Wireless Pers Commun (2018) 100:145–159
https://doi.org/10.1007/s11277-018-5615-7

# Impact of 5G Technologies on Industry 4.0

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Published online: 13 March 2018


**Abstract** Manufacturing has evolved over the course of centuries from the days of handmade goods to the adoption of water- and steam-powered machines, the invention of mass production, the introduction of electronic automation, and now beyond. Today, the benchmark for companies to keep up with, is Industry 4.0. Here, Manufacturing systems go beyond simple connection, to also communicate, analyse and use collected information to drive further intelligent actions. It represents an integration of IoT, analytics, additive manufacturing, robotics, artificial intelligence, advanced materials, and augmented reality. The paper looks at the evolution of the Industrial revolution and the technologies that have impacted their growth. The proposed features of 5G technologies are listed and described how these features impact the Industries of the future, leading to Industries 4.0. 5G promises to be a key enabler for Factories of the Future, providing unified communication platform needed to disrupt with new business models and to overcome the shortcomings of current communication technologies.

**Keywords** Industries 4.0 · 5G technologies · Internet of Things (IoT) · Machine 2 machine (M2M) · Information and communication technologies (ICT) · Artificial intelligence (AI) · Machine learning · Industrial Internet of Things (IIoT) · Cyber-physical systems (CPS)

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# 1 Introduction

During earlier centuries, goods including food, clothing, houses and weapons were manufactured by hand or with the help of work animals. Manufacturing began to change dramatically by beginning of nineteenth century with the introduction of Industry 1.0, and operations rapidly developed from there. The core of Industrial automation is essentially the reliable exchange of information. Any attempt to automate, i.e. reduce/remove human intervention, requires a flow of information between some kind of sensors, controllers and actuators. To this effect, many kind of industrial communication networks evolved over the years. The evolution of the industrial revolution is described below.

## 1.1 Industrial Evolution

### *1.1.1 Industry 1.0*

Industries 1.0 started with introduction of water and steam powered mechanical manufacturing systems during end of 18th century and beginning of nineteenth century. Water- and steam-powered machines were developed to aid workers. As production capabilities increased, business also grew from individual cottage owners taking care of their own and maybe other's needs to organizations with owners, managers and employees serving customers.

### *1.1.2 Industry 2.0*

Industries 2.0 started in 20th century with introduction of electrically powered mass production based on the division of labour. By the beginning of the 20th century, electricity became the primary source of power. It was easier to use than water and steam and enabled businesses to concentrate power sources to individual machines. Eventually machines were designed with their own power sources, making them more portable.

This period also saw the development of number of management programs that made it possible to increase the efficiency and effectiveness of manufacturing facilities. Division of labour, where each worker does a part of the total job, increased productivity. Mass production of goods using assembly lines became commonplace. Studies were done, and processes introduced to enhance worker productivity and methods of Just-in-time manufacturing. The focus was on increased quality and productivity with optimization of labour.

### *1.1.3 Industry 3.0*

Industries 3.0 started around 1970 with the introduction of Electronics and IT to achieve further automation of manufacturing. In the last few decades of the 20th century, the invention and manufacture of electronic devices, such as the transistor and, later, integrated circuit chips, made it possible to more fully automate individual machines to supplement or replace operators. This period also spawned the development of software systems to capitalize on the electronic hardware. Integrated systems, such as material requirements planning, were superseded by enterprise resources planning tools that enabled humans to plan, schedule and track product flows through the factory. Pressure to reduce costs caused many manufacturers to move component and assembly operations to low-cost countries. The extended geographic dispersion resulted in the formalization of the concept of supply chain management.

### 1.1.4 Industry 4.0

Industry 4.0 today is based on Cyber- Physical systems. In the 21st century, Industry 4.0 connects the internet of things (IOT) with manufacturing techniques to enable systems to share information, analyse it and use it to guide intelligent actions. It also incorporates cutting-edge technologies including additive manufacturing, robotics, artificial intelligence and other cognitive technologies, advanced materials, and augmented reality [1]. Some of the programs first developed during the later stages of the 20th century, such as manufacturing execution systems, shop floor control and product life cycle management, were farsighted concepts that lacked the technology needed to make their complete implementation possible. Now, Industry 4.0 can help these programs reach their full potential.

## 1.2 Industries 4.0—Definition

The term Industries 4.0 was originally developed in Germany by the integration of IoT and Cyber Physical Systems to the industrial automation domain to create factory and process automation in bring products faster to the market in a very efficient way [2].

**Industry 4.0** is a name for the current trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of things, cloud computing and cognitive computing. Industry 4.0 creates what has been called a "smart factory". Within the modular structured smart factories, cyber-physical systems monitor physical processes, create a virtual copy of the physical world and make decentralized decisions. Over the Internet of Things, cyber-physical systems communicate and cooperate with each other and with humans in real time, and via the Internet of Services, both internal and cross-organizational services are offered and used by participants of the value chain.

Industries 4.0 aims to bring together advances of machines, networks, facilities that came from the industrial revolution. And advances in ICT brought in by the Internet and communication revolution, automating the operation of the Industries with embedded computers, real-time monitoring and control. Industries 4.0 brings is about Connected factories with globally interconnected value chains linking global suppliers, customers, business partners etc. [3]. In addition, systems within the Industries 4.0 scenario are self-aware and provide complete insight into the factory, enabling faster decisions [4].

## 1.3 Benefits of Industries 4.0

Industry 4.0 being a German initiative, has stretched across the world now. Supply chain managers all around the world regard Industry 4.0 as the new standard by which to measure their own supply chain operations and systems.

Benefits of Industries 4.0 include:

- Enables people, machines, sensors and devices to connect and communicate with one another.
- Automation and robotics provide vital support in environments that are too dangerous for humans. The next phase is building a system that can support humans in decision-making and problem-solving. This interdependence of systems and humans is a hallmark of Industry 4.0.
- Creation of cyber-physical system, which enables systems to seamlessly and instantly share data as required in real-time.

- Systems can become autonomous and able to make simple decisions on their own in real-time.
- Increased technological integration and predictive analytics increases efficiency and thereby helps to save costs.
- Companies can offer more customized products which will be profitable and helps to expand business.
- Supply chain management will become global and businesses will become competitive.

## 2 Implementing Industries 4.0

The key technologies required are AI, IoT, Machine Learning, Cloud systems, Cybersecurity, robotics and a robust communication network.

### 2.1 Preparation for Implementation

There should be agreement amongst all the stake holders to the implementation of Industries 4.0. A cost–benefit analysis has to be done to determine the level of automation required to get the desired benefits. An external expert agency maybe involved to get correct technology advice and directions. A cross functional Project team has to be constituted with representatives from manufacturing, engineering, human resources, accounting and marketing, since all these functions have a role to play in this. Project plan has to be developed, executed and monitored and controlled. It maybe necessary to change/update many legacy infrastructures to bring in automation. A very important factor is to get the culture of the organisation changed to accept this disruption, as there could be fear of job loss. This could happen and hence it is necessary to upskill/cross skill existing staff to be able to do the new tasks required in future [5].

### 2.2 Design Principles

Industry 4.0 is based on the following design principles, which support companies in identifying and implementing Industry 4.0 scenarios.

- It should be possible for the cyber physical systems, humans and factories to communicate with each other over IoT.
- Software applications have to be integrated throughout the enterprise.
- Real-time Data acquisition and control systems have to be integrated and enabled.
- Data analytics are essential through-out value-chain. Historical trends have to captured and displayed.
- Completely integrated mobile functions should enable data access even remotely.
- Innovative technology in many areas; sensors, wearables. M2M communication should cover the entire shop floor.
- Interoperability across all machines, need to be designed.
- Sensor data obtained from monitoring the production processes have to be linked with plant model, to create a virtual copy of the factory.
- Robotic automation has to be designed.
- Enable the cyber physical systems in the factory to take their own decisions.
- Enable value added services to be offered.

- The processes have to flexible to accommodate changing requirement scenarios [4].

### 2.3 Industries 4.0—ICT Requirements

Cyber-Physical-Systems (CPS) is the basis of intelligently connected production systems that operate well beyond the physical boundaries of the factory premises. A wireless, broadband, global, reliable network with mobile support is the basis for operation of CPS in the factories of the future [3].

In the manufacturing environment, these Cyber-Physical Systems comprise smart machines, storage systems and production facilities capable of autonomously exchanging information, triggering actions and controlling each other independently.

The ICT requirements are as follows:

- *Industrial Internet of Things (IIoT)* Automation is introduced throughput the entire process through implementing IIoT. IoT devices controls all machines and systems and the network of these IoT to the central control system.
- Cloud Computing required for scalability and global connectivity.
- Flexible inventory control and logistics to enable Just-in-time (JIT) manufacturing as required for customer's specific product configuration.
- Big Data and High-Performance Data Analytics to cover sensor and network connections, Cloud, Content, collaboration, and customization.

The ICT requirements should facilitate on-demand manufacturing, which should satisfy customer demands and preferences and enable elasticity and flexibility in manufacturing [6].

## 3 Current Limitations in Implementing Industries 4.0

Standardization in Industries 4.0 has been a challenge. This is required to make standard interfaces so that any machine in the Smart factory should be capable of talking to any other machine to share data seamlessly in the Industries 4.0 ecosystem.

The requirements of Industries 4.0 like device automation, automatic guided vehicles, augmented reality needs, extremely large number of devices to monitored and controlled, process automation etc., need features like ultra-low latency, very high reliability, very high bandwidth and data rates etc. cannot be met by the current communication systems.

Enterprises in the IIoT era cannot not just purely rely on unlicensed wireless like WiFi/ZigBee/Low Power Wide Area Network (LPWAN) for their future, mission-critical connected systems.

Wireless IoT markets is limited in potential with 3G/4G networks since limitations are experienced in:

- Reliability of wireless connections which is not enough for mission critical applications. Target reliability should be $> 99.999\%$.
- Energy consumption of devices being too large to meet battery life duration targets.
- End to end delay which is too long and not predictable for remote control and actuation. Latency of less than 1mS is not possible.
- Supporting extreme density of IoT devices.

## 4 What is 5G?

There has been a rapid evolution of radio technologies since the launch of analogue cellular systems in 1980s, termed as 1st Generation or simply 1G. Thereafter, digital wireless communication systems are consistently being evolved, one generation being advanced every decade. The Second Generation (2G) happened in 1990s, primarily using the GSM standard and using digital transmission instead of analogue transmission, which had the benefit of lower battery power consumption. SMS text messaging was introduced. The Third Generation (3G) came in 2000s, bring in high-speed IP data networking. Packet switching was used for data transmission as against circuit switching done earlier. This enabled media streaming of digital content to 3G handsets. Fourth Generation (4G) in 2010s saw the growth of mobile broadband, with improvements in speed up to tenfold over 3G and was an extension of 3G with higher bandwidth and services. Data transfer speed up to 100 Mbits/s downloads is possible in 4G Long Term Evolution [7].

Now, the progress is towards Fifth Generation (5G). 5G is the fifth generation of mobile, cellular technologies, networks and solutions. It is expected to bring in a major change in mobility and is a major driver of the growth of IoT. We are advancing towards more and more sophisticated and smarter technology. The features of 5G has the potential to change the meaning of mobile communications enabling revolution in connected society.

5G network comprises an architecture which is software defined [8], allowing dynamic programming for providing separate layers for different applications. This will enable new and diverse business use cases. 5G supports “network slicing”, which allows a VNO to define its own network architecture, enabling rapid roll out of scalable services at lower costs.

5G features [9] of 10 Gb/s data rates has the potential to support ultra-high definition video and virtual reality applications, whereas its latency of less than 1mS supports real-time applications. It is 10–100 times faster and have greater capacity than current 4G LTE networks. It supports several billions of applications and hundreds of billions of machines with improved device battery life, providing an always-on user experience.

5G would enable new diverse use cases and applications like:

- Relaxed latency requirements—Remote meter reading for billing purposes.
- Strict latency requirements $< 1$ mS—Process industry safety and control systems, real-time patient monitoring, Security and Video surveillance, real-time traffic light control, Two-way gaming, Virtual and Augmented reality etc.
- *High levels of network reliability*—Electrical grids, industrial control, traffic, e-health and smart-city management.
- Relaxed level of network reliability—Temperature/moisture sensors at home.
- High Volume of information—Remote video surveillance etc.
- Low volume of information—Cargo tracking in the shipping industry. Etc.
- Low device cost/low energy—Battery powered sensor networks.

5G promises to bring the reliability, latency, scalability, architecture, services, edgeless computing and ubiquitous mobility that is needed for several mission critical IoT applications.

## 5 5G—A Technology Enabler for Industries 4.0

A hyper connected environment has many variations in context of IoT enabled applications as some have moving parts, some have remotely located parts, some needs extreme reliability etc. Many of the network technologies that we have today do not really fit for the future. Even today, we often need to use a mix of fixed and wireless network technologies to realize massive IoT projects.

The target performance features of 5G like reliability up to 99.999%, latency of < 1mS and low power requirement will satisfy the shortcomings of the existing communication technologies. 5G promises handing very high capacity of IoT devices. To make the production process flexible, it should be very easy to add/change existing machines or sensors. This flexibility is being offered by 5G through standardization.

### 5.1 Industries 4.0 Demand Drivers

Exponentially growing technologies, listed below, will be main driver for Industries 4.0

- 3D printing or additive manufacturing.
- Sensor technologies.
- Nano technologies.
- Artificial intelligence.
- Robotics.
- Drones.

The above technologies have been for a while. However, with the advent of new Communication technologies, massive boost on computing power, cloud and big data analytics etc. have made them extremely useful for Industrial use. These exponential growths will drive Industries 4.0 [10].

Industries 4.0 needs a communication technology which has to satisfy the industry specific needs w.r.t network infrastructure, timing, heterogeneity, safety and security. Timing requirements are specific to industry and production process Typically, Utility and food processing industries are not very time critical and require cycle time of about 100 mS. Automotive production and heavy machinery require typical cycle times of 10 mS. Highest demands are set by motion control applications which require latency of less than 1 mS [3].

Factories of the Future leverage the technical integration of Cyber-Physical-Systems in production and logistics as well as the application of "Internet of Things and Services" (IOTS) in industrial processes. There will be a interplay of technological innovations in manufacturing with the latest ICT-related technologies. Robots, 3D-printing, advanced materials, novel sensors, autonomous vehicles, etc. all contribute individually to increased efficiency and flexibility.

Requirements of Smart Factory [10]

- Smart factories should implement production which can be customized as per individual customer requirements, Smart sensor technology has to be in place to monitor and control the production processes, Data integration and analytics should be extensive. Even Maintenance has to be automated by implementing networking of resources and products. Focus is on efficiently using resources like material, human and energy. This warrants new IT solutions and systems to developed to integrate sensors, electronics, data acquisition and control systems, business and other applications through efficient communication networks, Industries 4.0 will be data intensive and warrants high performance data analytics to be done in real time. Cloud based solutions will have to employed to deliver anytime, anywhere access to important data. The real-time data analytics helps in faster decision making and brings in transparency in production processes.

- There has to be transparency and flexibility across all processes including Just in Time Process, where materials can be procured just in time for actual production which is demanded by Sales for immediate delivery to customers. Customer specific requirements has to be met not only in production lines, but also in design and development. There will be integration with global chains i.e. Global Suppliers, logistics to provide a truly global value chain. Cloud based solutions enables data interchange between factories and across the whole global network. Industries 4.0 enables new Business Models which can disrupt existing way of doing business and result in leap frogging in business outcomes. These new Business Models can handle individual customer needs and integrate supply chain networks with vendors and business partners. Smart logistics function of Industries 4.0 has to integrate flexible logistics systems, new customer services, distribution method along with internal production processes through autonomous technologies. Also, it should provide high level of data security as data is now shared amongst various entities.
- It is required to modify or add new production systems for new products. This needs a cross disciplinary engineering across the full life cycle of products and services, which has to happen concurrently during design, development and manufacture of new products and services. Here again, Data and information has to be available at all stages of the product/manufacturing life cycle. Innovation is the key to the success of Industries 4.0 and has to be efficiently managed. The availability of data will enable efficient life cycle management of products.
- The exponential technologies, as mentioned above, will allow faster implementation of Industry 4.0, The automation required is supported by AI, advanced robotics and sensor technology.AI can enable driverless vehicle inside the factory to do many tedious jobs and also automate Supply Chain Management. Another example is 3D Printing. Industries have to make full use of the potential of exponential technologies in achieving digital transformation to Industries 4.0.

The Smart connected factory eco-system requires a communication system which meets strict requirements and has to deliver as per stricter service level agreements. Support is required in the following:

- Wireless communication has to integrate automatic guided vehicles and robots into manufacturing process. This needs very high reliability communication.
- Smart factory will have both wired and wireless network which should provide the same experience to the user.

## 5.2 5G—Industries 4.0 Technology Enabler

The use cases need ultra-low latency, very high reliability and very high data rates cannot be supported by the existing communications technologies and need a new technology. This is where 5G come into picture.

5G will have a “massive impact” on industry and mobility, its usage will go beyond the application of consumer mobile broadband. 5G will allow manufacturers to automate end-to-end operations and setup or take down new product lines or entire factories virtually. With billions of sensors, machine-controlled robots and autonomous logistics, all capable of communicating and operating remotely in real-time via 5G, manufacturers can achieve massive productivity gains. 5G will be the platform enabling growth and transformation in many industries, directly contributing to social and economic development [3].

Ultra-low latency, combined with MTC and Intelligent analytics, will make it easier for people and robots to work collaboratively. It will also enable control of machines in real time. This means the workforce can move more freely, away from heavy machinery which helps to increase safety. And with massive connectivity, all the machines can interact with each other, providing continuous updates to back-office systems.

With massive Machine Type Communications (MTC), real -time control of machines, robot/human interactions and edge cloud analytics, 5G will be key to supporting the wireless connectivity needed to power these new “Smart Factories”.

IoT technology, cloud solutions, big data crunchers, and cyber security components are key ingredients for this digitalization. 5G technologies can play a key enabling role in integrating these technologies and offering a unifying platform to interconnect machines, robots, processes, auto guided vehicles, goods, remote workers, etc. By integrating these technologies in a manageable way and extracting data for taking actions, efficiency and flexibility of the system are enhanced.

5G technologies will be the key in supporting all communication scenarios, and offers mobility-features and seamless service experience. This role of 5G technologies very well corresponds with the 5G objective to integrate networking, computing and storage resources into one programmable and unified infrastructure. This unification will allow for an optimized and more dynamic usage of all distributed resources, and the convergence of fixed, mobile and broadcast services.

The envisioned 5G platform will need to link wireless access with wired industrial ethernet and will include also components like edge computing, cloud, local gateways, big data and analytics, IoT management, etc. Furthermore, the boundary between wide-, local- and personal-area networks is getting more blurred, calling for a seamless interaction between those domains [3].

## 6 Industries 4.0 Use Cases enabled by 5G

Automation is the key for Industries 4.0 and can be classified under: [11].

- Factory Automation which is the automation of operations in the production of goods which can be vehicles, home appliances, electronics products etc.
- Process control automation in which the processes are automatically controlled based on continuous data acquisition and analysis. Process industries include oil refineries, power plants, paper mills etc.

There could be many use cases in the Industries 4.0 based on above automation scenarios. These Use cases will have their own specific requirements in terms of data rates, latency, reliability, number of connections supported, field coverage etc.

Some of the typical Use cases are listed below: [12].

- Cell Automation—Devices in a assembly line communicates with the control system. Here the requirements if for very low latency of at least less than 1 mS and extremely high reliability.

- Automated Guided Vehicles to move around in the factory carrying products to different stages as programmed. This requires mobility and very high reliability.
- Process Automation—High number of sensors and actuators are connected to the control units. This requires very high reliability.
- Logistics transportation tracking of goods throughout the supply chain i.e. from raw material to shipped goods. Should be able to track at least 100,000 devices per Sq Km and should have global coverage.
- Components tracking. Should be able to track at least a Million static devices per Sq Km.
- Remote assistance provided through two-way augmented reality requires very high reliability.
- Augmented reality—Requires very high data rate of 10 Gbps.
- Remote Robot control requires Very high reliability.

From the above, we see that each of the use cases has specific requirements in terms of latency, data rates, reliability and density of connections, coverage area etc.

## 6.1 Use Cases Types can also be Classified Based on the Following Parameters, to Realize Connected Factory

### *6.1.1 Time Critical and Reliable Processes in the Factory*

Industries 4.0 needs efficient production lines with real-time monitoring of the performance and quality of finished goods. The sensors and actuators in the production process would need ultra-low latency and very high reliability. Also, the vision controlled robots in the assembly line would need time critical and reliable high bandwidth communication. Here, the involved machines and robots are part of closed, time critical control loops, 5G is the answer for this.

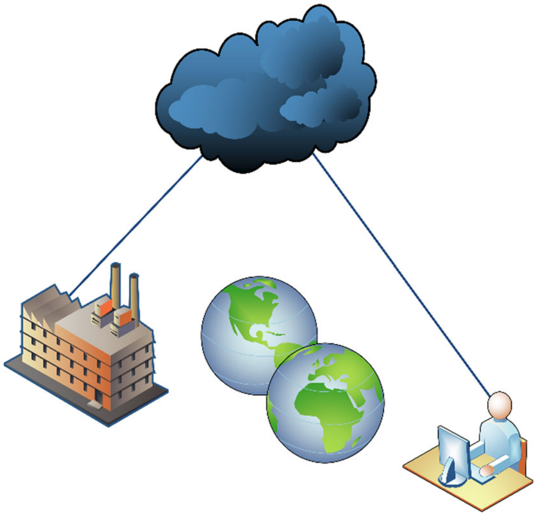
### *6.1.2 Non-Time Critical Communication in the Factory*

There are several cases in which time is not critical like logistic process involving assets and goods, quality control process or data acquisition wherein the data is used for later purposes. Also, communication amongst factory personnel and packaging and shipping of goods etc. would not require critical timing as compared to machine level response times. However, high availability would be required for coverage in harsh environments, indoor locations. 5G would be best suited for this.

### *6.1.3 Remote Control of Factory*

The earlier use cases used local on-site communication. Here, we look at outside factory communication between remote workers and the factory, as shown in Fig. 1. Remote workers could control the operations inside the factory through smartphones or a Remote Factory Operation Centre which provides Virtual back office control through augmented reality devices. Augmented reality support ensures precise remote-control assembly and also facilitates machine repair remotely. Here, the requirement is for high availability and high bandwidth network with low latency and high security. 5G fits in perfectly.

**Fig. 1** Remote control of factory



## 6.2 Connected Factories

An organisation might have many factories in multiple locations in their city or globally. Ex Cisco, Apple etc. Their raw material suppliers and vendors could be anywhere across the world. They may be conceptualizing the product in some location, designing in another and producing it in a different location across the globe and selling in different countries. Communication networks should ensure connectivity amongst all these locations for seamless real-time operations, as shown in Fig. 2. This should allow monitoring of

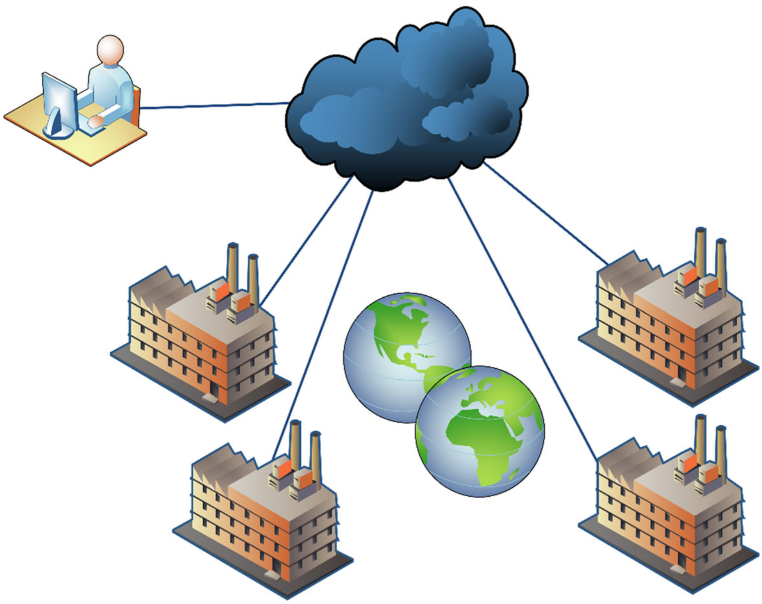


**Fig. 2** Globally connected factories

distributed assets. The key communication requirements include high level of network and service availability and reliability.

5G technologies will be needed to address the above scenario.

### 6.3 Connected Goods

There would be a shift from selling only produced goods towards selling value added services associated with the smart goods i.e. connected goods [3]. These services will be of important for the manufacturing industry. Here, instead of selling the product, the trend is to sell product hours. This will be "Product as a Service". This requires acquiring and analysing product lifecycle data extensively. This will give rise to data driven eco system.

Cost-effective communication schemes are needed to accelerate these data collection scenarios.

## 7 Socio-Economic Impact of 5G on Industries 4.0

According to ABI Research [13], the Industrial manufacturing applications will generate more than $138 million from mobile and satellite connectivity fees and Industrial IoT Connections will surge to 66 million global connections in 2017. Digitization of industrial processes has become possible due to the decreasing costs of data storage and compute processing. The largest growth of IIOT connections is happening at Asia Pacific region. The global connection is forecasted to grow by 18 million new IIoT connections annually by 2021. 25% of these connections will be wireless in 2017. This will significantly grow over the next few years.

According to MGI report [7, 14], 75 million to 375 million workers amounting to 3–14% of global workforce will be impacted by 2030, due to automation and will have to switch their occupation. Also, there would be 50 million new technology jobs by 2030 which are required for development and deployment of technology.

## 8 Conclusions

Industry cannot depend on today's 3G/4G wireless systems for providing the target immersive experience like reliability, short delay, device energy efficiency etc. which are required for Industries 4.0 vision. 5G is essential for the implementation of IoT and M2M, which forms the backbone of Industries 4.0 and hence becomes enabler to the vision of Industries 4.0. 5G will connect wireless networks to billions of devices to machines, manufacturing systems, logistics systems etc. Thereby, 5G will enhance the "Internet of Things" and allow Industries 4.0 to develop.

5G will bring in flexibility in Industrial operations with its faster reliable communications between machinery, sensors and computing systems resulting in real-time flexible automated production processes. This would result in overall productivity improvement. Wireless connectivity makes it easier to reconfigure the machines in factory floor to meet changing demands. Operation cost is reduced due to lower wired fixed systems by bringing in wireless operations.

Overall efficiency and productivity is enhanced with automated information and knowledge sharing throughout the production life cycle enabled by the ultra-low latency and high reliability offered by 5G. Maintenance and repairs can also be benefitted by enabling virtual/augmented reality communication between field personnel and factory/product specialists. With 5G, we can have critical servers on the cloud, so that maintenance and upgradation is done seamlessly without having to be in the factory premises. This can enhance safety of personnel.

Factory of the future—'Industry 4.0'—will be enabled by 5G. This will allow manufacturers to automate end-to-end operations and setup or take down new product lines or entire factories virtually. To leverage the complete potential offered by 5G in the Industrial sector, it is required that the experts in each sector collaborate effectively and this is the key in bringing new possibilities to the market. Cross-industry collaboration is essential to define the overall 5G architecture that incorporates the requirements of the wider ecosystem.

IoT and Cyber Physical Systems largely depend on mobile internet from a communications perspective. Telecommunication networks have not played a major role so far in industrial automation. Now, it provides a very good opportunity for Telecom Operators to address this new market- Industrial automation. 5G will be the platform enabling growth and transformation in many industries, directly contributing to social and economic development.

5G could enable new opportunities in Industries by creating employment due to its own network infrastructure implementation and also as a result of the new applications being enabled by it. Also, we can expect job losses in the conventional businesses due to the automation. Example—Robots replacing manual labour, etc. There will be more demand for high technology jobs. Workers will need to adapt to the new industrial environment as they have to work alongside of capable machines. This will require re-skilling. There would be demand for highly qualified automation personnel, whereas middle level and low-level jobs would take a hit. Jobs involving routine, repeatable work like production, office support etc. would decrease. i.e. job functions which are capable of being automated, would be reduced. Jobs involving knowledge like implementing automation, technical roles, research and innovation areas would increase.

Businesses will be able to make more products with less manpower. However, more people would have become poorer due to job losses and would not be able to afford to buy products. This could lead to a situation leading to excess supply and no demand. This will totally change socio-economic political scenario all over the world.

This could increase the divide between rich and poor countries. Currently, rich and developed countries subcontracted high volume manufacturing jobs to developing and poorer countries to take advantage of cost arbitration in low wage countries. However, this provided large employment to such countries having large population. Now, with Industries 4.0, the advanced countries could fully utilize the benefits of Industries 4.0 by implementing them faster and in a larger way to produce mass quality goods with less labour and be able to flood the global market with cheaper goods. As they can automate manufacturing, the need to subcontract to low-cost countries may reduce. Developing and poor countries who have abundant of manual labour will become victims of Industries 4.0 and will have large scale unemployment leading to social unrest there. The rich countries who can afford 5G enabled Industries 4.0, can greatly benefit with new opportunities.

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