A Review on Information and Communication Technologies for Industry 4.0

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ABSTRACT
Industry 4.0 is not always investing in new innovations and tools to increase production quality, but it also about revolutionising and improving the way whole company operates and develops. Industry 4.0 and its information and communication systems are transforming the landscape of services and manufacturing sector. Although every business and organisation operating today is different, they all face a normal challenge. It is the need for connectivity and access to real-time insights through systems, partners, products and other individuals. This is where Industry 4.0 comes into play. Industry 4.0 describes the increasing trend in the manufacturing industry towards automation and data exchange in technology and processes.This trend has already been evident through business models such as offline programming and adaptive control for arc welding, taking the method from product design through simulation to production workplace. The integration of digitalization with conventional manufacturing processes is part of Industry 4.0. This leads to smart value chains and lifecycles of goods that start with development, undergo production, assembly, delivery and maintenance of products, and end with recycling. It is primarily a replacement process that focuses mainly on interconnectivity, automation, and data in real time. This paper focuses on various issues related to Industry 4.0 design principles, benifits, components, primary drivers and technologies.The technologies that are part of industry 4.0 such as artificial intelligence, big data, industrial internet of things, cloud computing, and additive manufacturing, create a more comprehensive and better integrated environment for supply chain management in manufacturing industries.

Keywords
Industry 4.0,Industrial Internet Of Things, Big data, Cloud Computing, Additive Manufacturing Artificial Inteligence

1. INTRODUCTION
One of the two things that might come to mind when people think of the industrial revolution. Some people automatically think of the improvements in manufacturing brought on in the eighteenth century by the use of machinery. The industrial revolution can be seen by some as a continuing reality that we still live in today. These are both right[2].Goods, including food, garments, houses and weapons, have been created by hand or with the aid of working animals for centuries. By the beginning of the 19th century, however, with the advent of Industry 1.0, production started to change significantly, and operations grew rapidly from there. The summary of the evolution is here[1].

1st Industry Revolution
In the 1800s, machines powered by water and steam were built to support employees [1]. In the 18th century, the First Industrial Revolution started with the use of steam power and manufacturing mechanisation. The mechanised version, which had generated threads on simple spinning wheels before, achieved eight times the volume at the same time. Steam power was established then. The biggest advance in rising human productivity was its use for industrial purposes [3]. The move to modern manufacturing methods using water and steam was the First Industrial Revolution. In terms of producing a greater variety of different products and providing a decent quality of life for others, it was highly beneficial. In particular, the textile industry was transformed by industrialization. Fuel sources such as steam and coal made the use of machines more feasible, and the idea of machine manufacturing quickly spread. Machines allowed production to be faster and simpler, and they also made all sorts of new inventions and technologies possible [4].

2nd Industry Revolution
Through the invention of electricity and assembly line manufacturing, the Second Industrial Revolution began in the 19th century[3]. New technological systems were implemented during this period, most notably superior electrical technology, which allowed for even grea production and more advanced machines [4]. Manufacturers have started experimenting with more synthetic materials at this time and machines have developed to play an even more important role in the industry. Computers were invented by inventors, automated processes came into being and plastics joined the manufacturing line[2].
It was simpler to use than water and steam and made possible for companies to focus power sources on individual machines. Machines were eventually designed with their own power sources, making them more portable. This period also saw the development of a number of management programmes that enabled manufacturing facilities to increase efficiency and effectiveness. Increased productivity in the division of labour, where each worker performs a portion of the overall work. Mass manufacturing of products using assembly lines has become a common position[1].

3rd Industry Revolution
The first computer era started with it. Compared to the computing power they were able to offer, these early computers were often very basic, unwieldy and extremely huge, but they laid the foundations for a world today that without computer technology one is hard-pressed to imagine[4].

The Third Industrial Revolution took place around 1970 and involved the use of electronics and IT (Information Technology) to further automate development. Industry 3.0 implemented more automated processes, i.e. using programmable logic controllers, on the assembly line to execute human tasks (PLC). They still depended on human input and intervention, while automated systems were in place [4].

In the '70s, the Third Industrial Revolution started by partial automation using memory-programmable controls and computers in the 20th century. We are now able to automate the entire manufacturing process after the advent of these innovations - without human assistance. Robots that run programmed sequences without human interference are established examples of this [3].

The invention and development of electronic devices, such as transistors and, later, integrated circuit chips, made it possible to more completely automate individual machines to complement or replace operators in the last few decades of the 20th century. The development of software systems to capitalise on electronic hardware also spawned this period. Integrated systems, such as planning of material requirements, were superseded by tools for planning enterprise resources that allowed humans to plan, schedule and monitor product flows through the factory[1].

4th Industry Revolution

The Fourth Industrial Revolution we are now introducing. This is defined by the application of ICTs to manufacturing and is often referred to as 'Industry 4.0.' It builds on the Third Industrial Revolution's advances. A network link extends production processes that already have computer technology and have, so to speak, a digital twin on the Internet. These allow contact and the production of information about themselves with other facilities. The next step in production automation is this. The networking of all systems contributes to 'cyber-physical production systems' and thus to smart factories, where production systems, components and people interact through a network and where production is almost autonomous [3].

The Fourth Industrial Revolution is the era of smart machines, storage systems and manufacturing facilities that can autonomously exchange information without human intervention, trigger actions and control each other. With the Industrial Internet of Things (IIoT) as we know it today, this exchange of information is possible. Cyber-physical machine, a mechanical device powered by computer-based algorithms, the Internet of Things (IoT), cloud computing, cognitive computing, are core elements of Industry 4.0 [4].

Industry 4.0 has the ability to produce some amazing developments in factory environments as these enablers come together. Examples include machines that can autonomously predict failures and activate maintenance processes, or self-organized logistics that respond to unexpected production changes.

And it has the ability to change the way people work. Industry 4.0 can pull people into smarter networks, with the ability to function more effectively. The digitalization of the manufacturing system enables more efficient ways to get the right information at the right time to the right person. With the growing usage of digital devices within and outside factories in the region, maintenance professionals can be provided with documentation of equipment and service history in a more timely manner and at the point of use. Professionals in maintenance want to fix issues, not spend time attempting to find the technical knowledge they need[4].In short, in industrial environments, Industry 4.0 is a game-changer [3].

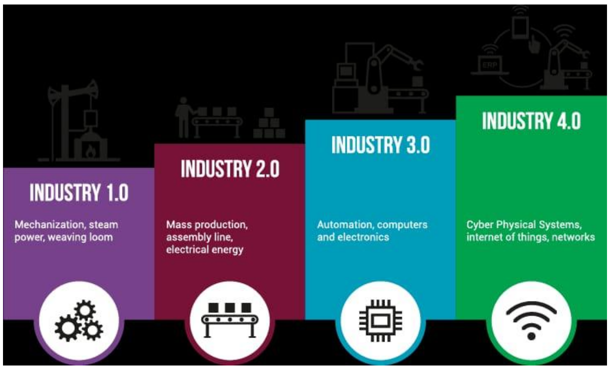

Fig: Evolution of Industry 4.0[16]

The paper is organized as follows

Section II describes the related work, Section III addresses a general view of industry 4.0 design principles ,components, primary drivers,and its benefits. Section IV is a description of why is big data the core of the 4.0 Industry, Section V presents the role of cloud computing in boosting industrial revolution 4.0, Section VI gives an insight into IIOT and industry 4.0, Section VII describes additive manufacturing in industry 4.0, Section VIII covers AI the driving force of industry 4.0, and finally, the conclusions are summarized in Section IX.

2. RELATED WORK

The Evolution of Industry 1.0 to 4.0,By Momentum /August 2,2019(updated October 10,2019).

The author has tried in this article to concentrate on the revolution of Industry 4.0 from the first to the latest collection of innovations from Industry 1.0 to Industry 4.0. They also emphasise how to easily apply smart manufacturing to current companies.

APICS FOR INDIVIDUALS/SCM NOW MAGAZINE/ Industry 1.0 to 4.0: The Evolution of Smart Factories, Richard E Crandall, Sepetember/October 2017

This article is a sidebar to updating smart manufacturing with Industry 4.0. The author focuses specifically on the evolution from Industry 1.0 to Industry 4.0 and concludes that the emergence of new technologies has been a primary catalyst of the 4.0 industry revolution.

EPICOR/Resourse Center/Articlbes/What is Industry 4.0-The Industrial Internet of Things

This article provides an in-depth overview on the topics of Industry 4.0 and IIOT , and provides a deeper discussion of what, why, and how Industry 4.0 is. It discusses how you understand when your company can invest in Industry 4.0, and finally gives a key note on Industry 4.0 benefits and challenges.

Research gate/ Big data/Article/Nancy Velasquez, Patrica peso,univirsidad Nacional de la plate

This article provides a deeper perspective on why big data is the centre of the 4.0 industry, and how this contributed to the fourth industrial revolution, and they thought that the amount of information generated by IOT and today's production systems must be converted into actionable ideas, which is why big data classifies the information gathered and draws relevant conclusions that allow companies to develop their operations. so they can present different use cases,and they present a deeper view on big data and bussiness strategy and finally they can provide a glance on what would Industry 4.0 be without big data in a précised manner.

ELETS/the banking and finance/ Why is Big Data the core of the 4.0 industry?

This article mainly discusses the life cycle of Industry 4.0, the role of cloud computing in boosting the Industrial Revolution 4.0, and why cloud computing is important for Industry 4.0, including the potential of cloud computing to transform the banking and financial sector and help the Industrial Revolution 4.0. In industry 4.0, the advantages of today's cloud technologies will go beyond reliability, scalability and storage.

ATS-Industrial Technology Services.Inc /Blog/IIOT VS Industry 4.0

This blog mainly covers the information about how the two key concepts IIOT and Industry 4.0 are necessary to remain competitive in today's manufacturing landscape.They also point out that while IOT and Industry 4.0 are separate concepts,they should not be viewed that way when introducing greater efficiency into the process through more automation.They conclude that Industry 4.0 would not exist without IIOT but IIOT would not be very effective without the bigger picture framework of Industry 4.0.

SEE BURGER-The Engine Driving your digital transformation/Blog/IIOT (Industrial-IOT) and Industry 4.0 Examples

The author provides examples of how IOT and Industry 4.0 operate in practise in this article. It also illustrates how IOT and Industry 4.0 can optimise production and business processes and also points out that new opportunities are discovered every day using IIOT. The fundamental premise for this is, therefore, the deep integration and networking of all systems and the creation of comprehensive networks with digital value added.

Role of Additive Manufacturing in Industry 4.0 for Maintenance Engineering/Book chapter-January 2020,Arun kumar Ravindra Rai Singh,Gurminder Singh,Pulak M Pandey, Indian institute of technology, Delhi

The role of additive manufacturing for maintenance engineering in Industry 4.0 is explained in this paper. This paper provides different Additive Manufacturing process with proper contributions in the industry sectors, and the difference between the manufacturing capabilities of conversional and additive manufacturing technologies. And it also covers the obstacles to the manufacturers' adoption of AM technology and presents the remedial actions and they conclude that the current industry is the threshold of its new revolutions called Industry 4.0, marking the paradigm shift from a centrally controlled manufacturing process to a decentralised production process.

DATAQUEST/Empowering Industry4.0 with Artificial Intelligence, feb12, 2020

A survey on empowering Industry 4.0 with Artificial Intelligence is provided in this article. Artificial Intelligence emerges from real life to real life in the author's viewpoint to become the frontier of changing world technologies and there is an urgent need for artificial intelligence to be systematically developed and implemented to see its real impact in Industry 4.0.

3. INDUSTRY 4.0 DESIGN PRINCIPLES,COMPONENTS, BENIFITS & CHALLENGES

Who is Industry 4.0 ideal for? [6]

With many tech players, you are in an especially competitive industry.

You have several empty positions in your company to employ. You want greater visibility in the supply chain.

You want to find and fix problems before they turn into bigger issues.

You want to maintain productivity and sustainability in the entire organisation.

You want to have informed, up-to-date, specific views on development and business processes from everyone on your team.

To boost customer loyalty and customer experience, you want to

You want to increase the quality of the commodity,

You want a more comprehensive method of business resource planning that includes not only inventory and planning, but also financing, customer relationships, supply chain management and execution of manufacturing.

You want a clear and versatile view of your organization's development and business activities targeted to particular areas or users.You want real-time insights that allow you to make smarter, quicker business decisions every day[6].

Benefits by implementing a blueprint for Industry 4.0 [6]

Industry 4.0 covers design, sales, inventory, scheduling, efficiency, engineering, and customer and field support across the entire product life cycle and supply chain.

Some of the advantages of your company following an Industry 4.0 model:

It makes you more competitive, particularly against Amazon-like disruptors. When businesses such as Amazon continue to simplify supply chain management and logistics, you need to invest in technologies and solutions that will help you develop and optimise your own operations. In order to remain competitive, you need to have the systems and processes in place to allow you to provide your customers and customers with the same quality of service (or better) that they might get from a company like Amazon.

It makes the younger workforce more appealing to you. In order to recruit and retain new staff, businesses investing in modern, creative Industry 4.0 innovations are best placed.

It makes it stronger and more collaborative for your team. Companies investing in Industry 4.0 technologies will improve productivity, enhance department-to-department cooperation, allow predictive and prescriptive analytics, and enable individuals, including operators, managers, and executives, to leverage real-time data and information more completely to make informed decisions when managing their day-to-day duties.

It helps you to solve future challenges before they become major issues. When it comes to addressing and mitigating possible maintenance and supply chain management challenges, predictive analytics, real-time data, internet-connected equipment, and automation will all help you be more proactive.

It helps you to cut costs, increase profits and increase fuel growth. Technology from Industry 4.0 helps you manage and optimise all facets of your production processes and supply chain. It gives you access to the knowledge and insights you need in real-time to make better, quicker business decisions, which can eventually improve the productivity and profitability of your entire operation

Design principles and goals[5]

1. Interconnection is the power of computers, devices, sensors and other individuals to communicate and interact with each other through the network of things.

2. Transparent data provides operators with accurate information to make decisions. Inter-connectivity enables operators to collect vast quantities of information and knowledge from all points of the development chain, identify key areas that would be improved to expand functionality.

3. Technical assistance is the technological facility for programmes to assist people in decision-making and problem-solving, and hence the capacity to assist people with challenging or dangerous activities.

4. The ability of cyber-physical systems to make decisions on their own and to execute their tasks as autonomously as possible is decentralised decisions.

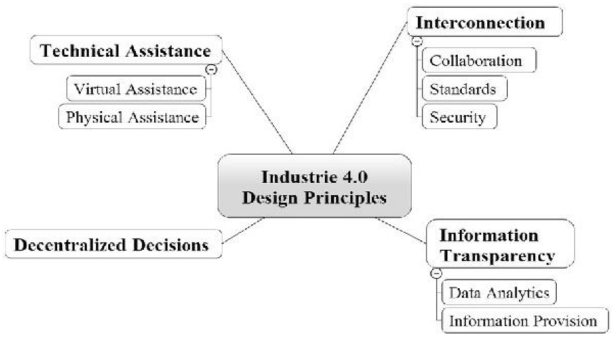

Fig-2: Industry 4.0 design principles[17]

Components[5]:

The Fourth technological revolution consists of the many components when looking closely into our society and current digital trends.

- Mobile devices
- Internet of things (IoT) platforms
- Location detection technologies
- Advanced human-machine interfaces
- Authentication and fraud detection
- 3D printing
- Smart sensors
- Big analytics and advanced processes
- Multilevel customer interaction and customer profiling
- Augmented reality/ wearables

Primary drivers[5]:

1.Value chain digitization-Industry 4.0 vertically incorporates processes across the entire enterprise, including growth, processing, structuring, and service processes; horizontally, Industry 4.0 involves internal operations from suppliers to consumers as well as all main value chain stakeholders.
2. Digitization of goods and services by introducing new information collection and analysis approaches, such as by extending existing products or developing new digitised products, allows businesses to produce product usage data in order to optimise products.
3. Customer satisfaction is a perpetual, multi-stage process that involves real-time adjustment to respond to the evolving demands of customers themselves and to execute their tasks as autonomously as possible. Digital business models and customer access

Challenges in implementation of Industry 4.0:[5]

1.High economic costs, adaptation of the business model and unsustainable spending.
2.General resistance to change by stakeholders, risk of corporate IT department redundancy, loss of many jobs to automated processes and processes regulated by IT,
3.Unclear legal concerns and protection of data
4.Reliability and stability necessary for vital communication between machine-to-machine (M2M), security issues, the need to preserve the integrity of production processes, the absence of adequate skill sets to speed up the transition to a fourth industrial revolution, low commitment to top management Inadequate employee qualification[5].

4. WHY IS BIG DATA THE CORE OF 4.0 INDUSTRY

Big Data techniques allow the analysis of enormous data volumes produced in the production ecosystem of Industry 4.0. Techniques such as advanced, historical, predictive and descriptive analysis allow the state and function of the machines involved in manufacturing, control and monitoring processes to be evaluated. Predictive maintenance data analysis decreases inefficiencies and costs, anticipates equipment failures and allows better reactions to evolving and remote situations caused by various factors such as bad weather, high humidity, heat, gaseous exposure, etc.[7].
As another example, predictive analysis also helps route control to assess where disruptions are caused or where the roads are in poor condition. It also makes it possible to recognise trends and compare data for improving industrial processes, to make operational efficiency decisions in real time, to define new business models based on customer behaviour, to design new services relevant to existing products and to machine learning[5].Huge data usage does not depend on the sector's dimensions.
It depends on the business plan to take advantage of the knowledge to develop the production process and decide the goods that the industry can manufacture to meet the demands of the consumer. This causes the current manner in which the company investigates, analyses and evaluates the product to be released to the market to be changed, raising the probability of successfully selling the product [7].
Increasingly complex and interconnected, modern factories are generating new problems that can be solved by automation, powered by Big Data. The vast volumes of IoT data and modern computer systems have made it possible for smart factories to rapidly increase their productivity and make substantial gains in terms of improved uptime, accelerated performance and reduced errors.
Without Big Data, 4.0 technologies would not have been able to learn, produce predictive analysis patterns and function autonomously and in such a precise way to decipher and derive value from all that knowledge. Therefore, without Big Data, the 4.0 market, or the smart technologies that support it, will not exist[7].

Use of Big Data in Factories 4.0[8]

Improving warehouse processes: By detecting human mistakes, conducting quality controls and displaying optimum manufacturing or assembly paths, businesses can increase operational efficiency thanks to sensors and portable devices.
Elimination of bottlenecks: Big Data identifies variables that, at no extra cost, can affect output, guiding producers to identify the problem.
• Predictive demand: More detailed and meaningful forecasts due to the visualisation of behaviour beyond historical data through internal analysis (customer preferences) and external analysis (trends and external events). This enables the company

to modify/optimize its portfolio of products

Predictive maintenance: By detecting breakdowns in patterns, data fed sensors detect potential faults in the operation of machinery before it becomes a breakdown. In order for it to respond in time, the machine sends a knowledge of the computer.

These are just some of the advantages of big data analysis in production systems, but there are many more; improved security, optimization of loads, management of the supply chain, analysis of non-conformity, etc.

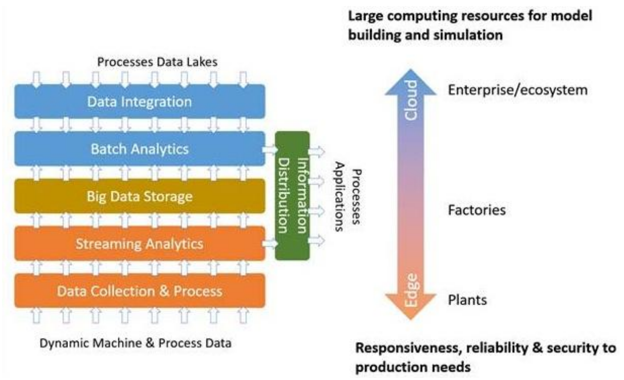

Fig-3:Big Data Challenges of Industry 4.0[18]

Big Data and Business Strategy(8):

The analysis of the large Data provides valuable information on key elements like markets or business directions, identifying which of them will potentially generate the very best profits. It is fundamental for creating strategic decisions like expansion and development plans or financial analysis. It has therefore become an indispensable source for the industrial sector in two main aspects:

1. Hyperconnected context

A very high and increasing percentage of business activities move through the Internet or are connected to it. This raises the amount of data recorded and processed by businesses to exponential amounts, both online and offline, making it impossible and difficult for companies to handle and maintain the data.

Although industrial firms existed exclusively in restricted geographical areas years ago and had a constant and highly concentrated demand, they now have to live and coexist with many other firms in a context where there are no physical barriers. Knowledge is power in this new sense, but only if it is used correctly.If an organisation decides not to adopt Big Data, it would be left behind and lose every competitive advantage designed not to thrive in favour of its rivals. If an organisation tries to incorporate Big Data in a complementary way and without a technique, like the first, it would have hung out and cash to finish up. But if a business succeeds in internalising its Big Data strategy and connecting its processes, it will have an exponentially greater chance of success in the 4.0 environment.

2. Smart Factories

In order for organisations to achieve a complete visualisation of the production processes, Big Data helps to incorporate previously separated structures. Furthermore, it automates the processing and review of data, enabling a deeper understanding of each system's status, both together and separately.

The data is analysed in three layers of perspectives that include history, current and future data, allowing a full view that includes rationale on causalities and future predictions[8].

5. THE ROLE OF CLOUD COMPUTING IN BOOSTING INDUSTRIAL REVOLUTION 4.0

Cloud Computing enables large amounts of data to be stored. In order to store the data produced during the entire production process, this capacity is primarily necessary, given that machines and sensors produce more data than a human, and such data is often related. Similarly, cloud computing eliminates expenditure in technical infrastructure, enabling on-demand storage space and processing power to be contracted, offering versatility, agility and adaptability.The cloud facilitates the consumption of resources on demand through a modular framework[7].

This makes it possible to minimise costs by preventingthe procurement of servers, licences and the recruiting of skilled maintenance staff, as well as saving resources. In addition, storage from various geographical points and different schedules is readily available, regardless of the network and the connecting devices.All this makes it easier for manufacturing ecosystems to be built and facilitates customer and supplier cooperation. The customer will, in particular, engage in all stages of the manufacturing process and their satisfaction is therefore increased.

There is latency time, due to the large amounts of data stored in the cloud, that can affect the production process efficiency. In addition, it allows the implementation of private clouds for the exclusive use of industries that require extreme confidentiality to improve data protection and privacy [7].

The actual capacity of the cloud to sustain the Fourth Industrial Revolution can only be assessed by the integration of cloud network computing services. Cloud systems support inventive and innovative applications by tapping into the power of computing resources [9].

Across the globe, industry reports agree that cloud technology is a crucial enabler of the Technological Revolution 4.0.Cloud computing is effectively enabling advances on the Internet of Things (IoT), automation and robotics as the latest Industry Revolution continues to ignite.

The Cloud-Industries 4.0 partnership is a winning mix. Although it definitely took time to mature and begin to bear fruit, this main collaboration now enables enterprises to reconsider their full spectrum of digitisation processes fundamentally and profoundly.

The Cloud is Industry 4.0's connective tissue, the main factor that makes it possible to build an advanced, more effective and efficient manufacturing strategy by leveraging sensors, artificial intelligence and robotics. According to the results, 6 out of 10 businesses believe that it is "necessary" to embrace an enterprise cloud architecture in order to leverage as much as possible on innovation investments, mainly based on robotics (62%) and AII (60 percent). Thus, the Cloud is a true accelerator of digital transformation in manufacturing businesses.

The Cloud provides businesses with the computational resources required to recognise and take full advantage of emerging market opportunities, extrapolating the applicable data within the multitude of data collected. If it is indeed true that AI and robotics are the main assets of factory digital transformation, Big Data and analytics are the instruments on which both strategic and tactical decisions can be based. But the 4.0 suffix makes it clear that the most significant breakthrough for CIOs and business line managers is the way the systems are used, which is now beyond the scope of every enterprise, large or small, of the latest Cloud-related pay-per-use and as-a-service formulas.

The possibility, also for small to medium-sized businesses, to select versatile implementation models for large-scale technologies with the assurance of a substantial competitive edge is one of the keys to the success of Industry 4.0 and of smart manufacturing. Businesses will now be able to select the best technical technologies through Cloud Computing, while complying with budget limitations, converting initial investments into recurring costs[10].

Operators of industrial plants are also reluctant to move their information to the cloud. The competitive environment today, however, is pushing businesses to combine and incorporate data from different plants and facilities in order to enhance process control, maintaining a more or less significant competitive advantage over businesses that remain rooted to more conventional models of operation management. Therefore, manufacturing experts are encouraged to choose the best of all worlds, on-site and in the Cloud, working closely with partners willing to host their data and applications in the Cloud[10].

The management of processes in the cloud, within the framework of carefully specified quality criteria, is definitely an interesting feature for large companies concerned with the relocation of production plants and sites. But in SMEs, which will finally have access to a versatile and on-demand processing and storage power, the potential of Cloud Computing is demonstrated to the fullest without having to incur the costs of setting up an internal data center-a wired, dependent and secured space and therefore very expensive [10].

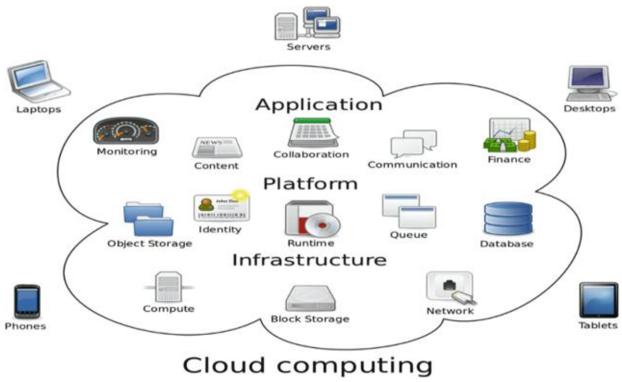

Fig-4:Cloud Computing in Industry 4.0[19]

6. IIOT AND INDUSTRY 4.0

Industrial Internet of Things:

Industry 4.0 refers to the importance of lean, efficient operations and the role of maintaining and advancing development, while IIoT distinguishes manufacturing devices from consumer devices that link wirelessly to internal networks and the internet.

Both IIoT and Industry 4.0 draw on current concepts that date back many years, but have been built to account for advances, modifications and inventions resulting from these original concepts.

The phrase "Industrial Internet of Things" differentiates production equipment from consumer equipment, but the principle underlying it is the same. IIoT devices are connected to all internal networks and the global Internet wirelessly.

Such devices reflect a new step of automation, storing and exchanging with a central server an unprecedented amount of data from all facets of a process. This data allows for previously unseen research and action, resulting in improved performance and productivity[12].

More precisely, the German government coined the word 'Industry 4.0' to explain the complexity of automation opportunities, the importance of implementing them, and the role of these innovations in advancing manufacturing. The object of the gravity of the 4th Industrial Revolution is to tell manufacturers that they have to change or be left behind.

IIoT is a part of Industry 4.0 in a basic sense, but not as an interchangeable word. Industry 4.0 will not exist without the networking and data that IIoT offers, let alone be as impactful on performance. IIoT allows for more research and intervention and is an essential catalyst of Industry 4.0.0. Without IIoT, Industry 4.0 would not exist, but without the larger-picture structure of Industry 4.0., IIoT would not be very successful.

Similarities and differences:[12]

1. IIoT and Industry 4.0 are both intended to streamline production processes and maintain viable and profitable manufacturing.

2. Without the high-speed, wireless, seamless Internet access of today, IIoT and Industry 4.0 will not be feasible.

3. Implemented in both IIoT and Industry 4.0, automation can only render current processes quicker and more efficient. The secret to its return on investment is people with the awareness of how to view and execute data and behaviour generated by this technology.

4. Almost always, IIoT applies solely to the instruments in a facility (and any potential off-site server locations). Industry 4.0 includes IIoT and positions it in the industrial sector in a much broader sense of research, intervention and long-term sustainability.

5.IIoT is an implementation of technology in many ways, whether referring to new, connected devices, or retrofitted sensors, data transmitters, wireless devices, etc. Industry 4.0 is more of a technology-driven ideology like IIoT, but retains a broader reach and view of the greater picture. In equipment investment, IIoT may be manifested, but Industry 4.0 is manifested by management and leadership buy-in.

IIOT AND INDUSTRY 4.0 EXAMPLES[13]

1. Product Development

Products today are also monitored over their entire lifecycle with the help of networked systems, from the original concept to the finished product, including maintenance and repair all the way to its modernization. The digital twin, that is, a digital picture of a product in use, provides new possibilities beyond pure production for collaboration between producers, consumers and suppliers. IIoT makes processes more effective, easier and safer, especially in collaborative production and data sharing in engineering and other technical industries. Fully decentralised and individualised goods up to batch size 1 can be optimised.

2. Manufacturing and Production

Even individual customer requirements are often met more and more effectively, not only in development , but consequently also within the manufacture of products. Interoperability is a core requirement of Industry 4.0. But also the cooperation between humans and robots, the so-called collaborative assembly, may be a key development in production in times of Industry 4.0. As planning and production are getting more and more complex, they require an in depth cooperation of all parties involved during a value chain and endless product life cycle management. This is made possible by providing end-to-end data exchange and knowledge technology support, even during ongoing production

3. Logistics

A core challenge of optimised logistics processes is to transfer the right items at the right time to the right location within the right quantity. In real time, these processes are mapped transparently and flexibly. It smoothly orchestrates the projection of the provision of customer information from the design of transport capacity utilisation to the optimization of auto turnaround times. Modern vehicle radio and sensor technology gathers raw data on position and movement status, mileage, load status and speed, for example. This data is also processed further by internal dispatching systems and used as a basis for digital customer services, for example.

4. After Sales Services

Together with other digital services, products and services are often mapped digitally via IoT platforms and offered as Smart Services. In this context, the provision of product details, such as the use of devices in relation to pay-by-use payment models, is becoming more and more relevant.

5. Marketing and Sales

Marketing and sales increase business value.In the area of selling and sales, IoT are often used, for example, to gather and evaluate data on customer behaviour (customer relationship management CRM). In this way, global advertising and sales strategies and branding concepts are often planned and executed more foresightedly and during a more target-group-oriented manner.

IIoT and Industry 4.0 solutions are implemented in all areas. As a result it gives efficient processes and opportunities for cooperation and monitoring at all levels, new and improved data-based business models and, in the end, more satisfied customers and employees[13].

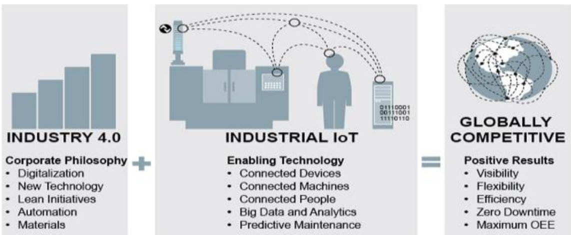

Fig-5: IIOT VS INDUSTRY 4.0[20]

Role of Additive Manufacturing in Industry 4.0

Additive Manufacturing (AM) can be a method of layer-by-layer manufacturing to create practical 3D prototypes from a model designed for 3D. Models are generally designed using CAD software or scanned reverse engineering model or model generated from the CT scan or cloud computing data medical scanning method. AM techniques provide the advantage of producing complex shape geometries at a reasonablecost and without the use of any additional machining or tooling. Complex shapes can be easily created in a few hours, such as rocket propellers, foams, heat exchangers, etc.In the field of modern industry, AM is increasing significantly to reduce waste and, as a result, to enhance work productivity.Centered on distinct truths of production principles, there are various types of AM techniques available. In various AM methods, several types of materials may be used.

One of the AM family's cheapest techniques is fused deposition modelling (FDM). It is based on thermal deposition of thin wire or filament based thermoplastic materials such as Acrylonitrile Butadiene Styrene (ABS), Poly-lactic acid (PLA), etc. After extrusion from the hot extruder, the plastic gets solidified layer by layer and a solid model can be obtained. To achieve a 3D shape, SLA (stereolithography) is based on the laser or light curing of a photo-sensitive fluid[14].

For the production of non-structural components, AM techniques such as SLS (selective laser sintering), Polyjet 3D printing, etc. are used. However, in order to obtain a good high-strength material model, it is important to melt metallic powder [14].

There are a range of AM devices available for the manufacture of metal 3D structures using CAD concept using melting metallic powder. One of them uses a high power laser source for the melting of powder layer-by-layer is SLM (selective laser melting). For the complex shape processing of high thermal conductive materials such as copper, brass, aluminium, etc., EBM (electron beam melting) is used.[15].

AM methods, such as SLS (selective laser sintering), Polyjet 3D printing, etc., are used for the development of non-structural parts. However, it is necessary to melt metallic powder in order to achieve a good high-strength material model [14].

For the manufacture of metal 3D structures using the CAD principle using melting metallic powder, a variety of AM devices are available. SLM is one of them that uses a high power laser source for powder layer-by-layer melting (selective laser melting). EBM (electron beam melting) is used for the complex shape processing of high thermal conductive materials like copper, brass, aluminium, etc[15].

The manufactured solid components obtained from these techniques have structural properties identical to those obtained from machined or cast metals. Other new emerging metal AM techniques are available, such as direct metal laser deposition, laser net shaping, etc. The complex shape supported the frameworks of the skinny truss and repeated in unit terms (known as lattice) are also easily produced for top structural efficiency by AM. Many of the earlier 3D printers used technology to run at elevated temperatures.

DISTINCTIVE FEATURES OF AM[15]

AM uses CAD data to realise the product and is thus uniquely capable of creating complex shapes that can not be produced using the traditional machining

process. There are other distinctive features of AM along with this design independence, which makes it an essential component of the new phase of the commercial revolution, i.e. 4.0.0.industry

1. Form Complexity: AM allows virtually any shape possible to build.
2. Complexity of materials: It also requires products with complex material compositions to be produced.
3. Hierarchical complexity: this refers to the multi-scale of AM-posible functions, sub-features, etc.
4. Functional complexity: In some AM machines, functional devices are also assembled directly by embedding components and kinematic joints as parts are being constructed.

Part Consolidation

AM makes it possible to create a specification for an assembly in such a way that it is possible to minimise the total number of components by consolidating them while retaining the same functionality as the initial con-structure. Consolidation of parts eventually decreases the number of components, but it also contributes to 9an increase in complexity. Such complicated components would be difficult to manufacture via traditional production methods, but AM makes part consolidation due to its high degree of design freedom and free-form manufacturing. It also helps to minimise production and tooling time for parts. [15].

Fig-6:Additive Manufacturing and Industry 4.0[21].

7. ROLE OF ARTIFICIAL INTELLIGENCE IN INDUSTRY 4.0

Artificial intelligence, powered by a new mode of interaction between man and machine, has brought about a revolution in the pattern of the activity of industry. Intelligent factories where humans and cyber-physical structures communicate in the cloud describe this industrial revolution, which has given rise to Industry 4.0[22].

Intelligent factories absorb automated structures and provide digital enablers that allow machinery, via an IoT configuration, to communicate with each other and with the factory systems as a whole.

AI applied to industry 4.0:

Artificial intelligence has been the most revolutionary technology needed to revolutionise organisations' management and business models. Within the 4.0 market, its key applications are:

OEE optimization by predictive maintenance and repair.

Quality 4.0 by operational excellence, which constantly increases the quality ofproduction.Generative design through AI and automation algorithms that produce multiple design solutions valid for the same target at the same time.Robotics by robotic and collaborative machines that allow operators to release methodical and/or highly accurate tasks from them[22].

Artificial intelligence’s impact on manufacturing can be organized into 5 main areas[23]:

1. Predictive Quality and Yield
2. Predictive Maintenance
3. Human-robot collaboration
4. Generative design
5. Market adaption/supply-chain

The complexity of using artificial intelligence in industrial automation requires that manufacturers collaborate with specialists to reach customized solutions. Attempting to build the required technology is costly and most manufacturers don’t have the necessary skills and knowledge in-house.

Impact of AI on industry 4.0[22]:

The transformation from conventional automation focused on autonomous industrial robots to networked 1.Cyber physical systems has revolutionised the operation of manufacturing plants and placed new productivity requirements on the industry.

2. Just-in-time production: A new level of optimisation has been achieved through adapted, real-time production models. These manufacturing systems powered by AI may generate pieces tailored to the order in an adaptive manner. Sensors track components to shorten lead times by ordering them according to demand trends and algorithms

3.Introduction of new products: Information systems that feed decision-making on issues as fundamental as the product line become production lines. This enables demand adaptation, making it easier to move from the raw materials that join the factory process to the finished product that leaves it.

4.Consumption changes: Between properties and consumers, one of the greatest changes in attitude has occurred. Via knowledge networks, customers are linked to the industry and expect goods and experiences of a higher quality and degree of personalisation. On the other hand, through digital designs and intelligent pr intelligence, manufacturers can produce personalised products without losing performance.

AI is one of the emerging technologies that manufacturers are already using to improve product quality, efficiency and cut operating costs. We are beginning to see a working relationship between human beings and robots, an area that benefits from the use of AI in production facilities. The smart factory, consisting of hyper-connected production processes, consists of multiple machines that all interact with each other, relying on AI automation platforms to collect and analyse all kinds of data, including images, standardised code text and categorised fixed field text[24].

AI in manufacturing process:

In their manufacturing processes, original equipment manufacturers (OEMs) who successfully operate in smart factories and implement Industry 4.0 use AI. The ability of AI and machine learning to enhance quality control, standardisation and maintenance by producing predictive analyses of equipment functionality and radically streamlining factory lines is used by manufacturers who have undergone a digital transition and can organise and use their data sets. Many businesses now aim to implement AI in their production processes, but far less have an AI development plan and, to a greater extent, are unsure of the appropriate type of automation platform.

Business leaders also need to establish employee buy-in at all levels and implement a management plan efficiently that will take into account the effects of automation on the workloads and roles of the organisation. This will also help identify which positions need retraining[23].The use of AI technologies to enable smarter machines that can autonomously take on tasks like self-monitoring and diagnosis is a big part of Industry 4.0. The ability of AI to assist manufacturers and other industrial companies in forecasting their maintenance needs and reducing downtime is also becoming critical, particularly as older, knowledgeable workers retire and leave a skills gap behind. With its Watson IoT solutions for industrial equipment, companies like IBM are helping technicians of all levels of experience leverage IoT and AI solutions to increase productivity in the Industry 4.0.0 era. The AI-powered repair assistant at IBM[25].

For Industry 4.0. AI innovations are a crucial success factor In multi-vendor factories, semantic technologies ensure interoperability and are the foundation for a revolutionary SOA development logic. A breakthrough for scalable automation is GPU-based automated production planning in real-time. The foundation for a new generation of worker assistance systems is user modelling, plan identification as well as intelligent multimodal interfaces[26].

8. CONCLUSIONS

Industry 4.0 is contributing to the age of digitalisation. It is all about business models, environments, methods of production, computers, operators, goods and services. It is all interconnected with the corresponding virtual representation within the digital scene. The physical flows can be continuously mapped on digital platforms. Many systems and software allow factory contact with the latest information and communication technology trends at a higher level of automation.This leads to state-of-the-art factories, not only within but also outside the factory, achieving all elements of the value chain in real-time interaction.

This disruptive impact on manufacturing companies will allow the smart manufacturing ecosystem paradigm. Industry 4.0 is the turning point to the end of the conventional centralized applications.

An industrial evaluation is happening based on a number of technological paradigms.The technology of information and communication continues to have a positive influence on several stages of the production environment. Intelligence from the beginning to the end of the supply chain keeps evolving. The Internet of Things is bringing information to endpoints, the modern way of running a company is becoming big data centric and Cloud Computing is the big data centre.

The advancement that this technology brings to production is changing individual businesses radically and shaping market dynamics. The fourth industrial revolution (Industry 4.0) focuses on the inclusion of new technology in manufacturing enterprises for automation and real-time data sharing processes. This paper demonstrated a vision of the present and future of industry 4.0. This paper includes an introduction to the history of industrial revolutions and exploits pillars such as the Internet of Things (IoT), Big Data and data analytics, additive manufacturing, cloud computing, and artificial intelligence, so we conclude that Industry 4.0 makes it easier for businesses to collaborate , increases efficiency and competitiveness, encourages the transition to a digital economy and creates opportunities for economic development and sustainability to be achieved.

FUTURE ENHANCEMENTS

Because of digital solutions, more flexible manufacturing, higher efficiency and the emergence of new business models are all possible today. But the industry's future offers even more potential: cutting-edge technologies will create new opportunities to meet the individual requirements of their customers for both the discrete and process industries. The Digital Enterprise solution portfolio allows industrial companies of all sizes to implement current and future automation and digitalization technologies. Only then they can tap into the full potential of Industry 4.0 and be prepared for the next step of their journey of digital transformation.

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