UNIT-1


3D PRINTING
SIMULATION
SCANNING
SYSTEM
SMART FACTORY
BIG DATA
THE CLOUD
AUTOMATION ROBOTS
INDUSTRY 4.0
INTERNET OF THINGS
ROBOT
WORK
ADDITIVE MANUFACTURING
MOBILE DEVICE
AUGMENTED REALITY
CUSTOMIZATION
SOFTWERE
AI

Reason behind the change :

- We had First, Second, Third Industrial Revolutions, before the "Fourth" industrial revolution. So, in the 1st , 2nd and 3rd Industrial revolutions, there is change or transformation in the process of manufacturing i.e., Manufacturing has undergone several eras of change since the 1st Industrial revolution.

- Every industry and organization operating today is different , & they all face a common challenge, they all wants to improve their business and making their factories as smart factories which helps them to complete their tasks efficiently and within less time and improve their productivity and profit .

- Industries need connectedness and access to real-time and data insights across processes, partners, products & people using which they can optimize their manufacturing process.

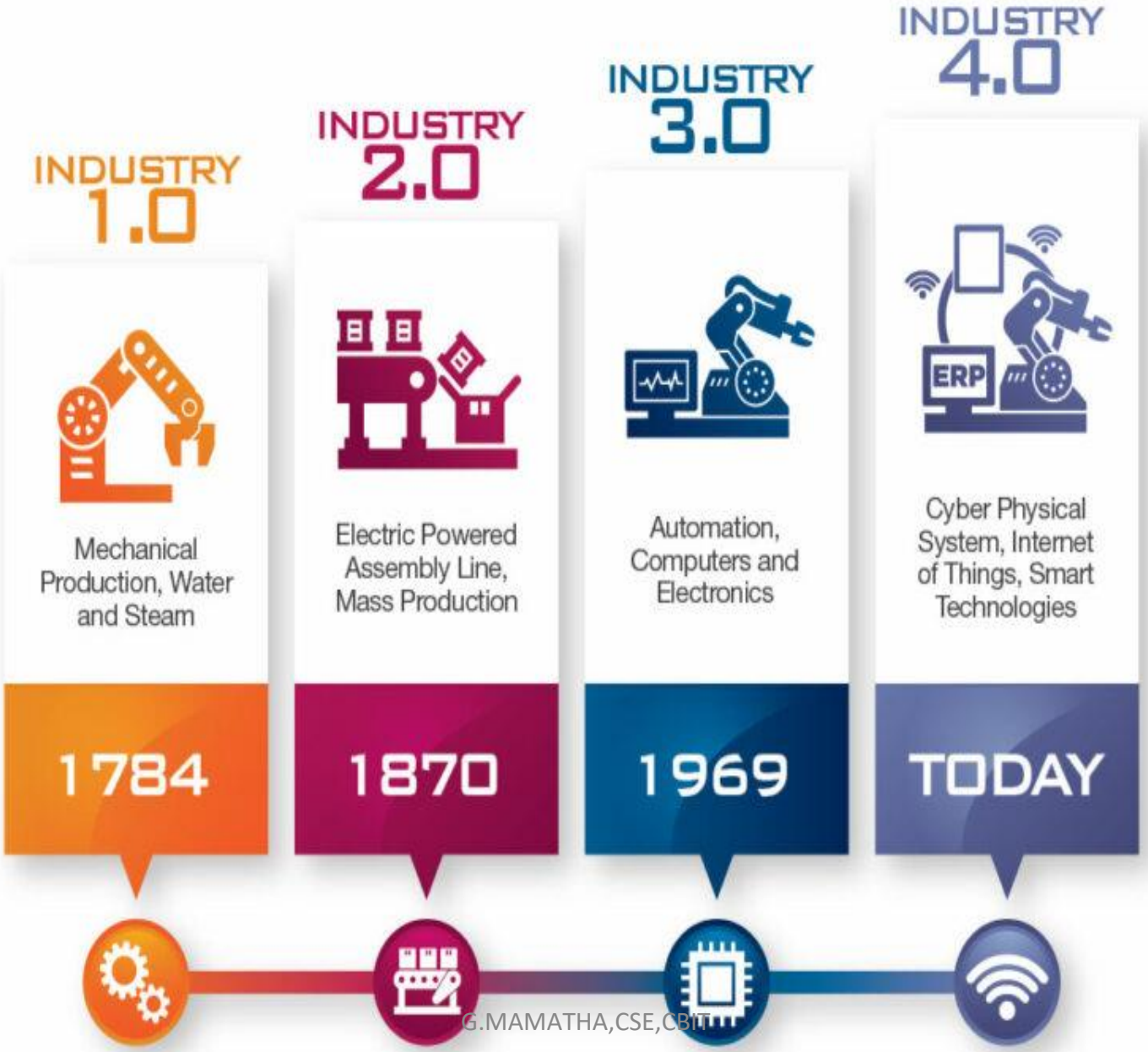
- The change in manufacturing process includes the entire value chain from raw materials to end use to recovery impacting business and support functions (Eg. Supply Chain, Sales). This can be achieve through industry 4.0.

- Industry 4.0 is not only about investing in the new technology & tools to improve the manufacturing efficiency – it is also about revolutionizing the way your entire business is going to operate and grow.

- Industry 4.0 can create the smart factories with personalization/customization of products.

Various Industrial Revolutions

- Technical advances also change the way humans produce things.
- The present production technology in industries or companies is completely different from the past.
- what are the various revolutions took place.
  - The First Industrial Revolution
  - The Second Industrial Revolution
  - The Third Industrial Revolution
  - The Fourth Industrial Revolution (or) Industry 4.0



The First Industrial Revolution

- The First Industrial Revolution happened between late 1700's and early 1800's
- During this revolution they focussed on transition from manual hand production methods to machines through the use of steam powered engines & water as a source of power
- In this revolution mechanical production was introduced called Mechanization.
- Some of the industries that benefitted from this transition & change is Textile industry, Iron production, Mining and Metallurgy machines tools, Steam factories and Agriculture.
- But, Textile Industry is the one which got most benefitted and was the first to adopt such method. (It gave huge economy & profit for British Govt.)

- Steam was powering everything from Agriculture to Textile manufacturing.

- During this revolution the world began to rely on steam power & machine tools, steam ships and Rail roads revolutionized

- And what emerged as the new centre of community life i.e., 'The Factory'.

- **But factory life was difficult:**

– Unskilled factory labourers were cheap and plentiful

– work long hours often in unsafe conditions. Children worked in factories

– Putting in 14 hours of work in unsafe conditions.

– Ultimately, advancing industrialization created a middleclass of skilled workers as a new techniques, machinery and tools are introduced.

– Cities and industries grew more quickly

The Second Industrial Revolution

- The Second Industrial revolution has started in the 19th Century i.e., between 1871 & 1914.
- It is also known as Technological Revolution.
- This revolution has began with the discovery of the Electricity.
- During this period of time, companies introduced steel & use of electricity, gas and oil in the factories, Electric power generators.
- Replaced water and steam powered generators.
- Large scale production is done. Large factories were introduced, such as steel revolution in manufacturing factories

- One more important aspect of 2nd industrial revolution is the ‘Mass Production’

- The Mass production concepts like Assembly line production was introduced to boost or speed up the productivity .

❖What is Assembly Line production:

- Assembly line production is the most commonly used method in mass production of products
- An Assembly line is a production process that divides up the labour process i.e., it breaks up the manufacturing process of goods into various steps that are completed in a pre-defined sequence
- Assembly lines are able to reduce the labour costs because unskilled workers could be easily trained to perform a specific task, instead of training them on the entire production.

- So, rather than hiring a skilled craftsman to put together or to do a entire work (For Eg. Making a furniture or Vehicle engine) we must hire a worker to only add a leg to a stool or bolt to a machine.

- So, this assembly line production drastically changed the way goods were manufactured this increases the efficiency of work.

- Invention of Combustion Engine which worked well with these fuel sources.

- Chemical based products entered into the market during this time.

- Developments in communication technology got a jump start with the telegraph and later the telephone.

- Transportation facilities are also grown with the invention of Plane and Car

- Automobile production, Turbines, Gasoline Engines, Refrigerators, Washing Machines all got introduced.

- This Second Industrial Revolution period was a period of great economic growth with an increase in the productivity which is also a reason for the unemployment since many factory were replaced by machines.

- **For Example**, Henry Ford's company was mass producing ground breaking Ford model T, a car with a gasoline engine built on a assembly line in his factories.

- In the early 1900's workers left their rural homes behind to move to urban areas & factory jobs. By 1900, 40% of the U.S population lived in cities it was just 6% in 1800

Ford model T Car built on assembly line production

The Third Industrial Revolution

- The Third industrial Revolution began in the late 20th century i.e., between 1970-1990.
- It is a also called as the Digital Revolution.
- In this Revolution, it brought the electronics and Information technology to automate the manufacturing process or production
- Things that used to be Analog moved to Digital technologies (Ex:- Like an old television you used to tune in with an antenna(analog) being replaced by an internet-connected TV or tablet that lets you stream movies(digital).
- In this revolution, Semi Conductors, Mainframe Computers, personal computers and internet have been introduced

- This period also opened the doors for space expeditions, research, bio technology, super computers, nuclear energy, transistors, micro processors, 3D printing.

- The two major inventions are done in this period
    - Programmable Logic Controllers (PLC's)
    - Robots

- So, manufacturers began using more electronics & computer technology into their factories which brought partial to high level automation in their works.

- The supply chain was made global.

- move from the analog devices and mechanical devices to the widely spreading digital technology has changed the industries manufacturing, production process from human made to automation

The Fourth Industrial Revolution

- The Fourth industry Revolution originated or began in 2011 from a project in the high tech strategy of the German Government. Its also called as the Industry 4.0.
- Industry 4.0 is also called Fourth Industrial Revolution
- Industry 4.0 is the ongoing automation and digital transformation of traditional manufacturing process and industrial practices using various smart technologies .
- The goal of this Revolution is to change or transformation of traditional industry manufacturing process to highly automated process through digitalization.

- Industry 4.0 is very popular topic today because of its influence on manufacturing.
- Industry 4.0 is focused on creating 'Smart' environment within production system or manufacturing system
- Smart means everything is automated and all the devices, machines are connected to each other through internet and sensors are attached to every device and object in need and made to collect and send the information regarding the operation or process to various systems for processing and analysis

- Industry 4.0 used various advance and modern technologies such as, Internet of things (IOT), access to real time data, introduction of Cyber physical systems (CPS), Robotics, Cloud Computing,

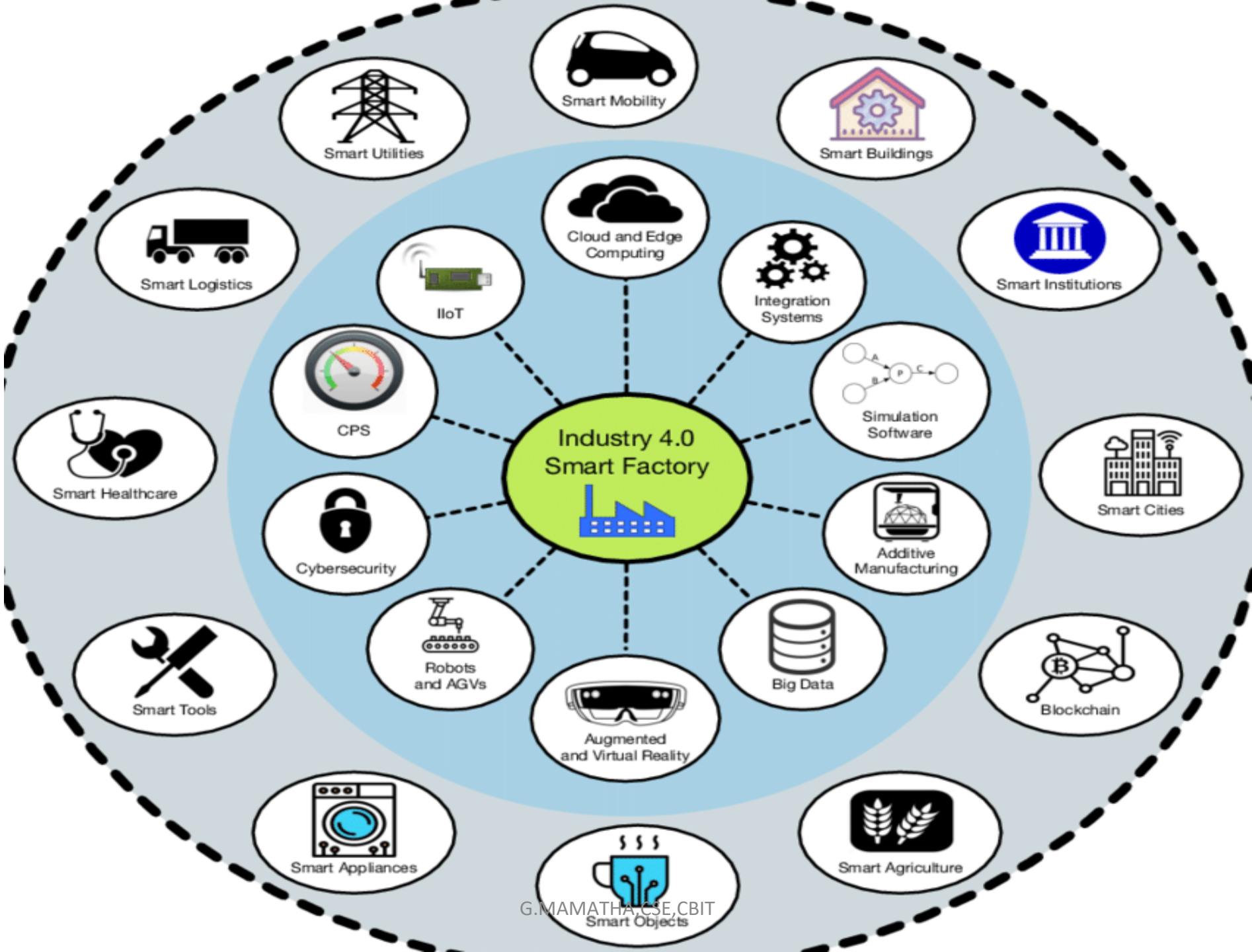
- Big Data, Machine Learning, Data Analytics, Artificial Intelligence(AI), Industrial Internet of things (IIOT).

- Through Industry 4.0, the devices & machines are equipped with internet connectivity & objects also equipped with sensor & internet and are made to communicate with each other i.e.,
- **machine-to-machine** communication (M2M) and the **internet of things** (IoT) are integrated for increased automation, improved communication and **self-monitoring**, and smart **production.**
- smart machines that can analyze and diagnose issues without the need for human intervention.

- No human intervention required. As all the industries are automated mostly the requirement of man-power or labour gets reduced.

- Industry 4.0 completely changed the manufacturing process through automation, digitalization which increases productivity & give more profit with less effort.

- In this period, people found more personalization/customization of products.
- Industrial companies play a major role in the world today. So, the manufacturer must include and be ready with new technological advances to improve their productivity, and give good competition to their opponents and maintain a proper relationship with customers and have great customer satisfaction.



- Industry 4.0 will do the transformation of the industrial processes through the use of various modern technologies such as, Artificial Intelligence(AI), Machine Learning(ML), Big Data, Internet of things (IOT),CyberPhysicalSystems(CPS's),Robotics and Automation, Cloud Computing, Data Analytics, sensors, communication & Computational processing. Industrial Internet of Things(IIOT), it is an application of IOT in industries to modify the various existing Industrial Systems.

- Cyber-physical systems create the capabilities needed for smart factories. products and means of production get networked and can 'communicate', enabling new ways of production, value creation, and real-time optimization.

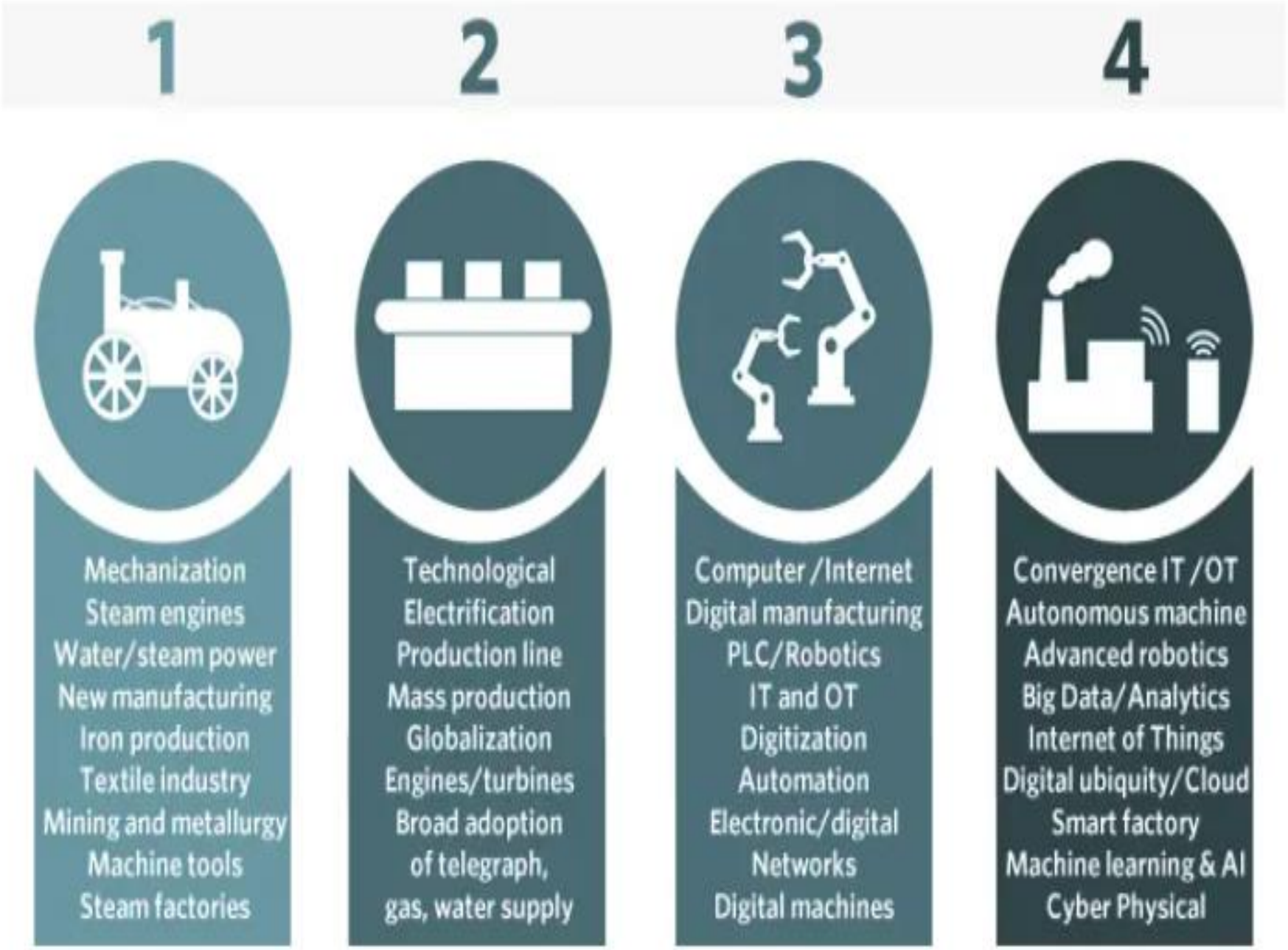
- In this Fourth industrial revolution(Industry 4.0) the automation and transformation of Industrial manufacturing is possible only through the usage of their advanced technologies.

- We define the Industry 4.0 as the Intelligent networking of machines and processes for the industry with the help of Information & Communication Technology (ICT).

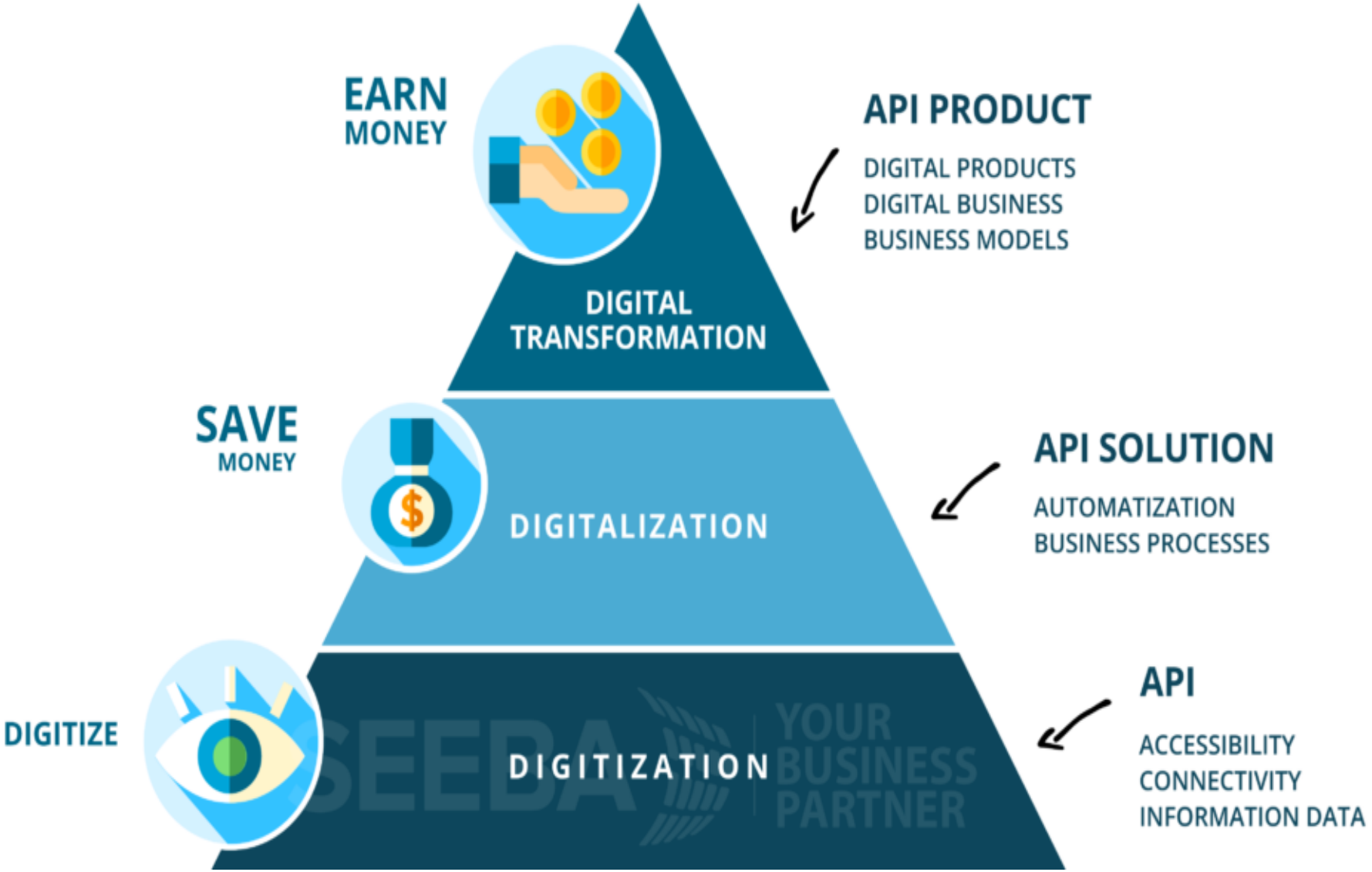
- ICT refers to technologies that provide access to information through telecommunications

- ICT refers to all communication technologies including the internet, wireless networks, Cell phones, Computers, Software, Middleware, Video Conferencing, Social Media, Broadcast Media, N/W based control & monitoring function, audio visual processing and transmission systems.

- Industry 4.0 also concentrates on connectivity, real time data, networks of advanced manufacturing devices controlled by computers combining them into a physical-digital environment.


1
2
3
4
Mechanization
Steam engines
Water/steam power
New manufacturing
Iron production
Textile industry
Mining and metallurgy
Machine tools
Steam factories
Technological
Electrification
Production line
Mass production
Globalization
Engines/turbines
Broad adoption
of telegraph,
gas, water supply
Computer /Internet
Digital manufacturing
PLC/Robotics
IT and OT
Digitization
Automation
Electronic/digital
Networks
Digital machines
Convergence IT /OT
Autonomous machine
Advanced robotics
Big Data/Analytics
Internet of Things
Digital ubiquity/Cloud
Smart factory
Machine learning & AI
Cyber Physical

Digitalization



- **Digitization:**
- Digitization is the process of converting information into a digital format or converting something non-digital into digital representation.
- Digitization is very important for storing the data, transmission of data, processing of data . As the data is stored in digital form (i.e., Binary form). It is easy to store, transmit, process and analyze it with same efficiency.
- Digitization is the conversion of Analog/physical things such as paper documents, photographs, sounds, signals, videos, records into the digital form or digital versions.
- When we digitize the data, this data is stored in the form of discrete units or sets of data called bits and these bits are Binary numbers which are understandable by computers.
- In Digitization, while converting analog data to digital data, the data itself is not changed it is simply encoded in a digital format.
- Example: We can scan a paper document and save it as a digital document (Eg. PDF), Converting handwritten or typewritten text into digital form.

- Other examples are scanning of printed photos or taped videos, 3D scanning that creates 3D modeling of an object's surface, signals, location data, identity cards.

ii) Digitalization:

- Digitalization refers to enabling or improving the processes by using the digital technologies and digitized data.

- It can also be defined as :- “Digitization is the use of various digital technologies to change a business model and provide new profits/revenue & producing good opportunities” (It is like process of moving to a digital business).
- Digitalization improves an existing business process but does not change or transform them.
- Digitalization increases productivity, efficiency and reduces costs.

- Digitalization can take the processes from the human driven event or some series of events to software driven.

- The digital innovations (new inventions based on digitalization) is one of the important business trends for future economy.

- Companies need to develop digital strategies and focus on what are the key success factors of digital transformation. Digitalization changed the economy and society

- Digitalization is technology driven.

❖Examples of digital technologies:

- Websites
- Smart phones
- Artificial Intelligence (AI)
- Cloud computing
- 5G data
- Video streaming
- eBooks
- Geo-location
- Social Media
- Gadgets
- 3D printing
- ATM Machines
- Digital Cameras
- Cars & other vehicles
- Digital Clocks
- Robotics
- Drones & Missiles
- Banking and finances
- Online Buying/selling

- The music, media industries first experienced the effects of digitalization then retail industry.

- Digitalization means turning business operation/business functions/ business models/processes/activities, interactions, communications into the digital form using the digital technologies.

- Digitalization can be for a ‘specific environment’ or area of business:

  - Take the ‘Digital workspace’, we often try to minimize the usage of paper, in the digital workspace the people might use various digital tools such as mobile devices and technologies and collaborate(meet) using communication platforms all these are digital systems which help them to work in more digital way.

  - Digitalizing your business, leads to the digital business.

iii)Digital Transformation:

- Digitization is the process of converting information from a physical format into a digital one; when this process is used to improve the business processes is called digitalization. Then, the result of this process is called digital transformation

- Example:
  1) Digital advertising can be measured more easily and more accurately than traditional advertising
  2) Email is better than a paper mail

- Digital transformation is more about people than it is about technology.

- Digital transformation requires changes that are happening inside the organization such as the organization's culture and use technologies that empower and enable employees & they are customer-centric (customer-centric means according to customer needs), sustained by leadership.

• We can say that customer-centric solution is always the start of the digital transformation not the technology

Networked economy

- In few decades, we transitioned from the industrial economy to the IT economy and the Internet economy.
- Now, we are looking at 'Networked Economy', its the next economic revolution.
- We can say that Networked economy is the combination of the economies that came before it and 'Hyper connectivity'.

❖**Hyper Connectivity**

- Hyper connectivity is a trend in computer networking in which all things are connected to each other through internet and will communicate through Network.
- They may communicate from person-to-person, person-to-machine and machine-to-machine communication.

Definition: Networked economy defined as emerging and evolving type of economic environment, which is created from the Digitization of fast growing, highly interactive, real-time connections, multi-layered among the people, devices & businesses".

(or)

In short, "We can say Networked economy is hyper connectivity between people, devices and business (All are connected in real-time)"

- The "Collaborative economy" and "shared economy" are forms of networked economies.
- The Internet of Things (IOT) is the technological foundation of this economy (connecting physical devices, people & businesses to one another through internet.)

i) What's driving the Networked Economy:

- Over the past decade, the world has seen the significant changes in how people and business connect to each other.
- Social Networks let billions of people collaborate, interact and communicate with each other in a variety of way.
- All the business Networks, are using Internet of Things (IOT), so that all the devices are connected so that a clear information from all parts of business can be known easily.
- *"The numbers of people-to-people connections — business networks, social networks — they've all been growing over the past 10 years," says Dinesh Sharma, SAP's vice president of marketing for the Internet of Things.*
- Every business is using this hyper connectivity concept and improving their business operations/processes and increase their profits.
- In just over a decade, the number of connected devices in the IOT will increase nearly 30 times more than devices now available.

ii) <u>What Businesess must do grow in the networked economy</u>:

- The Businesses must firstly understand that their customers, employees and business partners expect them to be very social, mobile, always on & active and continually connected.

- So these social media, mobile and cloud computing helped for setting up the ground work for Networked Economy and its important for businesses to understand that the revolutionary economic environment.
- Businesses must improve their business models with the real time digital connections across people, business and devices.
- **Examples:**

- Google Waze - An app allowing devices to share local real time traffic and road information
- Uber: A mobile app that connects people seeking taxi cabs and ride sharing services.
- Airbnb: The rental services

iii) Three pillars of the Networked Economy:

- Earning customer Loyalty
- Enabling open innovation
- Enhancing Resource optimization.

iv) The Networked Economy in action:

- The industries have understood the value of the Networked world. The following are the example to understand it better.

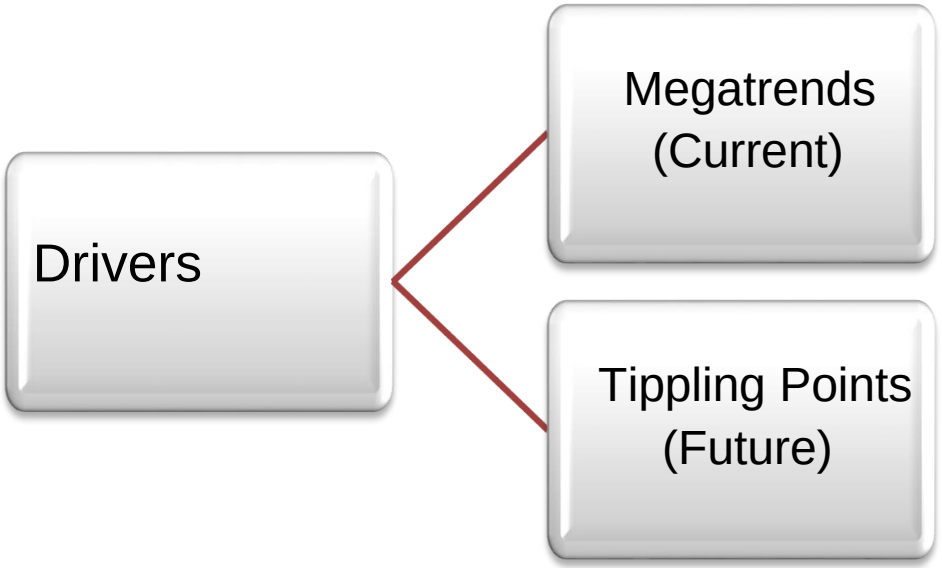
Example :

- German toolmaker Trumpf, a worldwide market leader of laser systems has used the first social machines to work in a number of ways.
- Each smart component knows what work has already been done on it in the production line.
- The company can even send its customers the pictures of the machines in real time
- So, the customers can offer the feedback during the production process as the machines are being built.

- This also helps the production facility to know about its capacity utilization and communicates with other facilities, As a result it can automatically optimize production process.

Drivers

- Various aspects that drive the fourth industrial revolution
  - Scientific Breakthroughs
  - New Technologies



Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.

DRIVERS OF INDUSTRY 4.0

The following are drivers of the industry 4.0:

i) Digitalization and integration of vertical and horizontal value chains.
ii) Digitization of product and service offerings
iii) Digital business models and customer access.

i)Digitalization and integration of vertical and horizontal value chains:

- The products are vertically and horizontally integrated.
- The industry 4.0 is not only about manufacturing. Its about integrating everything from product development to purchasing and then to logistics.
- By having the holistic view of the enterprise or organization industry 4.0 can actually deliver benefits to your customers.
- Industry 4.0 integrates processes vertically , across the entire organization, including process in product development , manufacturing ,structuring and service.
- When it comes to horizontal integration, the industry 4.0 includes the internal operations from suppliers to customers as well as key value chain partners

Vertical and horizontal integration under Industry 4.0 (graphic by [VDI-Wissensforum], translated from German)

Figure shows this development in a factory of Industry 4.0 and introduces the principles of vertical and horizontal integration. The merging of planning and development with the production is called vertical integration. With the networked production, interconnections and data and information exchange among departments and companies will increase, thus making integration and communication more important which is called horizontal integration

Source:[Federal Ministry of Education and Research, 2013] [Ganschar, 2013].

ii) Digitization of product and service offerings:

- Integrating new method of data collection and analysis by the expansion of existing products or creation of new digitized products.
- This will help companies to generate data on the product use in order to refine products .
- Its like you don't necessarily sell a product , you sell an ecosystem around it.
- (ecosystem may include products, services, retail, payments, entertainment ,cloud computing , advertising etc).
- Companies are then able to deliver the most amount of value or service to their customers while generating the most amount of revenue.

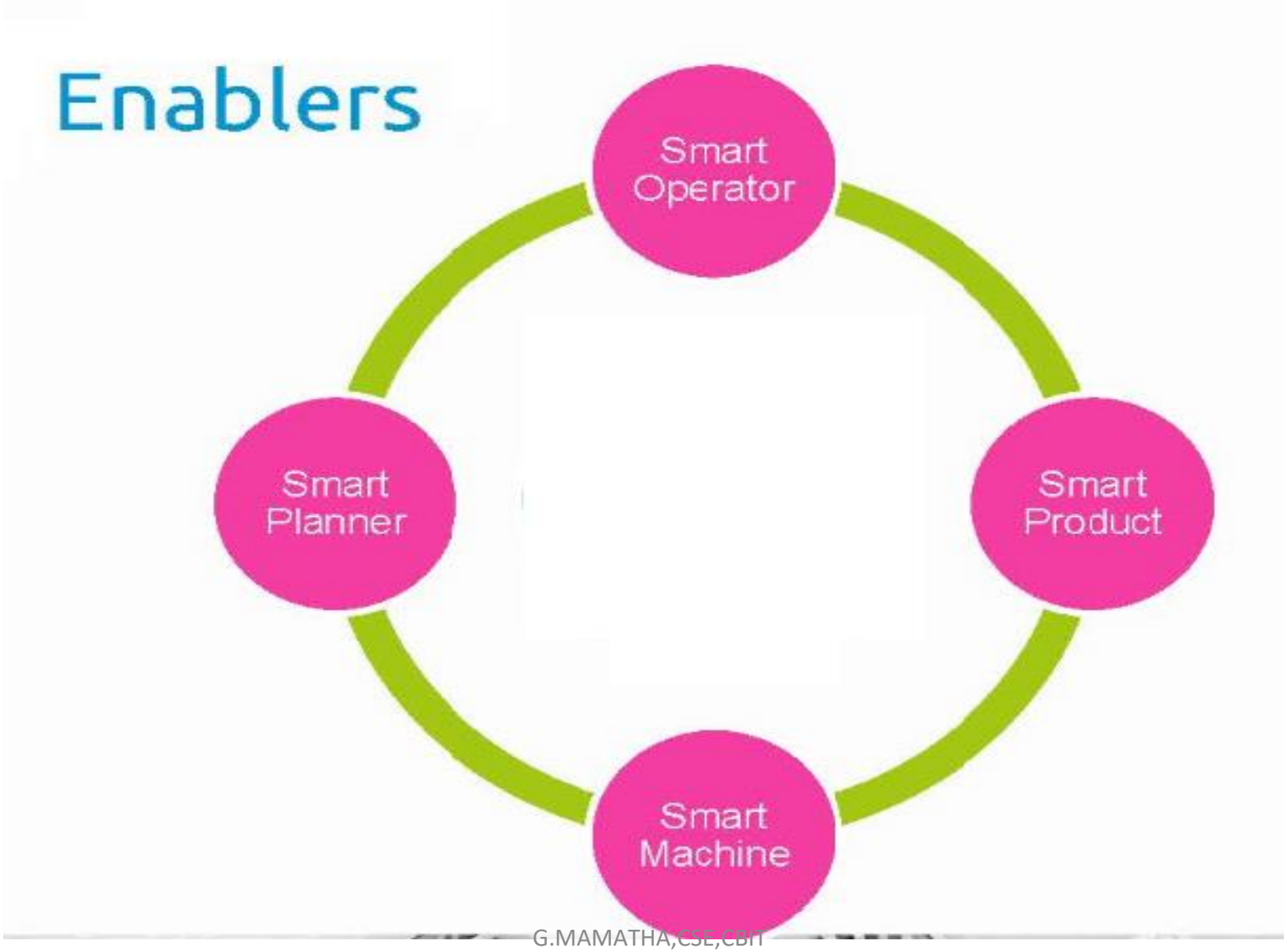
iii) Digital business models and customer access:

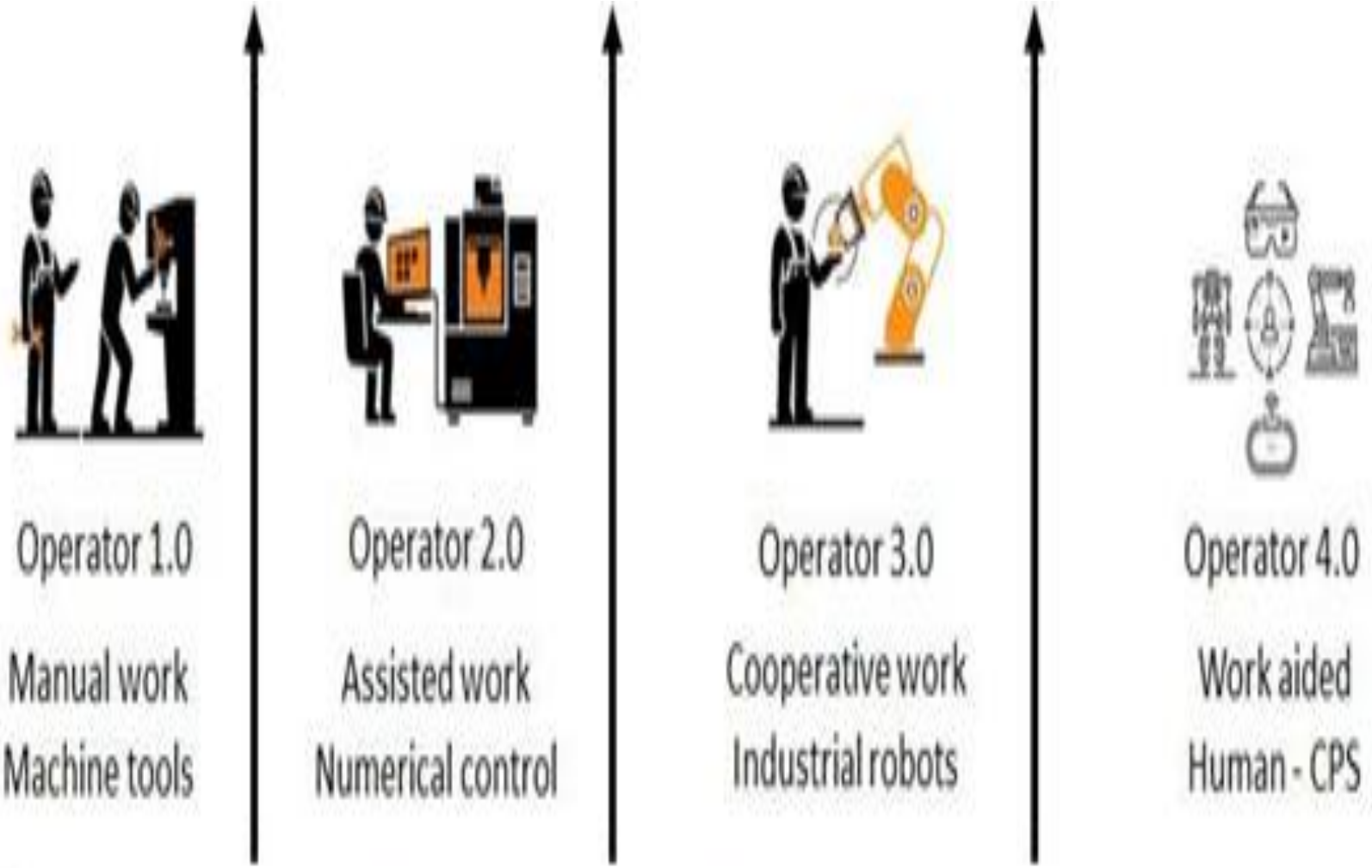
- Companies need to optimize customer interaction and offer a complete end –to –end solution.

(end to end means everything needed by customer should be provided without the involvement of other vendors).

- Everything now in industry4.0 is customer-centric or people centric.
- Businesses always talk bout the customers , they talk about the people who use our products and services.
- Customization is given the priority in industry 4.0 for companies to improve their business.
- For this , the business need to come up with business model which give great customization benefits to customers.
- The changing needs of customers need to be addressed in real time and modification requested should be done.
- At the end, customer satisfaction is almost important.

Enablers of industry 4.0




Operator 1.0
Manual work
Machine tools
Operator 2.0
Assisted work
Numerical control
Operator 3.0
Cooperative work
Industrial robots
Operator 4.0
Work aided
Human - CPS

i) Smart operator: operator uses intelligent personal assistant .

- A traditional operator is being transformed to the Operator 4.0. operator's role has enhanced in terms of physical, sensing, and cognitive capabilities.

- "Smart operator is defined as operator, who utilizes the benefits of technology to understand production through context-sensitive information. Smart operator enriches the real-world with virtual and augmented reality, uses a personal assistant and social networks, analyzes acquired data, wears trackers and works with robots to get the additional advantage".

- smart operator has a major role in manufacturing, also called the In Industry 4.0 , the smart operator is called Operator 4.0.
- Operator 4.0, requires "smart interaction" with machines mainly described as physical and cognitive interactions
- The new concept of work aided by machines, which is characteristic for the Operator 4.0, requires "smart interaction" with machines mainly described as **physical** and **cognitive interactions .**

- Wearable trackers can measure human performance under stressful or difficult conditions analyzing them and sending warnings if needed.

Operator 4.0 Typology:

Operator 4.0 Is divided into eight groups:

- Super-Strength Operator – operator uses exoskeleton (physical interaction),
- Collaborative Operator – operator uses a collaborative robot (physical interaction),
- Virtual Operator – operator uses virtual reality (cognitive interaction),
- Augmented Operator – operator uses augmented reality (cognitive interaction),
- Smarter Operator – operator uses intelligent personal assistant (cognitive interaction),
- Social Operator – operator uses social networks (cognitive interaction)
- Analytical Operator – operator uses Big Data analytics (cognitive interaction),
- Healthy Operator – operator uses a wearable tracker (physical and cognitive interaction).

ii) Smart Products:

- Smart products are those with "intelligence" embedded. Typically, this means embedded sensors that monitor usage, product state, or operational performance while also providing interconnectivity that enables this information to be transmitted back to the manufacturer.

- Smart products integrated into modern production flows are able to self-process, store data, communicate and interact within the industrial ecosystem.

- These products are also capable of monitoring themselves and comparing their behavior with the requirements provided by customers.

- Products can control their own production regarding quantity, quality, color, dimensions and similar features.
- After the delivery to customers, the products then monitor their status and send diagnostic or maintenance messages back to the producer.

- Today smart products don't only provide their identity, but also describe their status and lifecycle history.

- They can also be used to analyze the data, you have full trace-ability of the product, know upcoming maintenance operations, you have full trace-ability of any errors and problems that appear during manufacturing.

- Earliest approaches which enable products to identify themselves via RFID, now the products new capabilities are enhanced and evolved.

- They are capable of computing algorithms and machine learning,, including the productions stages resulting in the finished product.

iii) Smart Machines:

- Smart Machines are defined as machines with the embedded artificial intelligence.
- Smart machines are able to behave as autonomous systems and has inbuilt decision-making process and can be further grouped together to create multi-agent systems (MASs).
- With smart machines we can create intelligent and automated factories, where machines are networked with each other, able to diagnose and solve problems by collecting and analyzing big data in real-time.
- Production will become more seamless, from planning all the way to actual operations.
- Supply chains will become more closely connected and efficient, delivering finished goods to warehouse for distribution through autonomous machines.
- Most of all, robotic machinery handling collaborative roles in production will become smaller, more mobile, more easily programmable.
- They will learn and become artificially intelligent; they will become smarter, more autonomous, and able to self-optimize. use of sensory products is the key to building awareness of machine performance and maintenance .
- An increased use of sensors is a trend that has grown with the evolution of Industry 4.0.
- Industrial Automation products to be installed on machines, increasing the collection of data and the number of machine interactions

iv) Smart Planners:

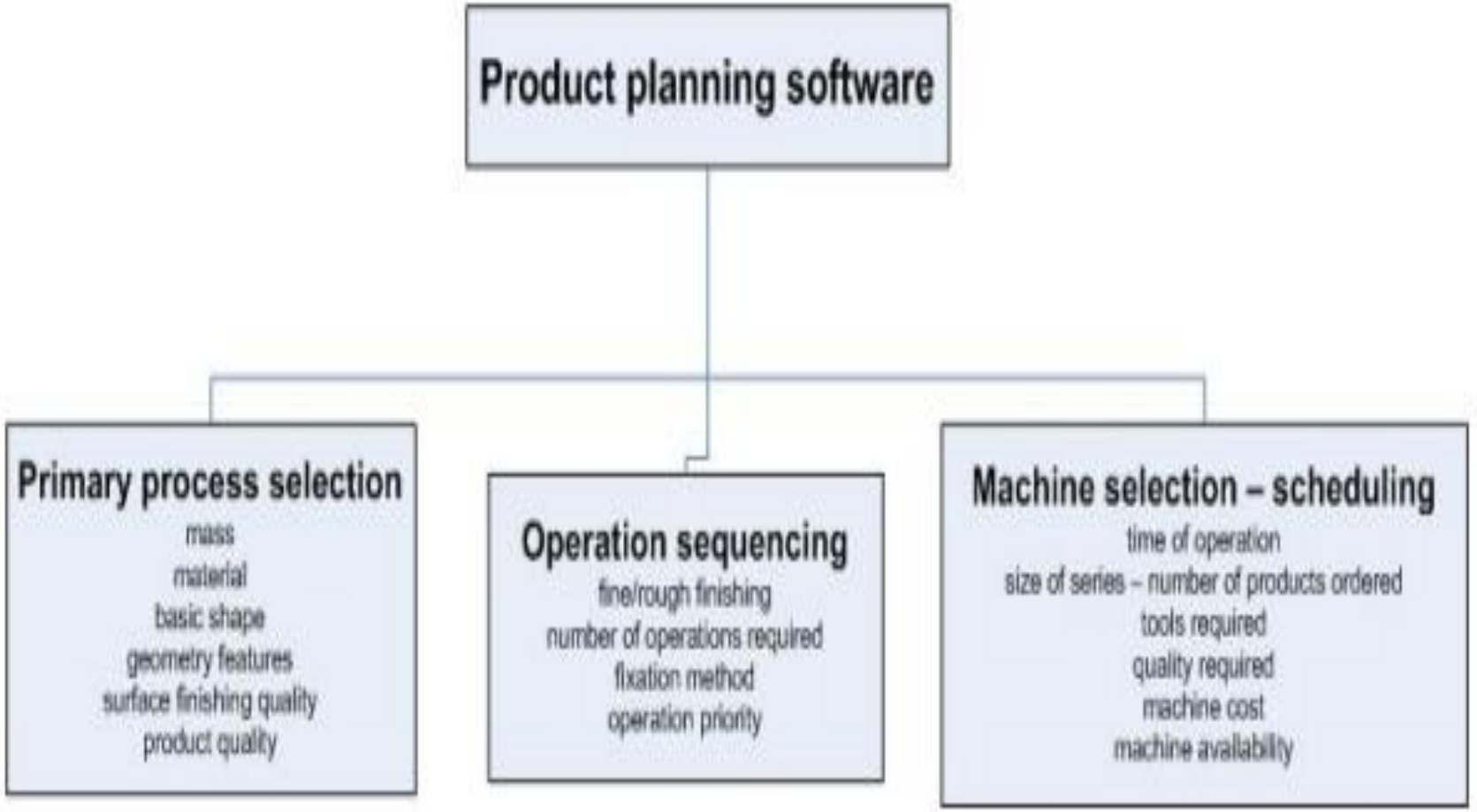
- Product planner is the name of software that is being connected to other parts of supply chain and uses advanced optimization algorithms to generate process plan, order of operations and scheduling automatically.

- In a modern smart factory equipped with smart sensors on machinery, production planners can monitor machine usage in real time. If a machine seems to be behaving abnormally, or throughput seems to be slowing, planners can identify the issue as it unfolds and take steps to address it.

- whether it can be scheduling some machine downtime in advance, or adjusting your production workflows to change the way your machines are being utilized.

- machines that produce and that sit along the production line, They need to gather data, they need to report data up stream and that leads to the smart planner.

- There is a centralized unit that allocates resources based on the global strategy of the company. So this global strategy means enhancing the product portfolio, so manufacturing more products and reducing of cycle time and improving quality. And that's the role of the smart planner.


Product planning software
Primary process selection
mass
material
basic shape
geometry features
surface finishing quality
product quality
Operation sequencing
fine/rough finishing
number of operations required
fixation method
operation priority
Machine selection – scheduling
time of operation
size of series – number of products ordered
tools required
quality required
machine cost
machine availability

Challenges for Industry 4.0

The below given are the challenges with the usage of Industry 4.0:

- Cyber threats
- Hacking
- Digital Infrastructure
- No clear, phased, strategic plan
- Training
- Skill shortage and Impact on work
- Cost
- Cyber Security
- Lack of culture of collaboration
- Handling data Growth
- Data sensitivity
- Network misconfiguration

- **Other challenges related to industries:**

- Making the organization realize action is needed.
- Change management, so often overlooked.
- Company culture.
- A true interconnection of departments.
- Talent….
- The rethinking of the organization and processes to maximise outcomes.

Challenges Category wise:

Broadly challenges are classified under below areas

- Economic
  - High economic costs
  - Business Model adaption
  - Unclear economic benefits/excessive investment
- Social
  - Privacy concerns, Surveillance, Threat of redundancy
  - Distrust
  - Stake holders oppose new changes
  - Loss of many jobs due to automatic process and IT controlled processes
- Political
  - Lack of regulations, standards and forms of certifications
  - Unclear legal issues and data security.
- Organizational level
  - security issues
  - Machine to machine communication should be stable
  - Lacking required skills and Recruiting new talent
  - Understanding new business model, Organizations are unsure about how to approach the actual implementation process

Mega Trends in Industry 4.0

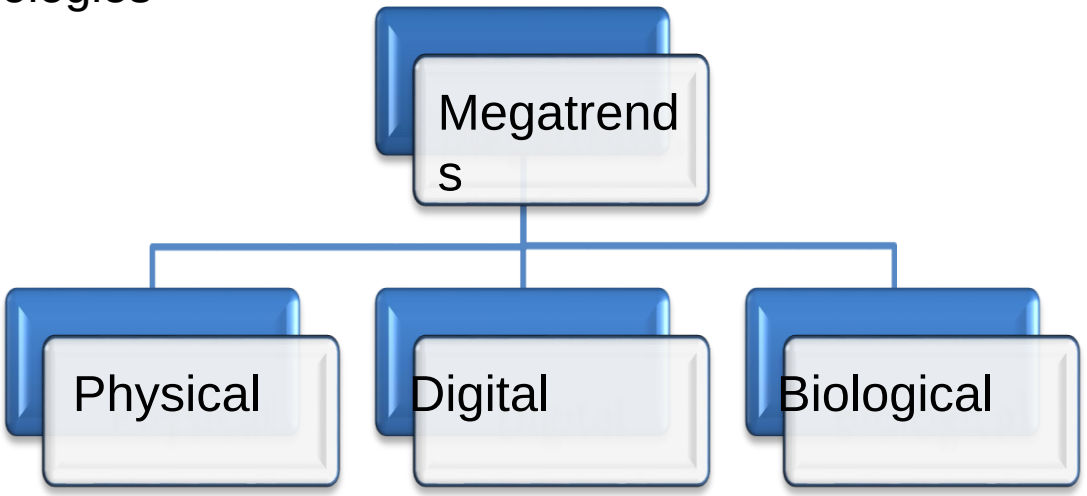
- All new developments and technologies have one key feature in common: they use the power of digitization and information technology.
- Innovations are possible and enhanced only through the digital power.
- In today's fast moving global markets, manufacturers need to respond quickly to changing demands, adapt to new technologies and maximize the new market opportunities.

Example:

- Gene sequencing, for example, could not happen without progress in computing power and data analytics.
- Similarly, advanced robots would not exist without artificial intelligence, which itself, largely depends on computing power.

Megatrends

- All recent technologies and development that leverage the pervasive potential of digitization and information technologies



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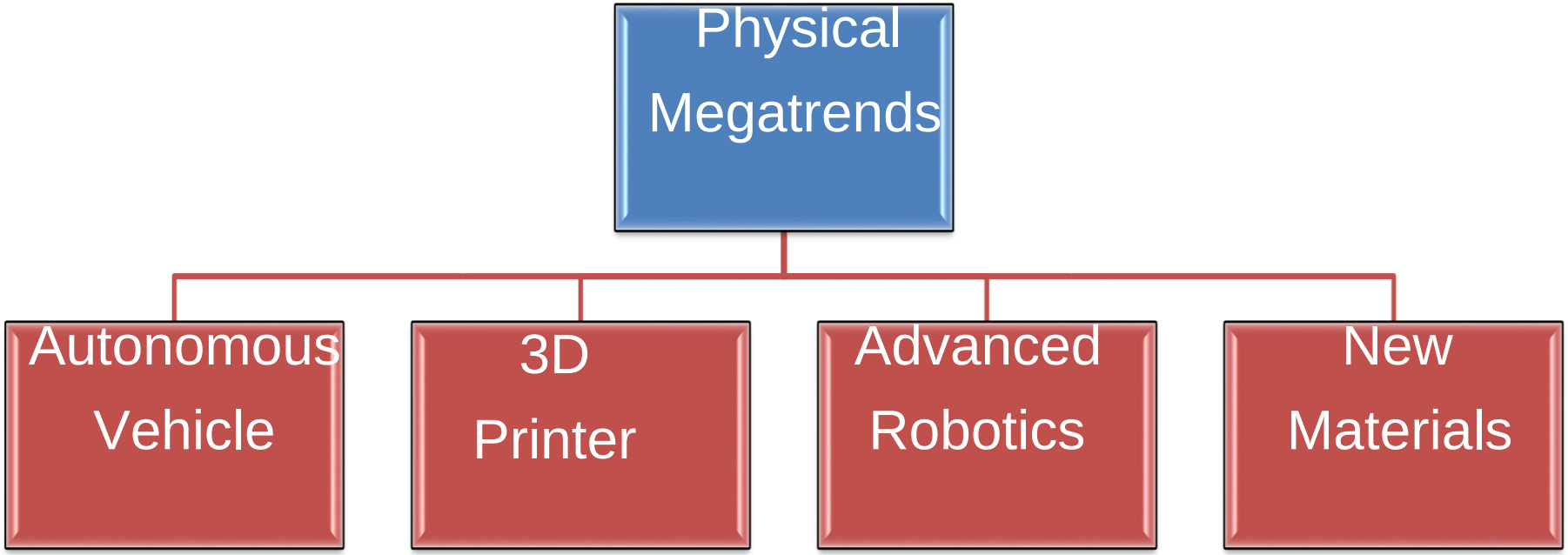
Physical Megatrends



Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.

❖ Autonomous vehicles:

- An **autonomous vehicle** is one that can drive itself from a starting point to a predetermined destination in "autopilot" mode using various in-vehicle technologies and sensors, including adaptive cruise control, active steering (steer by wire), anti-lock braking systems (brake by wire), GPS navigation technology, lasers and radar.
- advanced driver assistance system (ADAS) sensors, such as high-resolution stereo and/or mono cameras, RADAR, and LIDAR, as well as future human-machine interfaces (HMIs), such as large 4K/8 screens or head-up displays (HUDs).
- These systems will generate vast amounts of data, which will require sophisticated electronic support, including high-speed data nodes, links, cables, and assemblies.
- As drones become capable of sensing and responding to their environment (altering their flight path to avoid collisions), they will be able to do tasks such as checking electric power lines or delivering medical supplies in war zones.
- In agriculture, the use of drones – combined with data analytics – will enable more precise and efficient use of fertilizer and water.
- But there are now many other autonomous vehicles including trucks,, aircrafts and boats.
  - Driver less vehicle
  - ➢ Trucks
  - ➢ Drones
  - ➢ Aircrafts
  - ➢ Boats

Source: Wikipedia, By Dllu, Published: Nov 19, 2017, Online: https://en.wikipedia.org/wiki/Autonomous_car

Source: Wikipedia, By Bcschneider, Published: Jul 16, 2017, Online: https://en.wikipedia.org/wiki/Autonomous_car

3D Printers

- Manifesting physical objects based on digital specifications
- Application
  - Wind Turbines
  - Medical Implants

Source: Wikipedia, By Tyler Caros, Published: Feb 20, 2015, Online: https://en.wikipedia.org/wiki/Airwolf_3D

❖ 3D- Printing:

- Also called additive manufacturing, 3D printing consists of creating a physical object by printing layer upon layer from a digital 3D drawing or model.

- It is the process of construction of three dimensional object from computer aided design(CAD) model or a digital 3D- model.

- This 3D-printing is the ability to produce very complex shapes or geometries that would be otherwise impossible to construct by hand ,including hollow parts or parts with internal truss structures to reduce weight.

- Additive Manufacturing uses CAD software or 3D-object scanner which will direct hardware to deposit material layer upon layer in the precise geometric shapes.

- This is the opposite of subtractive manufacturing, which is how things have been made until now, with layers being removed from a piece of material until the desired shape is obtained. By contrast, 3D printing starts with loose material and then builds an object into a three-dimensional shape using a digital template.

- 3D-printed products can be easily customized.

How does 3D printing work?

- How does 3D printing work?

Step 1

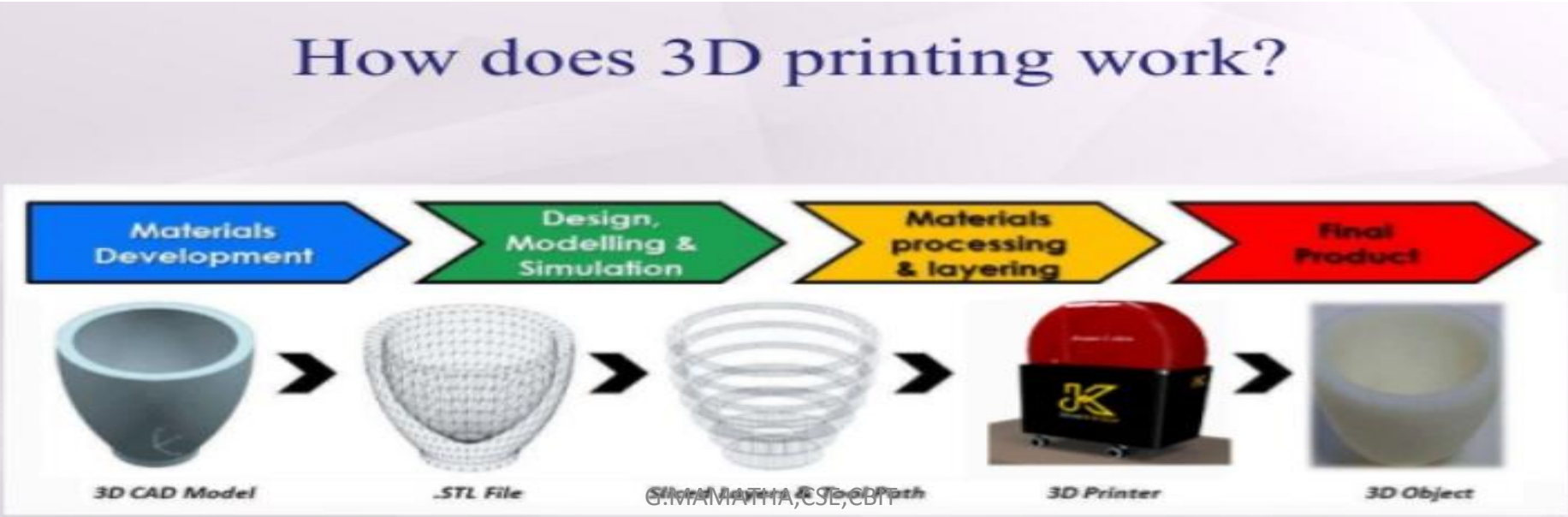
It all starts with making a virtual design of the object you want to create. This virtual design is made in a CAD (Computer Aided Design)

Step 2

Once completed, the STL file needs to be processed by a piece of software called a "slicer," which converts the model into a series of thin layers and produces a G-code file.

Step 3

This G-code file can then be printed with 3D printing software .



Application Area

- Medical Implants

  3D printers can be used to manufacture medical devices with a range of functional enhancements. Current developments include surface coatings for improved wear resistance, and 5-axis toolpath generation to coat complex 3-dimensional surfaces.

- Consumer application
  - Toys
  - Jewelery

- Architectural models

- Industrial parts

❖ Advanced robotics:

- Until recently, the use of robots was confined to tightly controlled tasks in specific industries such as automotive. Today, however, robots are increasingly used across all sectors and for a wide range of tasks from precision agriculture to nursing.

- Rapid progress in robotics will soon make collaboration between humans and machines an everyday reality.

- Moreover, because of other technological advances, robots are becoming more adaptive and flexible, with their structural and functional design inspired by complex biological structures (an extension of a process called bio mimicry, whereby nature's patterns and strategies are imitated).
- Advances in sensors are enabling robots to understand and respond better to their environment and to engage in a broader variety of tasks such as household chores.

- Contrary to the past when they had to be programmed through an autonomous unit, robots can now access information remotely via the cloud and thus connect with a network of other robots.

➢ Conventional application of robots: automotive

➢ Recently, robotics are used from precision agriculture to nursing

Source: Wikipedia, By BMW Werk Leipzig, Published: Jul 19, 2005, Online: https://en.wikipedia.org/wiki/Smart_manufacturing

❖ New materials:

- With attributes that seemed unimaginable a few years ago, new materials are coming to market. On the whole, they are lighter, stronger, recyclable and adaptive.

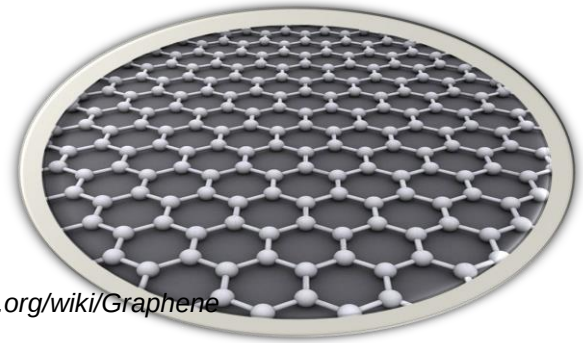
- There are now applications for smart materials that are self- healing or self-cleaning, metals with memory that revert to their original shapes, ceramics and crystals that turn pressure into energy, and so on.

- Take advanced nanomaterials such as graphene, which is about 200-times stronger than steel, a million-times thinner than a human hair, and an efficient conductor of heat and electricity ,it becomes more expensive (gram for gram, it is one of the most expensive materials on earth, with a micrometer-sized flake costing more than $1,000), it could significantly disrupt the manufacturing and infrastructure industries.

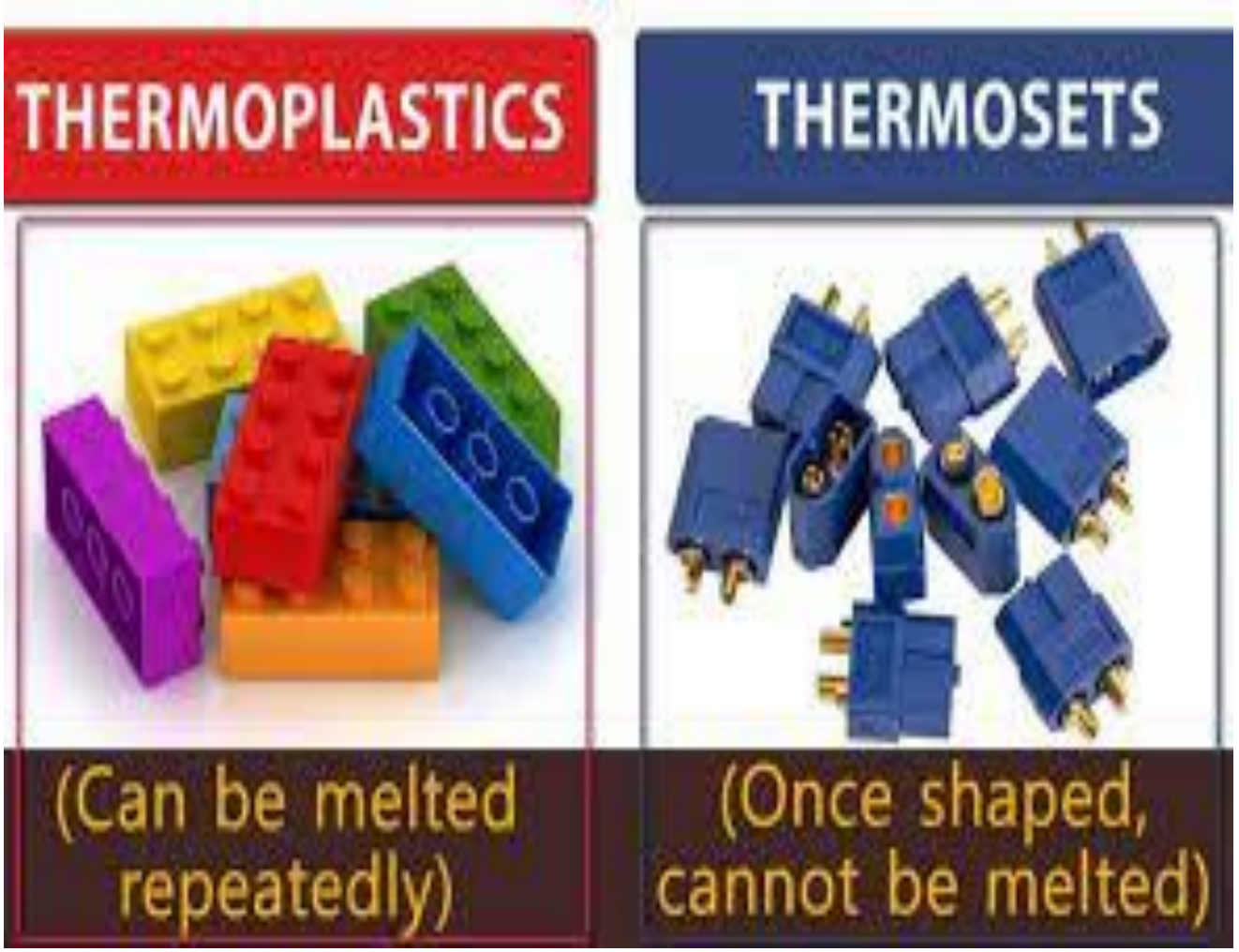
- New innovations in thermoset plastics, for example, could make reusable materials used in everything from mobile phones and circuit boards to aerospace industry parts.

- The recent discovery of new classes of recyclable thermosetting polymers called polyhexahydrotriazines (PHTs) is a major step towards the circular economy, which is regenerative by design.

- Lighter, stronger, recyclable and adaptive
- Example: Thermoset plastics, Graphene



Source: Wikipedia, By AlexanderAlUS, Published: Aug 26, 2010, Online: https://en.wikipedia.org/wiki/Graphene


THERMOPLASTICS
THERMOSETS
(Can be melted repeatedly)
(Once shaped, cannot be melted)

Digital

- Internet of Things (IoT)
- Application of IoT in Industry
  - RFID
  - Tracking of package delivery
  - Complex supply chain
  - Monitoring systems

- Bitcoin(digital currency) and Blockchain (securing bank/government transac

- Uber model for transportation (car pooling etc.)

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.

ii)Digital :

- One of the main bridges between the physical and digital applications enabled by the fourth industrial revolution is the internet of things (IoT) – sometimes called the "internet of all things".

- In its simplest form, it can be described as a relationship between things (products, services, places, etc.) and people that is made possible by connected technologies and various platforms.

- Sensors and numerous other means of connecting things in the physical world to virtual networks are increasing drastically.

- Smaller, cheaper and smarter sensors are being installed in homes, clothes and accessories, cities, transport and energy networks, as well as manufacturing processes.
- For example:
  - the blockchain,
  - Bitcoin is so far the best known blockchain application.
- The on-demand economy raises the fundamental question: What is worth owning – the platform or the underlying asset? As media strategist Tom Goodwin wrote in a TechCrunch article in March 2015:

- "Uber, the world's largest taxi company, owns no vehicles.
- Facebook, the world's mostpopular media owner, creates no content.
- Alibaba, the most valuable retailer, has no inventory.
- And Airbnb, the world's largest accommodation provider, owns no real estate.

- Digital platforms have dramatically reduced the transaction and friction costs incurred when individuals or organizations share the use of an asset or provide a service.

Biological

- Genetic sequencing
- DNA writing
- Recommender system (IBM Watson)
- Cell Modification
- Genetic Engineering (CRISPER)

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.

iii) Biological:

- Innovations in the biological realm – and genetics in particular – are nothing less than breath-taking.
- In recent years, considerable progress has been achieved in reducing the cost and increasing the ease of genetic sequencing, and lately, in activating or editing genes.
- It took more than 10 years, at a cost of $2.7 billion, to complete the Human Genome Project. Today, a genome can be sequenced in a few hours and for less than a thousand dollars.
- **Synthetic biology** is the next step.
- Many of our intractable health challenges, from heart disease to cancer. This genetic technology helps people to find individual genetic make-up in an efficient and cost-effective manner, so this will help in personalized and effective healthcare.

- Increasing amounts of data will make precision medicine possible, enabling the development of highly targeted therapies to improve treatment outcomes

- For example : By finding a persons tumour's genetic make-up, doctors will be able to make decisions about a patient's cancer treatment.

- For example: . Already, IBM's Watson supercomputer system can help recommend, in just a few minutes, personalized treatments for cancer patients by comparing the histories of disease and treatment, scans and genetic data against the (almost) complete universe of up-to-date medical knowledge.

Tipping Points

- Tipping points represent the radical changes in that are required in near future
- Probable tipping points in 2025
  - Clothes connected to the internet
  - Unlimited and free storage
  - 1 trillion sensors connected to the internet
  - Robotic pharmacist, etc.

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.

Tipping Points

- Industry 4.0 Techniques and technologies are growing day by day, we can say Industry 4.0 is still a burgeoning(Beginning to grow or increase rapidly) concept.

- However, there is a rapid and fast socio-economic developments and changes are causing few disturbances, and the Fourth Industrial revolution is beginning to take its few steps towards the developments.

- There are few tipping points that could push Industry 4.0 in the direction of becoming a fully realised concepts.

❖Connectivity Keeps Expanding:

- Improved connectivity allows people to work from home without ceasing communication with colleagues, clients and customers.

- Not only people, physical objects are also connected through internet and are made to communicate and exchange data for various purposes

- The entire world is now becoming a Network of all connected devices.

- Economic Globalization has also led to the globalization of supply chain; These supply chains are becoming increasingly common, but have some issues with it distances, time zones need effective and accurate tracking methods.

- They use RFID(Radio Frequency Identification) Tags which use the electromagnetic fields to identify and track the tags attached to objects is a valuable step towards resolve above issue.

- So, the Industry 4.0 solution for this is to create a virtual global factory(It is a network of businesses from the multiple regions that can resolve issues of connectivity between businesses and also for relationship between the customer and the supplier).

- **Data:**
- **Emerging or emergence of Smart Factory**
- **Customer**

Comparison of Industry 4.0 Factory and Today's Factory

- Manufacturing is an ever ending industry ,day by day it is growing a lot. And data shows that industry contributes to the significant amount of profit or revenue to any country .

- With this industry leaders have started to shift their focus from the traditional to smart manufacturing using industry4.0 solutions.

- Because switching the manufacturing process to smart way provides lot of benefits to operators , managers ,executives, industry owners and all people involved in this sector.

- And if they have a right partnership with any IOT app development company , the industries can grow.
- Before starting to know the difference between the today's factory and industry 4.0(smart factory);

we see few of the challenges the industry is facing with manual-only approach:

- Drawing information fast

- Improving services and products

- Marketing and selling products ,services.

- Communication issues

- Analyzing process performance of humans ,machines.

- Lack of the real time data extraction for faster decision making .

Traditional	Smart
Manual process, operations	Digitized process, operations
Time consuming & backbreaking	Faster and seamless
Legacy systems	Smart systems
Siloed data	Centralized data
Isolated operations	Integrated operations
Increased maintenance cost	Reduced maintenance costs
Frequent machine failures	Improved machine utilization
Zero or limited data for decision making	Complete data for faster decision making
Tied to systems or machines for data	Update or receive data on the go
Time consuming data update on backend	Instant backend data update
Manual checklist on machines	Automated checklist on machines
No integration with different systems, tools	Complete integration with existing systems, new systems, tools

Reduced productivity	Accelerated productivity
Isolated factory operations	Connected factory operations
Zero visibility on operations, productivity data	100% Transparency, visibility on operations and production data
Delayed go-to-market strategy for products	Faster product development to market
Tired workforce	Motivated workforce
Zero room for improvements	Always on improvements
Limited innovation in production development	Smart and intelligence products
Poor customer experience	Improved customer experience
Limited data for budgeting and growth	Complete data for future expansion, budget and growth
Limited technology involvement	IoT, Sensor, Mobile app,RFID enabled
Below par performance in market	Supercharged market performance
Increased TCO	Reduced TCO
Slow procurement	Faster procurement
Inaccurate asset tracking process	Accurate asset tracking using RFID, IoT
Manual labour and machine efficiency evaluation	Automated LE and OEE using IoT, Mobile App, Web App
Poor resource utilization	Improved resource utilization
Process-driven decision making	Data-driven decision making
Poor interoperability	High interoperability

Old Traditional Factory

- **More jobs**: labor-intensive
- Lower output and productivity
- Lower quality products
- Lower paying unskilled jobs
- Higher risk working conditions
- Higher environmental impact
- Higher production costs

New Smart Manufacturing Plant

- Less jobs: automation-intensive
- **Higher output** and productivity
- Higher quality products
- Higher paying skilled jobs
- Safer working environment
- Less waste, resource use
- Lower production costs
- More flexible customization
- Faster time-to-market
- IT-optimized (models,

Trends of Industrial Big Data

- There are hundreds of concepts, terms & technologies that relate to the Industry 4.0, but the following are some important and foundational concepts

1. **Big Data:**

- Big data is a collection of data that is large or very huge in size, which is fast and complex in nature which is being collected from various data sources and it has different formats.

- the traditional data-processing application cannot process Big Data as it deals with data sets which are large and complex,

- Lot of data is being captured through out the world but how to use this data is important and this data should not go waste, this Big Data should be analysed so that some valuable information can be extracted from it, which will be useful for the business and people for various operations and work.

❖ **Characteristics of Big Data are:**

- Volume
- Velocity
- Variety
- Veracity

Volume

- Volume refers to the size of the data. The size of Big Data is huge
- Huge volumes of data is being generated on a daily basis from various sources like: Social Media Platforms, Networks, Human interactions, Business processes
- Such a large amount of data stored in Data Warehouses.

Velocity

- Velocity refers to the speed at which the data is being generated or created in real-time
- It comprises the rate of change of data, linking of incoming datsets at varying speeds etc.

Variety

- Variety of Big Data refers to the type of data that is being gathered from various sources
- The Big Data may be structured, unstructured and semi-structured data
- In past, data could only be collected from the excel sheets(spreadsheets) and databases, but today data comes in an array of forms such as emails, PDF's, photos, videos, audios, Social Media posts and much more.

Veracity

- Veracity refers to the quality of the data, how accurate the data is very important. How trustworthy the data is, is the data from the right source, type etc.
- Quality of data is important for accurate analysis of data. Sometimes data may be noisy, abnormal, biased.
- Try to keep the data clean without having any incomplete and irrelevant and noisy data
- Big data cannot be processed using the traditional databases but it can be processed using the NO SQL databases.
- No SQL databases can store data in any form like text, images, logos, other formats such as XML. There several types of NO SQL databases and tools available to store and process Big Data

ii) Various trends in Industrial Big data:-

❖Predictive Maintenance:

- Predictive maintenance involves collecting and evaluating data from machines which can be used for preventing the failure or expensive manufacturing equipment.
- By analysing the data throughout the production, to find out the unusual behaviour ahead of time, to ensure that appropriate measures can be taken to avoid production downtime.

- Utilizing IOT technology to monitor the condition of machinery on the production line, streamline maintenance schedule, produce real-time data, which can lower cost, maximize output and improve quality of product.

- So, data generated from machines is huge and should be used in a effective way.

- Predictive maintenance uses an analytical approach, utilizing the real-time Big data and historical data to anticipate where a machine is not performing well or where a machine is not performing as it should so that it can be repaired ahead of time.
- Therefore, Industrially generated Big data improves the manufacturers data to remove problems in production of products

Example:- Predictive maintenance for milling machines

- Spindles in milling machines are prone to breaking during the production process. Repairing spindle can be very expensive. Therefore, being able to predict the damage and when the spindle will break can greatly reduce cost.

- To overcome this problem, special sensors (Eg. Ultrasonic or vibration sensors) identify the patterns of a Fragile spindle. Relevant alert setting for the current state of the machine can be created.

- Using this we can find when the spindle is about to break and this enables maintenance schedules to be planned accordingly.

Benefits:

- Lower maintenance costs,
- Reduced machine downtime,
- Higher process transparency

❖ Hyper connected:

- Day by Day the business activities are growing high with the internet. This will increase the amount of Big data recorded and stored by companies both online and offline to high levels, this makes for businesses to manage and analyze this big data.

- But this generated information has to be used correctly to gain some valuable information from it
- Lot of connectivity across the entire manufacturing unit .The higher the connected systems, the more data generated, since industry 4.0 has completely changed industrial manufacturing process , in which every object is connected to collect data .

- If a company manages to internalize its big data strategy and connect its processes, it will have infinitely more possibilities of success in this currently running industrial revolution era.

❖ Real time monitoring:

- Today's manufactures depend on data collection and its insight to make quick course corrections on the production floor.

- This makes the businesses to collect the real time data from existing machines , external IOT sensors , PLC’s and ERP Systems.

- Real time condition monitoring helps manufacturers to connect their individual machines , production lines, and entire factory floor to acquire data across supply chains.

- Machine level data help to predict the product quality problems, machine stability and reliability .

- This can measure and optimize production only when the big data generated from entire factory production line is used properly and analyzed to improve business.

- **Continuous improvement** can be done. **Reduce electricity waste** (get notifications when machines are idle but consume electricity)

- we can say that these smart factories , will create huge volumes of data. **Sensor** data from machines is recorded and displayed in real time, providing the basis for real –time condition monitoring.
- Data can be visualized ,anyone in the entire production unit of industries can access and see the data which will be stored in cloud.

❖ Preventive Maintenance:

- Preventive maintenance comprise of planning and execution of maintenance measures before a certain damage condition or uncontrolled machine failure can occur.

- Regular maintenance checks are needed to see the condition of machinery , this can be done by the data generated from the various smart equipment .

- Analyzing and seeing the data generated on daily basis , can prevent damage and maintain the product or machine condition without failing.

❖ Production efficiency:-

- Production Efficiency is increased using the big data .

Every manufacturer need this production efficiency , due to which they can gain a more revenue.

- Big data makes this possible. Big data analytics will reduce the breakdowns and unscheduled downtime by about 25% .

- Big data is created for analyzing real time performance , supply chain optimization, price optimization ,fault prediction ,product development and smart factory design.

❖ Self- Service Systems in industries:-

- Bulks of big data is produced from the production plants .

- Self service systems are a trend in the industries.

- **For example:-** global chip maker intel has smart factory equipment that sends real time data into a big data analytics system.

- The self service system then breaks down the real time data and will find patterns , detects faults and creates visualization for key decision makers.

- Self service means offering customers an employees tools and information so they can find answers to their questions and have a better experience with a product or service.

- **For example:-** A bike or bicycle manufactures might post customers –facing frequently asked questions, knowledge articles and videos related to choosing , adjusting and maintaining your bike.

❖ **Industrial Internet:-**

- The industrial internet is a way to digital transformation in manufacturing.
- Industries are equipped with internet, the network of sensors use this internet to perform various operations .
- It Collects critical production data and uses cloud software to run this data to know value information about the efficiency of manufacturing operations.

❖ **Automated Operational workflow:-**

- Workflow gets simplified with automated processes.

- As entire manufacturing process gets automated the operations are carried out in prescribed manner , without any breaks or failures.

- The workflow will be maintained , because the smart factories produce data from IOT device which can be used for smooth running of operations.

- Workflow automation is a created series of automated actions for the steps in a business process.

- Its used to improve everyday business processes because when you make your work flow, you can concentrate on getting more done and focus on the things that matter.

- Automated operational workflow helps in improve and quicken the product life cycle development, Standardize product quality, Safety reporting, shorten supply chain cycle for approval and receipt of goods, complex document approval process.

❖ **Improved customer satisfaction :-**

- Customers are the key role players in any industry .
- What is the secret of keeping your customers happy ? (It is by keeping them informed)
- Customers expect fast , on time delivery and real time visibility into order statuses.

- Manufacturers can now have real time visibility of the production and shipping process is now possible and it can be shared with your customers.

- Any delays in manufacturing processes can be informed to the customers and if the customer wants to change the design of a product being manufactured, it can be done. As they are informed with the manufacturing process.

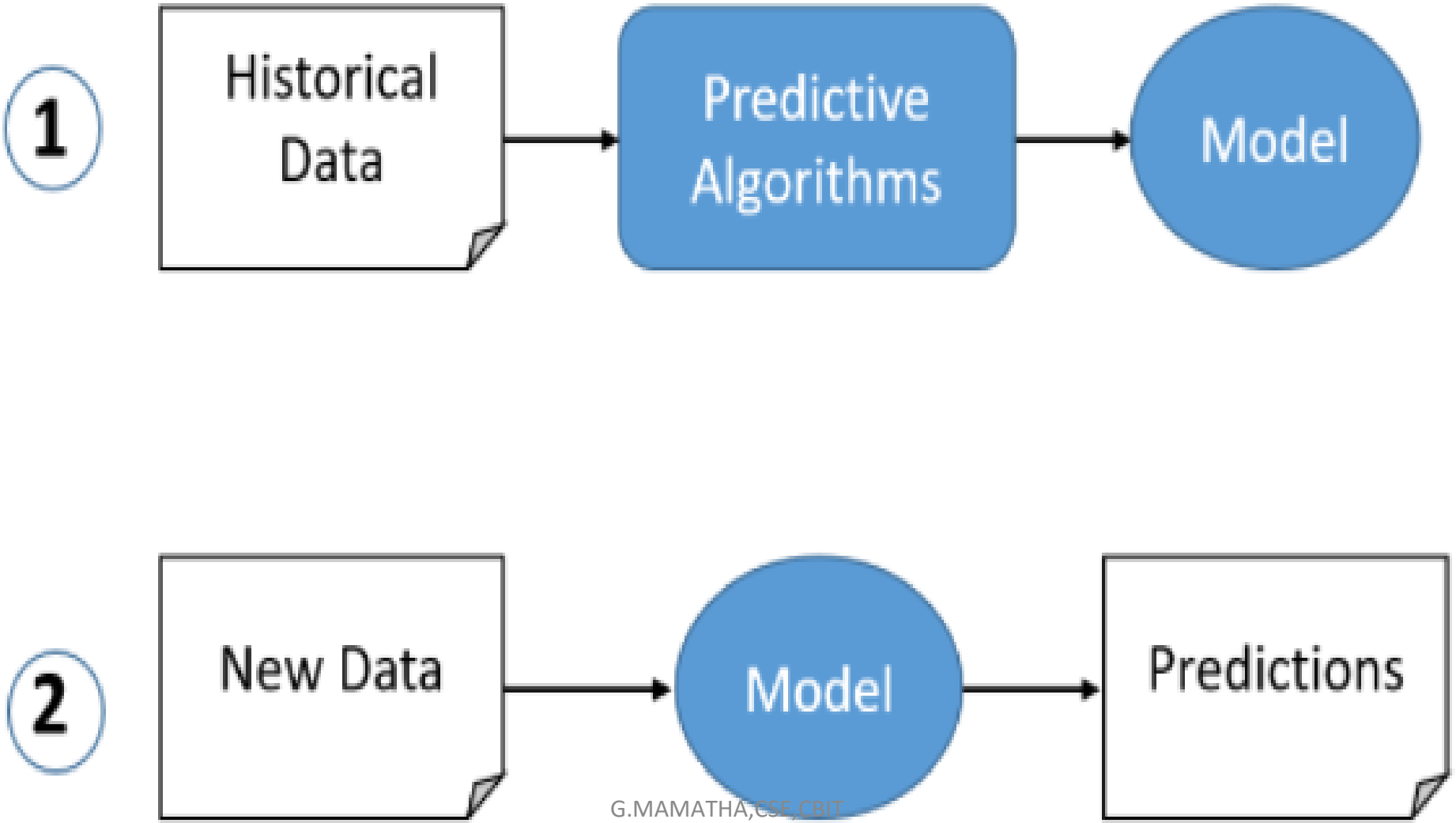
- Since all the systems , machines are connected , lot of industrial big data is generated , this can be used to improve customer experience and satisfaction.

Predictive analytics for business transformation

i) What is Predictive Analytics?

- Predictive Analytics is the branch of Advanced analytics which is used to make predictions about unknown future events.
- Predictive analytics has received a lot of attention in recent years due to advances in supporting technology, particularly in the areas of big data and machine learning.
- Predictive Analytics uses many techniques from data mining, statistics, modeling, machine learning and artificial intelligence to analyze current data and compare it with historical data to make predictions about future.
- It is used as a decision-making tool in a variety of industries and disciplines, such as insurance and marketing.

- The historical data is fed into a mathematical model that considers key trends and patterns in the data. The model is then applied to current data to predict what will happen next.



- You can see the likelihood of a coming event or a specific situation, given the data being analyzed. Predictive data analytics examples are wide-ranging:

❖ **Examples**:

➢ Ecommerce sites use predictive analytics to offer specific products likely to interest a visitor. Predictions are based on that visitor's past purchases and viewing of products.

➢ A human resources department might use predictive analytics to detect if employees are thinking of quitting, and then persuade them to stay.

➢ In IT security, the prediction could be about where malware has infected systems, based on network activity and data flows. These systems then get top priority for in-depth inspection.

What happened?

DESCRIPTIVE ANALYTICS

Why did it happen?

DIAGNOSTIC ANALYTICS

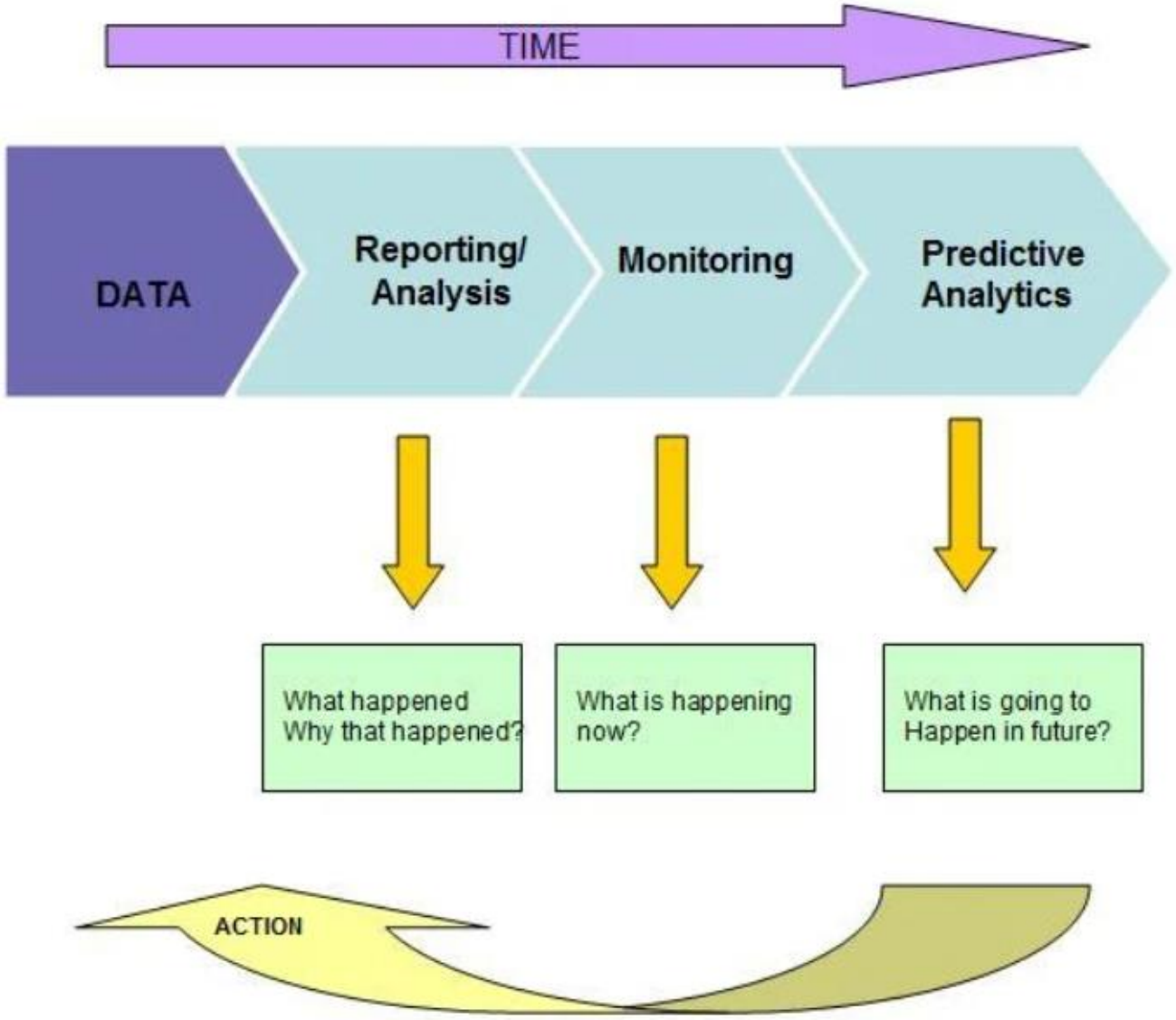
What will happen?

PREDICTIVE ANALYTICS

How can we make it happen?

PRESCRIPTIVE ANALYTICS

Predictive Analytics



❖Basic Steps for Predictive Data Analysis:

- Define the result you want, e.g. how to offer each customer additional products of interest.
- Collect the data that will be needed (ecommerce site tracking data, CRM logs, etc.).
- As necessary, prepare the data from each source, then combine the different datasets.
- Make predictive analytics models, using statistical analysis to see which outcomes typically follow which events.
- Apply your models to your business.
- Review the models to ensure they are working properly.

Predicitive Analytics Process

1. Define Project
2. Data collection
3. Data Analysis
4. Statistics
5. Modeling
6. Deployment
7. Model monitoring

ii) How predictive analytics helps in transforming business:-

- With the help of sophisticated predictive analytics tools and models, any organization can now use past and current data to reliably forecast trends and behaviors for milliseconds, days, or years into the future.

- With predictive analytics, organizations can find and exploit patterns contained within data in order to detect risks and opportunities. Models can be designed, for instance, to discover relationships between various behavior factors.

- Such models enable the assessment of either the promise or risk presented by a particular set of conditions, guiding informed decision-making across various categories of supply chain and procurement events.

- The patterns found in historical and transactional data can be used to identify risks and opportunities in future.

- Predictive analytics models, capture relationships among many factors to assess risk with a particular set of conditions to assign a score or weightage. By successfully applying predictive analytics the businesses can effectively interpret the big data for their benefit.

- Predictive analytics allows organizations to become proactive forward looking, anticipating outcomes and behaviors based upon the data and not on a hunch or assumptions.

- Predictive models can help businesses attract, retain and nurture their most valued customers.
- Predictive analytics can also be used to detect and halt various types of criminal behavior before any serious damage is inflected.

- By using predictive analytics to study user behaviors and actions, an organization can detect activities that are out of the ordinary, ranging from credit card fraud to corporate spying to cyberattacks.

- Predictive analytics tools give users deep, real-time insights into an almost endless array of business activities.

- Tools can be used to predict various types of behavior and patterns, such as how to allocate resources at particular times, when to replenish stock or the best moment to launch a marketing campaign, basing predictions on an analysis of data collected over a period of time.

- The results of predictive analytics are highly accurate and beneficial for companies of all sizes and industries

- The Big Data space is set to reach over $273 billion by 2023, and predictive analytics only is projected to reach approximately $10.95 billion for the next two years.

- As AI and machine learning move forward, the way we use analytics also continues to grow and change. While businesses previously focused on harvesting descriptive data about products and customers, they now start pulling predictive data from the information they collect.

- Predictive analytics is widely used in the marketing world and has been applied across various touchpoints, from initial brand awareness to post-purchase campaigns. In fact, it's nothing new for modern marketers.

- According to Adobe's report, more than 50 percent of marketers agree that data-driven marketing produces more relevant communications and allows them to be more customer-focused.

❖ Few examples of how organizations are making use of predictive analytics:

- Banking
- Healthcare
- Human resources (HR)
- Marketing and sales
- Retail
- Supply chain
- Cyber security
- Risk analysis
- Inventory management
- Aerospace
- Automotive
- Energy
- Financial services
- Manufacturing
- Government , public sector and Law enforcement