal results obtained by AI exceeding the capabilities of humans are fed back to physical space. This process brings new value to industry and society in ways not previously possible.

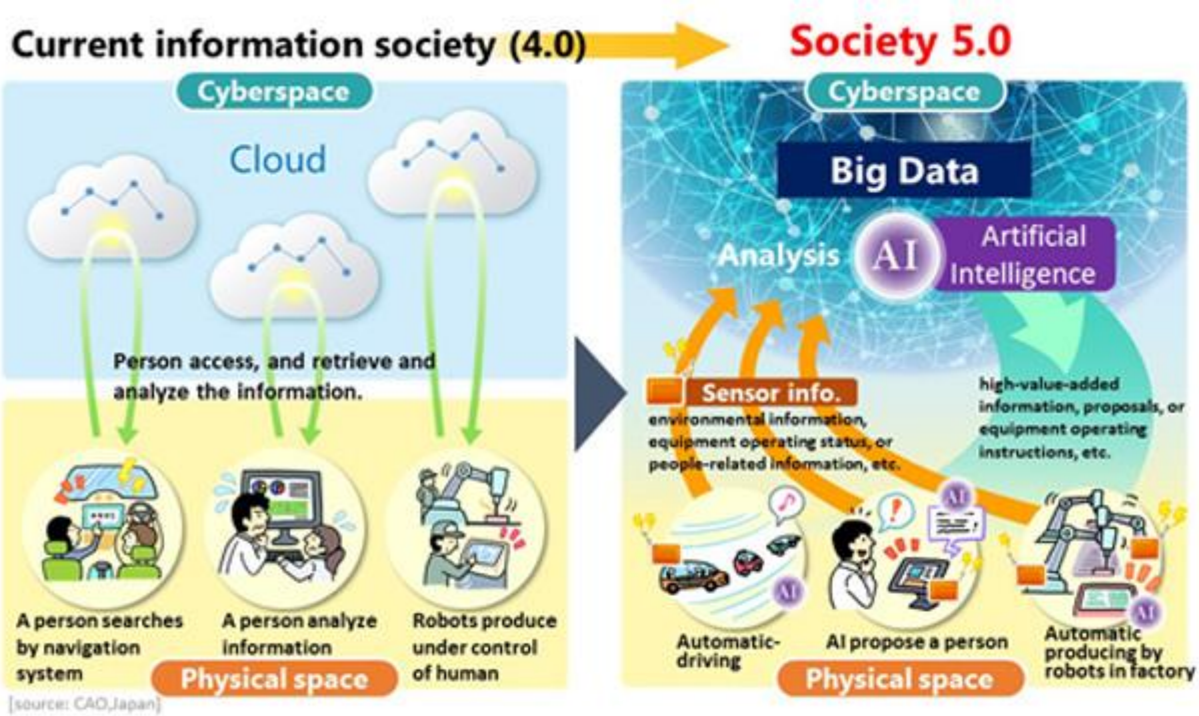

Fig3.5: Changing to Society 5.0

3.14 Humanity Vs Society:

In society up to now, a priority has generally been placed on social, economic, and organizational systems with the result that gaps have arisen in products and services that individuals receive based on individual abilities and other reasons. In contrast, Society 5.0 achieves advanced convergence between cyberspace and physical space, enabling AI-based on big data and robots to perform or support as an agent the work and adjustments that humans have done up to now. This frees humans from everyday cumbersome work and tasks that they are not particularly good at, and through the creation of new value, it enables the provision of only those products and services that are needed to the people that need them at the time they are needed, thereby optimizing the entire social and organizational system.This is a society centered on each and every person and not a future controled and monitored by AI and robots.

Achieving Society 5.0 with these attributes would enable not just Japan but the world as well to realize economic development while solving key social problems. It would also contribute to meeting the Sustainable Development Goals (SDGs) established by the United Nations.

Japan aims to become the first country in the world to achieve a human-centered society (Society 5.0) in which anyone can enjoy a high quality of life full of vigor. It intends to accomplish this by incorporating advanced technologies in diverse industries and social activities and fostering innovation to create new value.

Fig 3.6: Society 5.0 Will Bring About a Human-centered Society

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Question Bank:

PART-A

1.Define Digital Transformation

2. Define Digital Business Transformation

3.List the Causes of disruption and transformation

4.List the, myths of Digital transformation

5.What is elements of Society 5.0

6. Describe Digital transformation across urban Society

PART-B

1.Explain the Digital transformation across Retail industry and Urban Development

2.What are the Causes of disruption and transformation

3.Explain in detail the Elements of Society 5.0,

4.Discuss Humanity Vs Society 5.0.

5.Explain digital transformation in e-Governance and the public sector

6.Explain digital transformation in Healthcare, Food, Manufacturing, Disaster Control

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UNIT – 4

SMART WORLD

4. SMART WORLD

Introduction: Sensing & actuation, Communication, Electronics in Smart city, 5G Technology, Communication protocols, Integration of Sensors in Robots and Artificial Intelligence, Human-Machine Interaction, Industrial IoT- Application Domains: Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management., Intellectual Property Rights- Case Studies - Milk Processing and Packaging Industries.

4.1 Introduction: Sensing & actuation

Sensors turn a physical input into an electrical output, and actuators do the opposite. They take electrical signals from control modules and turn them into physical outputs. In a typical IoT system, a sensor may collect information and route to a control center. There, previously defined logic dictates the decision. As a result, a corresponding command controls an actuator in response to that sensed input. Thus, sensors and actuators in IoT work together from opposite ends. IoT sensor – An IoT device that observes one or more properties of a physical entity and converts those properties into information. IoT actuator – An IoT device that can change one or more properties of a physical entity in response to received information. An actuator is a device that produces a motion by converting energy and signals going into the system. The motion it produces can be either rotary or linear. An actuator is a device that produces a motion by converting energy and signals going into the system. Sensors play an important role in creating solutions using IoT. Sensors are devices that detect external information, replacing it with a signal that humans and machines can distinguish. An actuator is a part of a device or machine that helps it to achieve physical movements by converting energy, often electrical, air, or hydraulic, into mechanical force. ... Common examples of actuators include electric motors, stepper motors, jackscrews, electric muscular stimulators in robots, etc.

A sensor is a device that measures physical input from its environment and converts it into data that can be interpreted by either a human or a machine. ... People use sensors to measure temperature, gauge distance, detect smoke, regulate pressure and a myriad of other uses. A sensor is a device that detects the change in the environment and responds to some output on the other system. A sensor converts a physical phenomenon into a measurable analog voltage (or sometimes a digital signal) converted into a human-readable display or transmitted for reading or further processing. The most frequently used different types of sensors are classified based on the quantities such as Electric current or Potential or Magnetic or Radio sensors, Humidity sensor, Fluid velocity or Flow sensors, Pressure sensors, Thermal or Heat or Temperature sensors, Proximity sensors, Optical sensors, Position sensors.

4.1.1 Communication

The sensor nodes can communicate among themselves using radio signals. A wireless sensor node is equipped with sensing and computing devices, radio transceivers and power components. The working mode of the sensor nodes may be either continuous or event driven. A Wireless sensor network can be defined as a network of devices that can communicate the information gathered from a monitored field through wireless links. The data is forwarded through multiple nodes, and with a gateway, the data is connected to other networks like wireless Ethernet. A wireless sensor-actuator network (WSAN) is composed of sensor and actuator nodes interconnected in a wireless channel. Sensor nodes can deliver messages to only nearer nodes due to weak radio and messages are forwarded by sensor nodes to an actuator node. The sensor network connects to the internet or computer networks to transfer data for analysis and use. Sensor network nodes cooperatively sense and control the environment. They enable interaction between persons or computers and the surrounding environment.

They are hardware devices that produce a measurable response to a change in a physical condition like temperature or pressure. Sensors measure physical data of the parameter to be monitored and have specific characteristics such as accuracy, sensitivity etc. The continual analog signal produced by the sensors is digitized by an analog-to-digital converter and sent to controllers for further processing. Some sensors contain the necessary electronics to convert the raw signals into readings which can be retrieved via a digital link (e.g. I2C, SPI) and many convert to units such as °C. Most sensor nodes are small in size, consume little energy, operate in high volumetric densities, be autonomous and operate unattended, and be adaptive to the environment. As wireless sensor nodes are typically very small electronic devices, they can only be equipped with a limited power source of less than 0.5-2 ampere-hour and 1.2-3.7 volts.

Sensors are classified into three categories: passive, omnidirectional sensors; passive, narrow-beam sensors; and active sensors. Passive sensors sense the data without actually manipulating the environment by active probing. They are self powered; that is, energy is needed only to amplify their analog signal. Active sensors actively probe the environment, for example, a sonar or radar sensor, and they require continuous energy from a power source.

Narrow-beam sensors have a well-defined notion of direction of measurement, similar to a camera. Omnidirectional sensors have no notion of direction involved in their measurements.

Most theoretical work on WSNs assumes the use of passive, omnidirectional sensors. Each sensor node has a certain area of coverage for which it can reliably and accurately report the particular quantity that it is observing. Several sources of power consumption in sensors are: signal sampling and conversion of physical signals to electrical ones, signal conditioning, and analog-to-digital conversion. Spatial density of sensor nodes in the field may be as high as 20 nodes per cubic meter.

4.2 Electronics in Smart city

The smart city concept integrates information and communication technology (ICT), and various physical devices connected to the IoT network to optimize the efficiency of city operations and services and connect to citizens. Smart city applications are developed to manage urban flows and allow for real-time responses.

4.2.1 Smart city

A smart city is the one that uses information and communication technologies (ICT) to increase operational efficiency, share information with the public and improve both the quality of government services and citizen welfare. Smart cities use intelligent solutions to optimize infrastructure and smart and responsive governance to engage citizens in the management of their city. A system of sensors, networks, and applications collect useful data, like traffic congestion, energy use, and CO2 levels.

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The purpose of the Smart Cities Mission is to drive economic growth and improve the quality of life of people by enabling local area development and harnessing technology, especially technology that leads to Smart outcomes. Smart cities use Internet of Things (IoT) devices such as connected sensors, lights, and meters to collect and analyze data. The cities then use this data to improve infrastructure, public utilities and services, and more. The four pillars of comprehensive development-institutional, physical, social and economic infrastructure.

4.2.2 Features of Smart Cities

- adequate water supply
- assured electricity supply
- sanitation, including solid waste management
- efficient urban mobility and public transport
- affordable housing, especially for the poor
- robust IT connectivity and digitalization
- good governance, especially e-Governance and citizen participation

4.2.3 Electronics in Smart city

- Smart lighting
- Charging stations
- Smart parking
- Smart Buildings

Smart lighting

In a smart city, the lighting system is integrated with advanced sensors and communication channels to obtain a Smart Lighting System (SLS). The goal of an SLS is to obtain an autonomous and more efficient lighting management system. Smart cities use IoT devices such as connected sensors, lights, and meters to collect and analyze data. The cities then use this data to improve infrastructure, public utilities and services, and more.

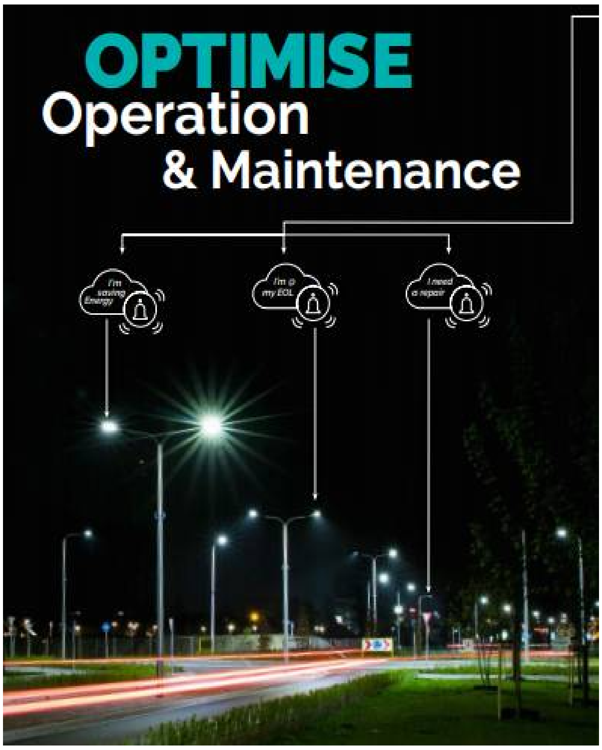

Figure 4.1 **Smart Lighting**

Figure 4.2 **Smart Lighting impact**

Smart parking

Smart Parking is a parking strategy that combines technology and human innovation in an effort to use as few resources as possible—such as fuel, time and space—to achieve faster, easier and denser parking of vehicles for the majority of time they remain idle. Smart Parking and its sister approach, Intelligent Transportation, are based on the fundamental ecological principle that we are all connected. Parking and transportation are both essential in the movement of people and goods. The Smart Parking and Intelligent Transportation vision and overlapping technologies are steadily melding into one integrated stream.

Figure 4.3 Smart Parking

Smart Buildings

A smart building is any structure that uses automated processes to automatically control the building's operations including heating, ventilation, air conditioning, lighting, security and other systems. A smart building uses sensors, actuators and microchips, in order to collect data and manage it according to a business' functions and services. This infrastructure helps owners, operators and facility managers improve asset reliability and performance, which reduces energy use, optimizes how space is used and minimizes the environmental impact of buildings.

Smart buildings use Internet of Things (IoT) devices—sensors, software, online connectivity—to monitor various building characteristics, analyze the data, and generate insights around usage patterns and trends that can be used to optimize the building's environment and operations. Smart buildings use information technology during operation to connect a variety of subsystems, which typically operate independently, so that these systems can share information to optimize total building performance. Smart buildings look beyond the building equipment within their four walls.

Semiconductor Solutions for IoT-Enabled Smart Buildings

- Climate control, including temperature, humidity, vibration, etc.
- CO monitoring.
- Electrical usage.
- Fire detection.
- Heating, ventilation and air conditioning systems (HVAC)
- Lighting control.
- Occupancy.
- Predictive maintenance.

Figure 4.4 Smart Building

4.3 5G Technology

5G is the 5th generation mobile network. It is a new global wireless standard after 1G, 2G, 3G, and 4G networks. 5G enables a new kind of network that is designed to connect virtually everyone and everything together including machines, objects, and devices. 5G wireless technology is meant to deliver higher multi-Gbps peak data speeds, ultra low latency, more reliability, massive network capacity, increased availability, and a more uniform user experience to more users. Higher performance and improved efficiency empower new user experiences and connects new industries.

4.3.1 Evolution from 1G to 5G Technology

Generation	Speed	Technology	Key Features
1G (1970 – 1980s)	14.4 Kbps	AMPS, NMT, TACS	Voice only services
2G (1990 to 2000)	9.6/ 14.4 Kbps	TDMA, CDMA	Voice and Data services
2.5G to 2.75G (2001-2004)	171.2 Kbps 20-40 Kbps	GPRS	Voice, Data and web mobile internet, low speed streaming services and email services.
3G (2004-2005)	3.1 Mbps 500- 700 Kbps	CDMA2000 (1xRTT, EVDO) UMTS and EDGE	Voice, Data, Multimedia, support for smart phone applications, faster web browsing, video calling and TV streaming.
3.5G (2006-2010)	14.4 Mbps 1-3 Mbps	HSPA	All the services from 3G network with enhanced speed and more mobility.
4G (2010 onwards)	100-300 Mbps. 3-5 Mbps 100 Mbps (Wi-Fi)	WiMax, LTE and Wi-Fi	High speed, high quality voice over IP, HD multimedia streaming, 3D gamming, HD video conferencing and worldwide roaming.
5G (Expecting at the end of 2019)	1 to 10 Gbps	LTE advanced schemes, OMA and NOMA	Super fast mobile internet, low latency network for mission critical applications, Internet of Things, security and surveillance, HD multimedia streaming, autonomous driving, smart healthcare applications.

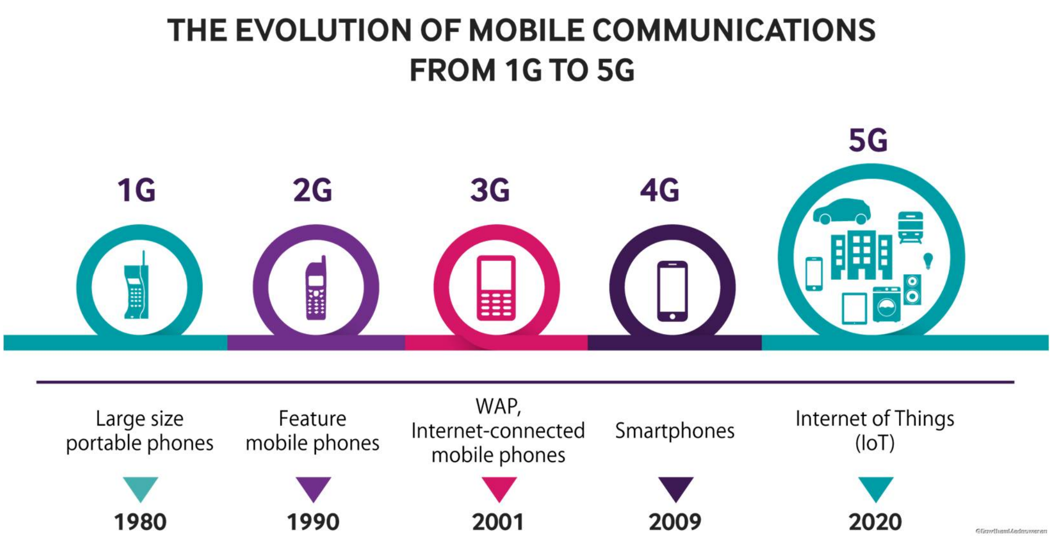

Figure 4.5 Evolution from 1G to 5G

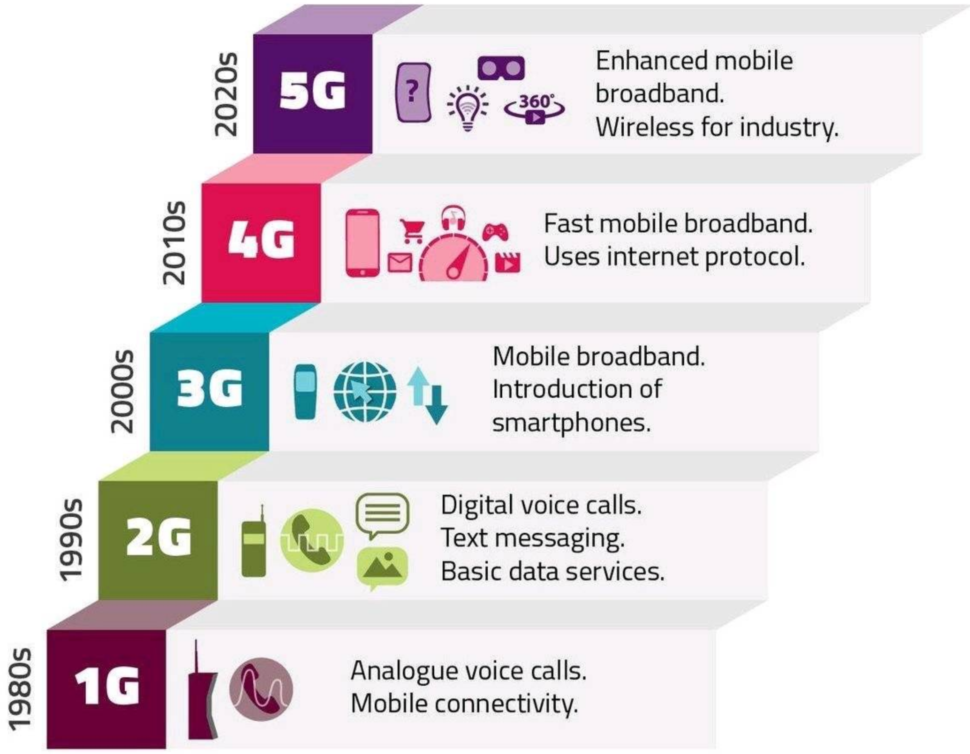

Figure 4.6 Transition from 1G to 5G Technology

4.3.2 4G – Fourth generation communication system

4G systems are enhanced version of 3G networks developed by IEEE, offers higher data rate and capable to handle more advanced multimedia services. LTE and LTE advanced wireless technology used in 4th generation systems. Furthermore, it has compatibility with previous version thus easier deployment and upgrade of LTE and LTE advanced networks are possible.

Simultaneous transmission of voice and data is possible with LTE system which significantly improve data rate. All services including voice services can be transmitted over IP packets.

Complex modulation schemes and carrier aggregation is used to multiply uplink / downlink capacity. Wireless transmission technologies like WiMax are introduced in 4G system to enhance data rate and network performance.

Key features of 4G system

- Much higher data rate up to 1Gbps
- Enhanced security and mobility
- Reduced latency for mission critical applications
- High definition video streaming and gaming
- Voice over LTE network VoLTE (use IP packets for voice)
- Disadvantages of 4G system

- Expensive hardware and infrastructure
- Costly spectrum (most countries, frequency bands are is too expensive)
- High end mobile devices compatible with 4G technology required, which is costly
- Wide deployment and upgrade is time consuming

4.3.3 5G – Fifth generation communication system

5G will be using advanced technologies to deliver ultra fast internet and multimedia experience for customers. Current LTE advanced networks will transform into supercharged 5G networks in future. In order to achieve higher data rate, 5G technology will use millimeter waves and unlicensed spectrum for data transmission. Complex modulation technique has been developed to support massive data rate for Internet of Things. Cloud based network architecture will extend the functionalities and analytical capabilities for industries, autonomous driving, healthcare and security applications.

Key features of 5G technology

- Ultra fast mobile internet up to 10Gbps
- Low latency in milliseconds (significant for mission critical applications)
- Total cost deduction for data
- Higher security and reliable network
- Uses technologies like small cells, beam forming to improve efficiency
- Forward compatibility network offers further enhancements in future
- Cloud based infrastructure offers power efficiency, easy maintenance and upgrade of hardware

5G: Much More Than Just "Ultrafast Internet" on the Smartphone. 5G will do much more than significantly improve network connection. It provides new opportunities, enabling to deliver ground breaking solutions that reach across society. Imagine billions of connected devices gathering and sharing information in real time to reduce road accidents; or life-saving applications that can take flight thanks to lag-free guaranteed connections; or production lines so predictive they can prevent interruptions well before they occur.

5G runs on the same radio frequencies that are currently being used for your smartphone, on Wi-Fi networks and in satellite communications, but it enables technology to go a lot further.

Beyond being able to download a full-length HD movie to your phone in seconds (even from a crowded stadium), 5G is really about connecting things everywhere – reliably, without lag – so people can measure, understand and manage things in real time. This has enormous potential – and together, will take it to the next level.

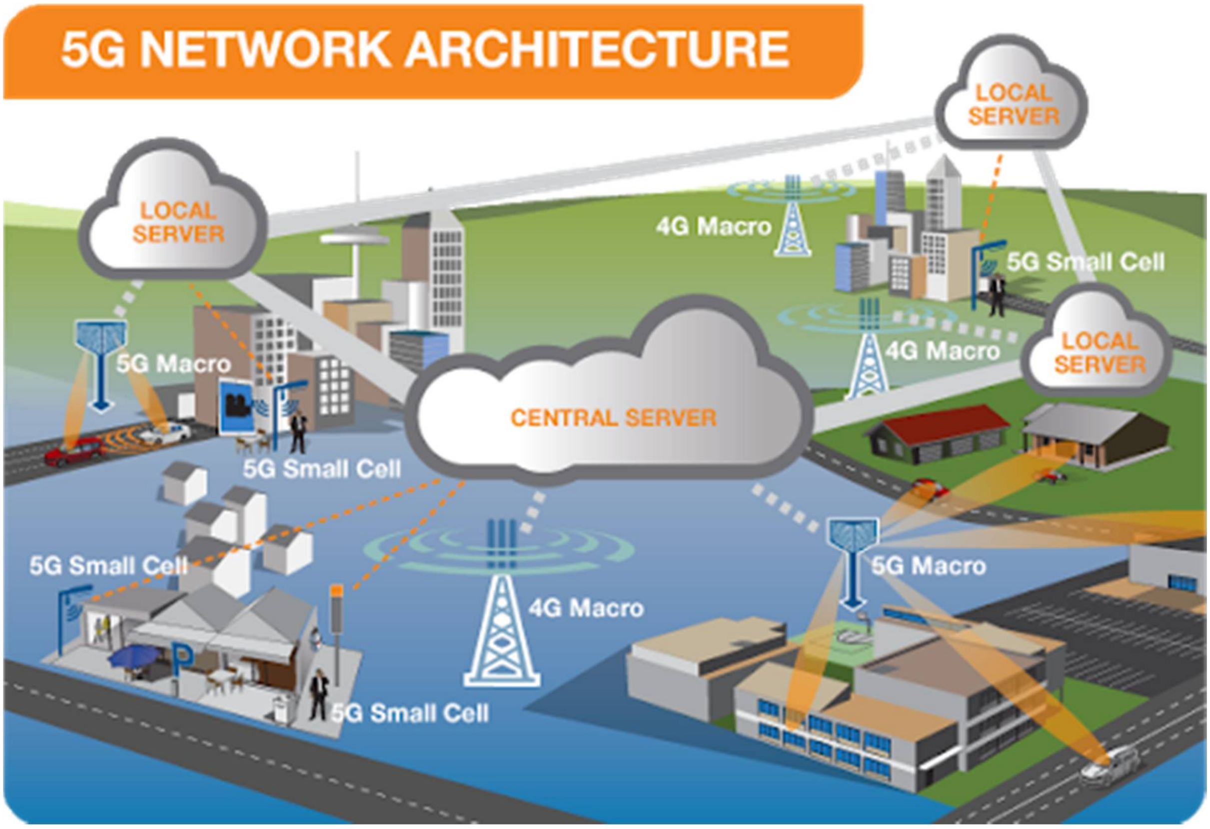

Figure 4.7 5G Network Architecture

4.3.4 Transforming industries

5G is the foundation for flexible, efficient and responsible business. Production lines autonomously reacting to supply and demand Digital replicas that can warn about real machinery faults ahead of time Logistic networks autonomously routing goods based on real-world conditions Full traceability down to the individual item at warehouses and ports Remote access to powerful robots and vehicles for improved safety in risky environments. Increased use of IoT in agriculture to efficiently grow crops.

4.3.5 Elevating experiences

5G sets the stage for more immersive entertainment and more engaging education. Greater realism in VR, AR and extended reality (XR) with lighter devices. Delivering sensory experiences, like touch, through devices. More engaging methods of teaching through immersive content. Immersive virtual meetings to boost remote team productivity. Stable and reliable connectivity in crowded spaces. New angles and interactions for live and remote event spectators.

4.4 Communication Protocols

Communication protocols assist varied network devices to converse with each other by transmitting the analog signals, digital signals, different files & process the data from one device to other devices.

These types of protocols are applicable in telecommunication & computer networks where suitable rules are executed to transmit information from source to destination.

The most vital protocols within networking are TCP (Transmission Control Protocol) & User datagram protocol (UDP).

TYPES OF ELECTRONIC COMMUNICATION PROTOCOLS

Inter System Protocol

Used to communicate between two different devices

Intra System Protocol

Used to communicate between two devices within the circuit board

UART PROTOCOL

UART stands for A Universal Asynchronous Transmitter And Receiver. UART Protocols is a serial communication with two wired protocols. The data cable signal lines are labeled as Rx and Tx. Serial communication is commonly used for transmitting and receiving the signal. It transfers and receives the data serially bit by bit without clock pulses. The UART takes bytes of data and sends the individual bits in a sequential manner. UART is a half-duplex protocol. Half-duplex means transferring and receiving the data but not at the same time. Most of the controllers have hardware UART on board. It uses a single data line for transmitting and receiving the data. It has one start bit, 8-bit data and a one-stop bit mean the 8-bit data transfer one's signal is high to low. Ex: Emails, SMS, Walkie-talkie. USART stands for A Universal Synchronous and Asynchronous Transmitter and Receiver. It is a serial communication of a two-wire protocol. The data cable signal lines are labeled as Rx and TX. This protocol is used to transmitting and receiving the data byte by byte along with the clock pulses. It is a full-duplex protocol that means transmitting and receiving data simultaneously to different board rates. Different devices communicate with microcontroller to this protocol.

Ex:-Telecommunications.

Figure 4.8 Types of USB

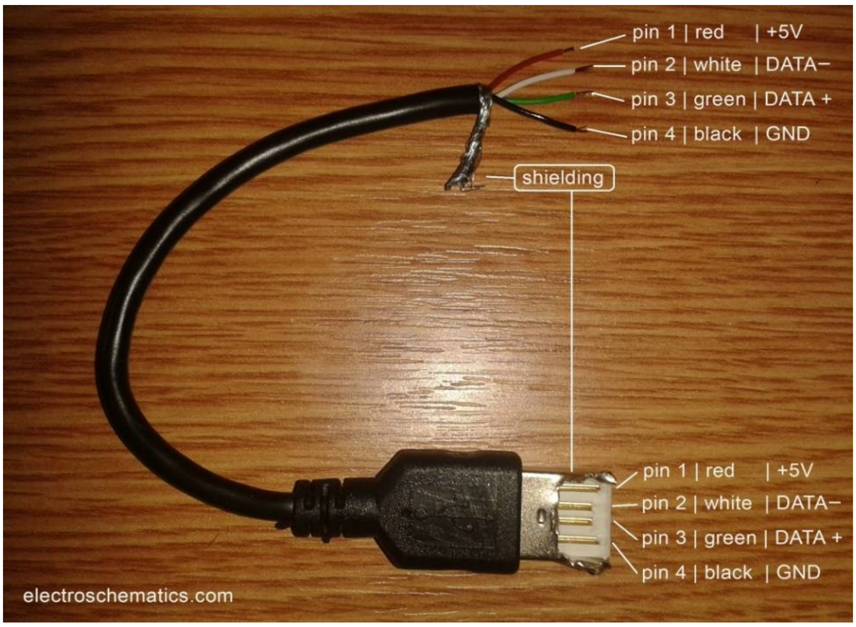

Figure 4.9 USB Cable wiring

DIFFERENCES BETWEEN THE INTER SYSTEM PROTOCOLS

UART	USART	USB
1. UART stands for Universal Asynchronous transmitter and receiver.	1. USART stands for universal synchronous and asynchronous Data transmitter and receiver	1. USB stands for universal serial bus.
2. It is a two wire protocol Rx and TX.	2. It is a two wire protocol Rx and TX.	2. It is a two wire protocol D+ and D-.
3. It is transmitting and receiving pockets of The data byte ·by byte without classes pulses	3. It is send and receives a block of data along with classes pulses.	3. Send and receives a data along with clock pulses
4. It is a half duplex communication	4. It is a full duplex Communication	4. It is also full-communication
5. It is slow compare with : USART	5. It is slow compare with USB	5. It is fast compare with USART and USB

DIFFERENCES BETWEEN THE INTRA SYSTEM PROTOCOLS

I2C	SPI	CAN
1. I2C stands for inter Integrated circuit.	1. SPI stands for serial peripheral Interface.	1. CAN stands for controller Area network.
2. It is developed by the Philips.	2. It is developed by the Motorola.	2. It is developed by the Robert Bosch.
3. It is a Half Duplex protocol	3.It is a full duplex protocol	3. It is a full duplex protocol
4. Syncronization	4. Synchronization	4. Synchronization
5. It is two wire protocols SCL and SDL.	5. It is a four wire protocol SCL and MISO/MOSI, SS	5. It is a two wire protocol CAN H+ and CAN H-.
6. It is multi master protocol	6. It is single master protocol	6. It is multi master protocol
7. With in the circuit board	7. With in the circuit board	7. With in two circuit board.

4.5 Integration of Sensors in Robots and Artificial Intelligence

A combination of various sensors allows an AI robot to determine size, identify an object and determine its distance. Radio-frequency identification (RFID) are wireless sensor devices that provide identification codes and other information. Force sensors provide the ability to pick up objects.

AI and computer vision technologies can help robots to identify and recognize objects they encounter, help pick out details in objects and help with navigation and avoidance. AI-enabled manipulation and grasping. Long considered a difficult task for robots, AI is being used to help robots with grasping items.

Just like sense organs are important in the human body, electronic sensors play a vital role in artificial intelligence. AI work programming intelligence or making computers behave like humans. AI algorithms are used to control robots

AI in robotics helps robots perform the crucial tasks with a human-like vision to detect or recognize the various objects. A huge amount of datasets is used to train the computer vision model, so that robotics can recognize the various objects and carry out the actions accordingly with right results.

Sensors used in AI robots are the same as, or are similar to, those used in other robots. Fully-functional human robots with AI algorithms require numerous sensors to simulate a variety of human and beyond-human capabilities. Sensors provide the ability to see, hear, touch and move like humans.

Sensors in robot allow it to react with its environment in a flexible way. With the help of sensors, robots are able to see and feel, and this would help the robot to perform complex tasks. In order to control their own actions, robots need to know information about the position and the movement of its body and parts.

Robots also have senses in the form of sensors. Sensors are used to evaluate the environment in which the robot is operating and allows the robot to adjust actions based on collected data. Contact sensors—to avoid obstacles. Proximity/Distance sensors—to detect distance of objects in relation to the robot.

Robotic sensors are used to estimate a robot's condition and environment. These signals are passed to a controller to enable appropriate behavior. Sensors in robots are based on the functions of human sensory organs. Robots require extensive information about their environment in order to function effectively.

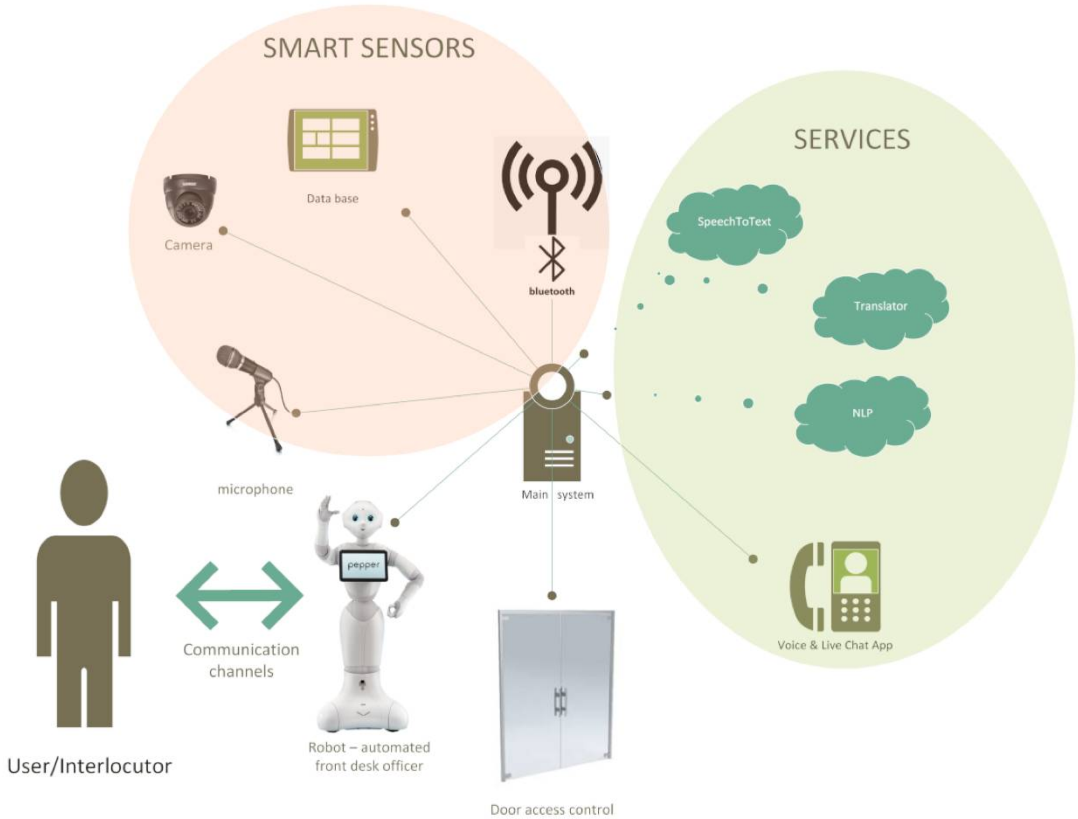

Figure 4.10 Integration of sensors in Robotics

Role of Sensors in AI (Artificial Intelligence)

Just like sense organs are important in the human body, electronic sensors play a vital role in artificial intelligence. AI work programming intelligence or making computers behave like humans. AI algorithms are used to control robots. For example, AI algorithms are used in virtual assistants like Google Assistant, Amazon Alexa and Apple Siri. Without sensors, AI robots are blind, deaf and dumb.

Local Intelligence:

Sensor solutions are mostly responsible for only data acquisition. The raw-data needs to be extracted from the sensor and transmitted to another, more computationally capable device within the network. The receiving end collects the raw-data and performs pre-processing in order to present relevant results. Frequently the raw-data of the IoT device needs to be processed using artificial intelligence, for example as in speech recognition. The demand for artificial intelligence is expected to increase dramatically over the next years since sensor solutions become more complex.

In future, the tendency of processing data within the cloud will be additionally shifted back to local on-device processing. That allows more complex sensor solutions, which include sensor fusion or pattern recognition.

For that kind of applications, local intelligence of the IoT device is needed. Sensor solutions will become resourceful, as they already deliver finalized meaningful data. But, computing elaborate AI solutions within an IoT device, need new solutions which meet power, speed and size constraints. In order to archive this, the trend is shifting to integrated circuits optimized for machine learning. This type of processing is commonly mentioned as edge AI.

4.6 Plant Safety and Security (Including AR and VR safety applications)

Augmented reality (AR) and virtual reality (VR) are closely related but not the same. Augmented reality enhances or 'augments' the real world by adding digital elements – visual, auditory, or sensory – to a real-world view.

AR/VR in Cyber Security

An SOC is a focused facility where security specialists monitor, assess and defend against computer security issues. Introducing Virtual Reality (VR) and Augmented Reality (AR) technology into this environment can enhance team performance, which translates into opportunity gains.

Augmented reality can help provide remote assistance to customers as they repair or complete maintenance procedures on products. It's also a valuable training tool to help inexperienced maintenance crew complete tasks and find the correct service and parts information when they are on-site. Augmented Reality (AR) adds digital elements to the camera of your smartphone, creating the illusion that holographic content is a part of a physical world around. Unlike virtual reality (VR), it is not immersed in an artificial environment.

4.7 Facility Management

Facility management (FM) is a profession that encompasses multiple disciplines to ensure functionality, comfort, safety and efficiency of the built environment by integrating people, place, process and technology. In general, facilities managers are responsible for the maintenance and upkeep of an organization's buildings, ensuring that they meet legal requirements and health and safety standards. Facility managers (FMs) operate across different business functions, working on both a strategic and operational level.

There are two major types of facilities management, Hard FM and Soft FM. Hard FM refers to services relating to the actual structures and systems that make a facility work, and can include fire safety, plumbing, structural, and elevator maintenance.

Facility management (FM) is a profession that encompasses multiple disciplines to ensure functionality, comfort, safety and efficiency of the built environment by integrating people, place, process and technology.

Figure 4.11 Facility Management

4.8 Intellectual Property Rights

Intellectual Property Rights (IPRs) are legal rights that protect creations and/or inventions resulting from intellectual activity in the industrial, scientific, literary or artistic fields. The most common IPRs include patents, copyrights, marks and trade secrets. Intellectual property rights are the rights given to persons over the creations of their minds. They usually give the creator an exclusive right over the use of his/her creation for a certain period of time.

Intellectual property rights are customarily divided into two main areas:

(i) Copyright and rights related to copyright

The rights of authors of literary and artistic works (such as books and other writings, musical compositions, paintings, sculpture, computer programs and films) are protected by copyright, for a minimum period of 50 years after the death of the author.

Also protected through copyright and related (sometimes referred to as "neighbouring") rights are the rights of performers (e.g. actors, singers and musicians), producers of phonograms (sound recordings) and broadcasting organizations. The main social purpose of protection of copyright and related rights is to encourage and reward creative work.

(ii) Industrial property

Industrial property can usefully be divided into two main areas:

One area can be characterized as the protection of distinctive signs, in particular trademarks (which distinguish the goods or services of one undertaking from those of other undertakings) and geographical indications (which identify a good as originating in a place where a given characteristic of the good is essentially attributable to its geographical origin).

The protection of such distinctive signs aims to stimulate and ensure fair competition and to protect consumers, by enabling them to make informed choices between various goods and services. The protection may last indefinitely, provided the sign in question continues to be distinctive.

Other types of industrial property are protected primarily to stimulate innovation, design and the creation of technology. In this category fall inventions (protected by patents), industrial designs and trade secrets.

The social purpose is to provide protection for the results of investment in the development of new technology, thus giving the incentive and means to finance research and development activities.

A functioning intellectual property regime should also facilitate the transfer of technology in the form of foreign direct investment, joint ventures and licensing.

The protection is usually given for a finite term (typically 20 years in the case of patents). While the basic social objectives of intellectual property protection are as outlined above, it should also be noted that the exclusive rights given are generally subject to a number of limitations and exceptions, aimed at fine-tuning the balance that has to be found between the legitimate interests of right holders and of users.

Figure 4.12 IPR

4.9 Case Studies - Milk Processing and Packaging Industries

Learn, understand the following NPTEL course link and create case study based on that.

https://nptel.ac.in/courses/106/105/106105195/

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Question Bank

Part A: Two Marks:

1. What is a sensor question?
2. Why do we need transducers in sensing and actuation?
3. How do sensors and actuators work together?
4. What are the types of sensors?
5. What is meant by inventory management and quality control?
6. Brief about facility management.

Part B:

1. Explain in detail about 5G Technology.
2. Interpret the Integration of Sensors in Robots and Artificial Intelligence.
3. Discuss the Integration of Sensors in Human-Machine Interaction, Industrial IoT.
4. Elaborate the applications of Industry 5.0 in healthcare and power plants.
5. Explain in detail about plant safety and security measures with respect to AR & VR applications.
6. Discuss in detail about Intellectual property rights.

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UNIT – 5

CYBER SECURITY IN INDUSTRY 5.0

UNIT-5 CYBER SECURITY IN INDUSTRY 5.0

Introduction to Cyber Physical Systems (CPS), Architecture of CPS, Data science and technology for CPS, Prototypes of CPS, Emerging applications in CPS including social space, crowd sourcing, Networking systems for CPS applications, Wearable cyber physical systems and applications, Domain applications of CPS: Agriculture, Infrastructure, Disaster management, Energy, Intellectual Property Rights (IPR) : Case Studies- Augmented Reality Virtual Reality

5.1- Introduction to Cyber Physical Systems (CPS):

A cyber-physical system (CPS) or intelligent system is a computer system in which a mechanism is controlled or monitored by computer-based algorithms. In cyber-physical systems, physical and software components are deeply intertwined, able to operate on different spatial and temporal scales, exhibit multiple and distinct behavioral modalities, and interact with each other in ways that change with context. CPS involves transdisciplinary approaches, merging theory of cybernetics, mechatronics, design and process science.The process control is often referred to as embedded systems. In embedded systems, the emphasis tends to be more on the computational elements, and less on an intense link between the computational and physical elements. CPS is also similar to the Internet of Things (IoT), sharing the same basic architecture; nevertheless, CPS presents a higher combination and coordination between physical and computational elements.

Examples of CPS include smart grid, autonomous automobile systems, medical monitoring, industrial control systems, robotics systems, and automatic pilot avionics. Precursors of cyber-physical systems can be found in areas as diverse as aerospace, automotive, chemical processes, civil infrastructure, energy, healthcare, manufacturing, transportation, entertainment, and consumer appliances.

5.2 Architecture of Cyber Physical System:

CPS is the integration of physical or mechanical system and network or computations system. According to Liu et.al (Liu et al.,2011), there are four main characteristics of CPS; physical system, information system, the product of integration and heterogeneous systems and requirement of security, real-time capability and predictability. The physical system is a mechanical part such as actuator or electromechanical system that is used in production line or processing system.

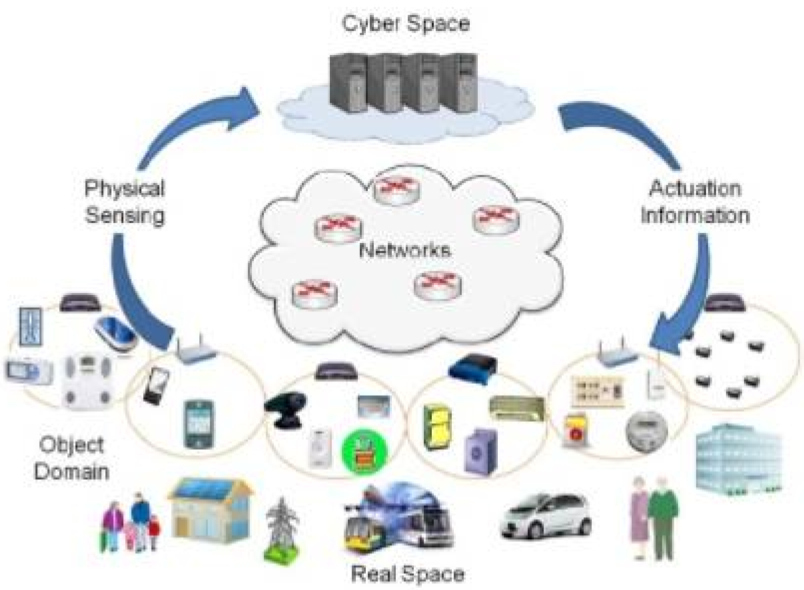


Fig 5.1: Architecture of CPS

Information system is more on network, data storage, and memory management. Meanwhile, heterogenous systems is the interaction controlling between physical and network. External communication network is a common system. This external communication system may disturb by a malicious cyber-attack. Requirement of security, real-time capability and predictability is one of the important characteristics in CPS. It is to avoid any issued occurred that caused the unpredictable system's behaviour (Jamaludin et al., 2018). Figure 5.1 shows CPS basic architecture.

According to the above figure the physical system consist of physical sensing will send an analogue signal to the cyber space. The analogue signal will be converted into digital data. This data needs to be protected from malicious attack. Data encryption and integration will be involved to protect the data credential, privacy and integrity. Cyber space will control, stored and process the data. Control centre will send a control command to the actuator network. This is a close-loop processes. Another important characteristic in CPS is global reference time. Global reference time helps to make sure the CPS performance are conducted in a synchronous or asynchronous. This will help to ensure the data from physical system to actuator are send properly and accurately through cyber world.

5.3 Prototypes of CPS:

Hitachi, Ltd. has developed a prototype Cyber Physical System (CPS) for supporting the PDCA*1 cycle in facility operation geared toward a community-based shopping mall, which is a starting point of community revitalization. The prototype presents effective operational methods through AI analysis after incorporating the following data into **Digital Twin*2 in cyberspace:**

Sales data of each outlet based on POS System*3

Customer (human) flow data acquired from LiDAR sensor*4

Daily operational strategy data

Knowledge and views of site experts

This enables the shopping mall owner, site supervisors and tenant owners to devise their own convincing operational methods which fit the status quo of each outlet, such as customer base and geographical characteristics. Hitachi carried out a demonstration experiment at nonowa Kunitachi, a shopping mall adjacent to JR Kunitachi Station and operated by JR Chuo Line Community Design. The company confirmed that traditionally incomprehensive purchase trends and effects of operational methods are quantifiable, which has lead Hitachi to discover effective operational methods. Going forward, Hitachi aims to put this CPS into practical use as a solution supporting operational methods tailored to characteristics of domestic and global shopping malls. Hitachi is enthusiastic about contributing to regional community revitalization.

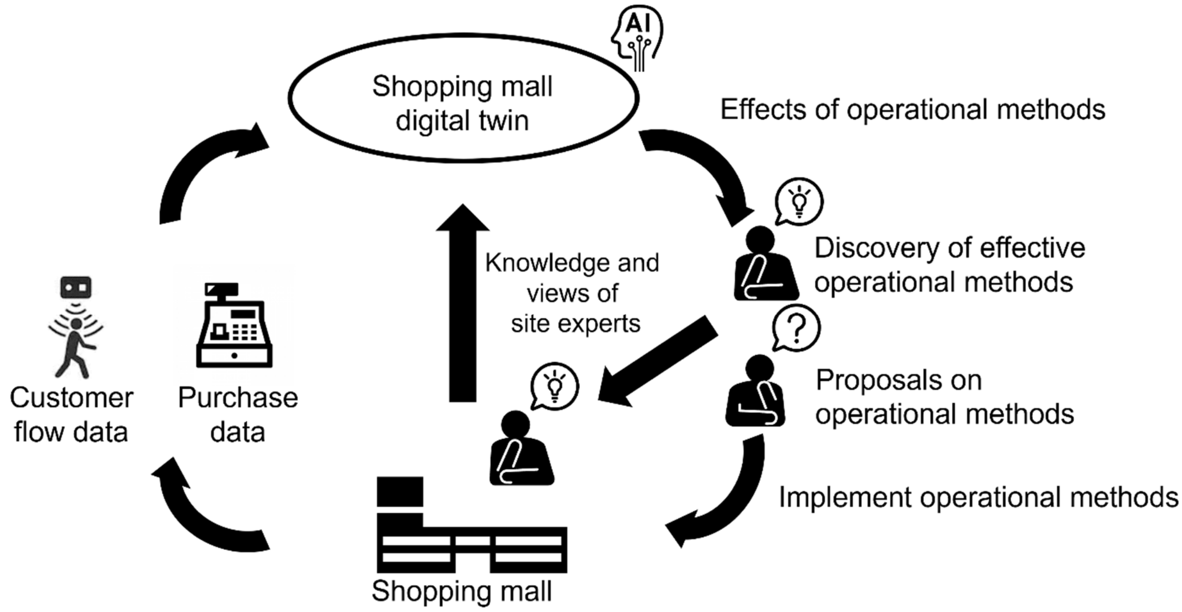


Fig5.2: Prototyping of CPS

5.4-Applications of Cyber Physical System

5.4.1: Networking Systems

Video-based sensing application which equipped camera in mobile phones used for capture, send and receive real-time videos have been a popular platform for social communication (Burke et al., 2006). In 2008, a group of researcher presented a network architecture known as AnySense that facilitates the internet hosts in CPS and 3G mobile phones. (Xing et al., 2008). AnySense, integrates transcoding of video streams which is open to 3G mobile service providers through the interface of internet and the 3G cellular framework.

In 3G network video modelling, the Perceptual Evaluation of Video Quality (PEVQ) is an important factor to consider and the key challenge in this video modelling is to remove the impact of video encoders which affect the score for PEVQ. As a consequence, 3G networks from various providers are not accessible to an encoder-dependent video quality model. Optionally, without the dependency of encoding schemes, a video quality model can only convey the effect of network transmission variables. To this end, Xing and his team

Researcher propose a new reference-based modelling approach that can effectively minimize the effect of encoding on video quality quantification. AnySense's approach is by associating the 3G networks of circuit-switched (CS) and the packet-switched (PS) Internet. Figure 7 is the architecture of AnySense.CPU and radio are the significant sources of power operating expenses on cyber-physical wireless networks. To deal with this, intensively research to implement this practice have been done (Rhee et al., 2008) but unfortunately bring to another challenge in embedded applications. Therefore, Darmawan (Darmawan, 2019) described a method to utilize the energy consumption in wireless CPS for real-time applications.

His work proves by implementing the radio sleep configuration for wireless sensor nodes and computer execution modes could optimize the power consumption on a CPS device system. Different schemes were proposed based on various wireless network topologies to reduce the expenditure of energy through maintaining the timing limit and limit of precedent. In practice, this technique is effective, though it's pseudo-polynomial algorithm.

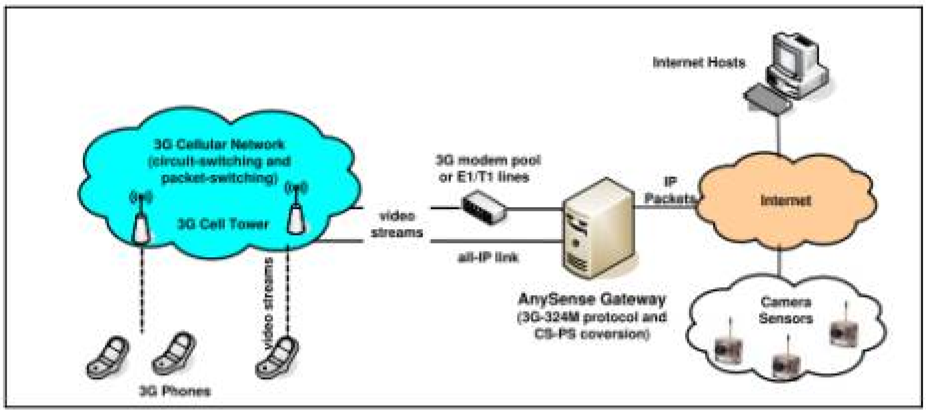


Fig 5.3: Networking

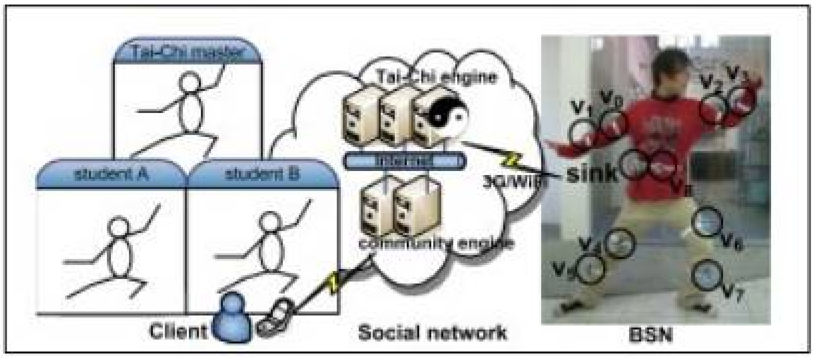
5.4.2Social Networking and Gaming:

The application of CPS technology in social networks and entertainment will bring about a revolutionary effect. For example, computer games that integrate CPS improve upon the virtual world that they create with added physical signals, such as those from sensing devices. This configuration will enhance the users' engagement and provide a more realistic experience. CenceMe is a technology order to facilitate information collected from mobile sensors to be shared through social networks (Miluzzo et al., 2008). In order to do this, CenceMe detects a single user's behaviour in various environments, after which a social network such as Facebook or Myspace will share the information received by the user's sensors and actuators.

Various sensing element such as the GPS, camera, accelerometers, Bluetooth and microphone were used in expanding the capabilities of mobile phone. However, the usage of

Bluetooth and GPS application serves a high number of energy usage. Therefore, power conservation is an important driver to be considered in the implementation of the CenceMe application. By carrying multiple sensors on the human body, also known as body-sensor networks (BSN), the human motion could be captured. Data from the body sensors are captured and transmitted in real-time. An idea of a CPS network whereby users can practise traditional Chinese particular skill, Tai Chi, was discussed in a study in 2010 (F.-J. Wu et al., 2010).

By implementing the wireless sensor networks (WSNs), any group of people could make-up Tai Chi exercises and lessons anywhere and anytime lead by a Tai Chi master. This platform provides users to communicate by sharing conventional messages and images and even some sensory signal across several interesting ways. Figure 5 illustrates the architecture of this



virtual-physical Tai chi social network.

Fig 5.4: Social Networking

5.5 Wearable cyber physical systems and applications

Cyber-Physical Systems (CPS) are collections of physical and computer components that are integrated with each other to operate a process safely and efficiently. Examples of CPS include industrial control systems, water systems, robotics systems, smart grid, etc.

CPSs are characterized by integration, across technologies, industrial domains, and the life-cycle, and by "smartness." CPS can be described using a corresponding set of characteristics: technical emphasis, cross-cutting aspects, level of automation, and life-cycle integration. "This requires three fundamental attributes to be present, also known as the three Cs – communication, control and computing. Unless these three elements are present you will not have a system where physical processes can affect computations and vice versa." Each includes smart networked systems with embedded sensors, processors and actuators that sense and interact with the physical world and support real-time, guaranteed performance in safety-critical applications. Standards, protocols and test methods that support the discovery, interoperability and composition of components used to build these cyber physical systems will promote innovation, improve economic viability at the same time allowing systems to become more efficient and reduce resource-use."

Medical cyber-physical systems (MCPS) are healthcare critical integration of a network of medical devices. These systems are progressively used in hospitals to achieve a continuous high-quality healthcare. Cyber-physical systems and medical CPS structure. Enormous economic impairment occurs in the case of CPS malfunction which affects the corresponding systems operation. The CPS has physical infrastructure requirements along with networking models. The CPS becomes more complex, prevalent, personalized and reliable.

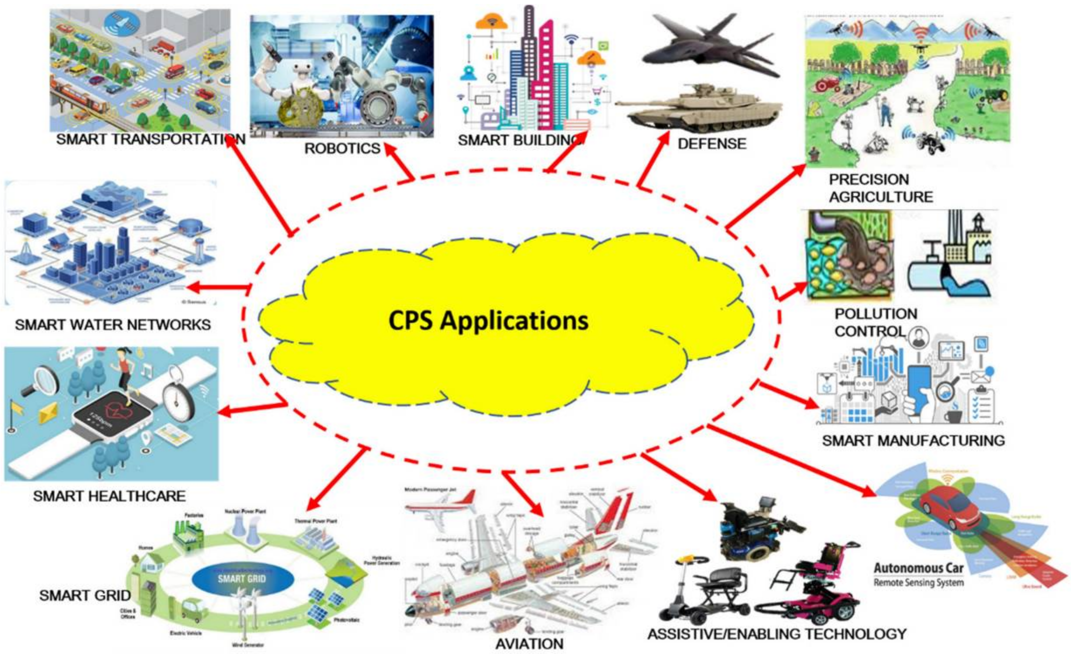


Fig 5.5: Cyber Physical Systems Applications

Controlled-environment agriculture (CEA) is a technology-based approach toward food production. The aim of CEA is to provide protection and maintain optimal growing conditions throughout the development of the crop. Production takes place within an enclosed growing structure such as a greenhouse or building. Plants are often grown using hydroponic methods in order to supply the proper amounts of water and nutrients to the root zone. Because of this, CEA does not depend on arable land and food can be produced in or near major population centers. CEA optimizes the use of resources such as water, energy, space, capital and labor. CEA technologies include hydroponics, aquaculture, and aquaponics.

The goal is to develop Smart Cyber-Physical Systems for Controlled-Environment Agriculture, to optimize the food production quality, quantity and schedule in balance with operational cost and resource usages. The features of such a system include, but not limited to, the follows:

- sense and control environmental parameters (such as temperature, humidity, carbon dioxide, light) and soil properties (such as moisture, nutrient concentration and acidity)
- monitor the crop health and provide expert advice and decision support for future actions
- minimize the energy cost of lighting, HVAC and irrigation systems with information from electricity market pricing signals, renewable energy supply, and weather forecasts
- implement the potential correlated benefits of including solar photovoltaic panels on greenhouse structures in terms of energy production, internal shading benefits for both cooling and heating seasons
- optimize food production schedules by connecting with food supply chain and logistics
- automate the seeding, phenotyping and harvesting processes for certain crops with robotics and other intelligent tools
- provide recommendation on optimized greenhouse design and operations based on local weather conditions, food needs, and energy supply profiles

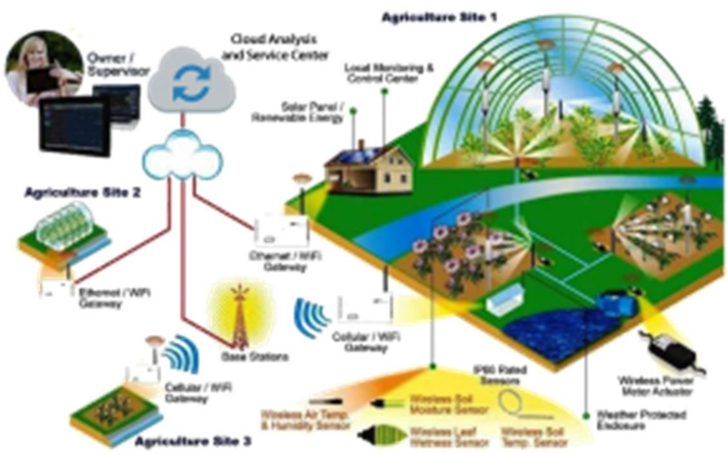


Fig 5.6: Cyber Physical Systems in Agriculture

5.6 Case Studies- Augmented Reality Virtual Reality

Develop an AR VR application in unity tool

https://nptel.ac.in/courses/106/105/106105195/

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[3] Alasdair Gilchrist, “INDUSTRY 4.0: Industrial Internet of Things”, Apress, 2016.

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[5] https://www.nsf.gov/news/special_reports/cyber-physical/

Question Bank

Part A: Two Marks:

1. **Define Cypher Physical System.**
2. **What is Prototype of CPS?**
3. **Draw the architecture of Cypher Physical System.**
4. **What are the emerging applications in CPS?**
5. **Give examples of wearable CPS.**
6. **What is the difference between IoT and CPS?**

Part B:

1. **Explain the architecture of CPS.**
2. **Explain the data science and technology for CPS.**
3. **Explain the emerging applications of CPS.**
4. **Describe about CPS application in Agriculture.**
5. **Elaborate about CPS in disaster management and IPR.**