Introduction to Industry 4.0 and Industrial Internet of Things

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Lecture - 06
Industry 4.0: The Fourth Revolution

In this lecture, and in the subsequent modules, we are going to go through an understanding of what is this industry 4.0 and what are the different changes in the revolution that is happening in order to transform the industries towards Industry 4.0. So, Industry 4.0 basically corresponds to the fourth revolution in the industries.

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Revolution, as you know, that English meaning of this term is basically some kind of shift, some abrupt change that is required in order to transform the way things have been happening. An abrupt change in the way things are being done, so that is the revolution. If you look at revolutions in the past earlier, if we go back more than 10,000 years ago, our predecessors used to collect food through foraging techniques. So, basically wandering around collecting food, bringing them, eating the food through the collected food materials like fruits, vegetables, etc whatever they used to find.

Further, foraging behavior was transformed to farming. Different crops were grown, different vegetable plants, different fruits, food plantations were started. The result of this transformation from foraging to farming was increased production, and increased

communication between different humans. There was growth of food production as the population growth increased. We are talking about this more than 10,000 years back.

Then came the industrial revolution where new technologies, new machines were produced, new approaches to the production processes were introduced. This shifted the economy from the primitive economy with simple agrarian-centric economies to more aggressive machine-oriented production systems. So, that was the industrial revolution.

Consequently, the economic models changed, the social architecture, everything changed with the revolution in the industries, with the introduction of new technologies, and new approaches.

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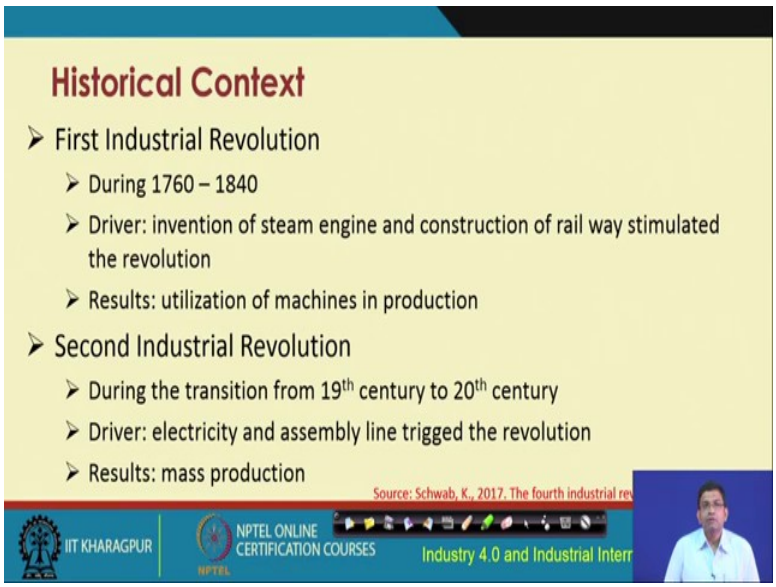

The industrial revolution again went through different stages. Back in 1760s to 1840s, it was the first industrial revolution. And this first industrial revolution was started with the invention of steam engine, introduction of trains, mobility increased, construction of railways stimulated the overall revolution. So, this resulted in the utilization of machines in production, during the first industrial revolution in the 1760s to 1840s.

Then came the second industrial revolution, which was during the transition from the 19th century to the 20th century, with the advent of electricity and increase of electricity in the society. This resulted in mass production, machineries could use electricity for large scale and faster production.

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Then came the third industrial revolution that was in the 1960s and so on. It was around that time that computers were starting to get popular. So, gradually with the increase of computers, different computers, and computing devices, peripherals, etc, the transformation in the industries also happened. There was increased use of digital technologies in the industry. The use of computers in digitization and so on was another revolution--the third industrial revolution, which again increased the production of goods and commodities in the industry.

The production was due to the increase in semiconductors and semiconducting devices, which was almost in parallel with the growth of computers. The result was increase in computing technologies such as mainframe computers, and personal computers. And eventually the connectivity between these different computers, internet, world wide web gradually started, and these basically were introduced in the industries to improve the efficiency of the machinery, processes in the industries, manufacturing processes and other processes in the industries. So, that was the third industrial revolution, which was basically the introduction of computers and information technology in the different machinery and manufacturing processes in the industry.

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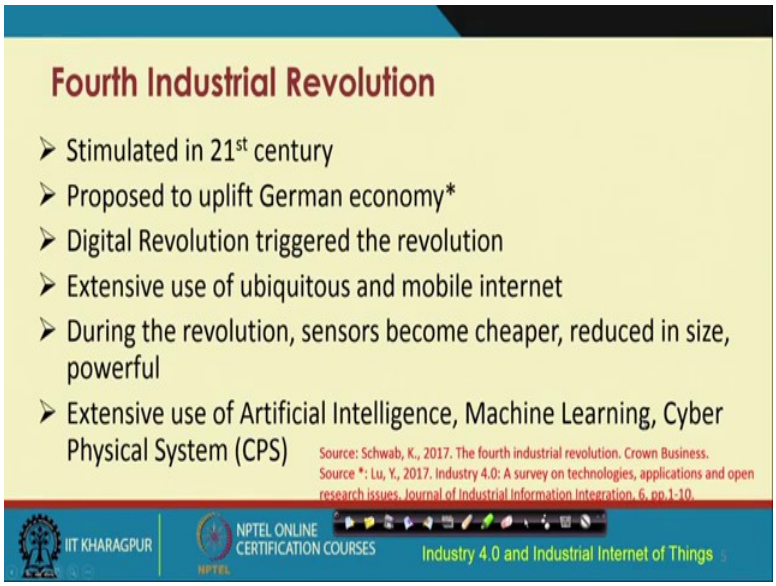

The fourth industrial revolution or this industry 4.0 is something, which has the origin in the German economy. So, it was required in the early 21st century to uplift the German economy. The individual industries having individual IT infrastructure everything was through the third industrial revolution. But how could we improve the production even faster and make the processes even more efficient.

So, people thought about how things could be done. There were different sensors and sensing technologies, which were becoming very popular. With the introduction of sensors, actuators, along with the regular infrastructure, the IT infrastructure, the internet together basically was able to transform the existing IT-based infrastructure in the companies to more efficient ones to connected, sensed machinery and so on, so that was the fourth industrial revolution. And this is fourth industrial revolution or the Industry 4.0 that we are going through at this moment.

So, this industry 4.0 or fourth industrial revolution started. The sensors and actuators are very small in size, cheap, and powerful. So, small sized, sensors, actuators, much more powerful internet and IT infrastructure together, and autonomous monitoring, use of technologies such as artificial intelligence, machine learning, cyber physical systems, use of all of these together is basically how this transformation is happening in Industry 4.0.

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Computers have become more sophisticated. They are smaller in size, but much more powerful, less energy consuming. These computers can be integrated and connected together. This has resulted in the radical transformation of the global economies, the societies, and the different industries. So, the fourth industrial revolution, this term was coined as the second machine age by Prof. Erik from MIT and Andrew McAfee from the same institute.

So, Industry 4.0, which is the synonym of industrial fourth industrial revolution; the term Industry 4.0 was coined in the Hannover fair in Germany in 2011. So, only a few years back, in 2011, the whole thing started. Now in the industries, through this kind of transformation, with the help of sensors, actuators, computers, IT infrastructure, much more efficient one, smaller in size, cheaper, and everything connected together, this fourth industrial revolution started.

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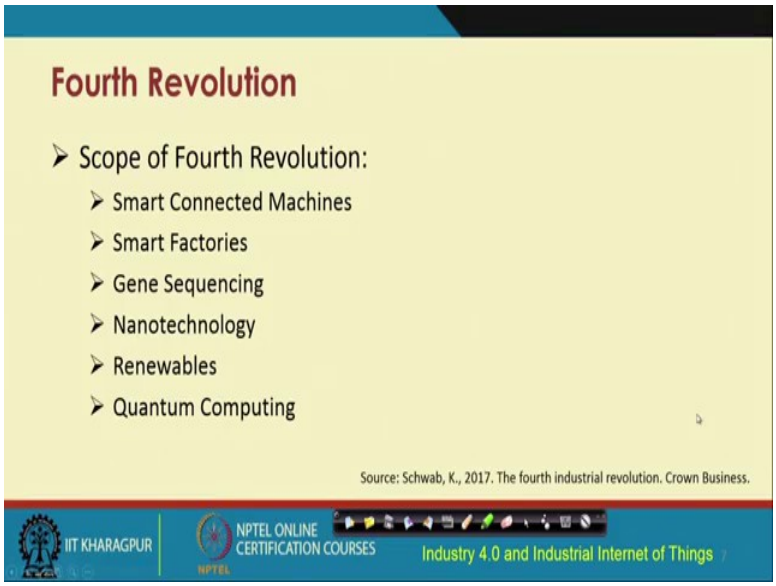

So, what is the scope of the fourth industrial revolution? Smart connected machines. Internet work, communication, connecting different standalone machinery, typically which used to be all IT driven, computer driven; and smart means we are using different for smartness, we need autonomous behavior things, which can be detected, corrected and taken forward in an autonomous manner that is basically the smartness. The introduction of small, cheap, energy-efficient sensors, and actuators have made it possible to make machines and connected machines smarter.

The smart factories are basically similar kind of concept extended beyond simple machinery, but having the entire factory operations, machinery in the factory, all of which made smarter with the introduction of connected sensors, connected machines and so on in the industries and so on.

Then came technologies such as nanotechnology, renewable energy, quantum computing, biotechnological interventions innovations like gene sequencing and so on. Everything together has helped in the overall growth. IT, sensing technology, sensor networks; then we have the biotechnology - gene sequencing, DNA sequencing, and so on; nanotechnology and quantum computing, everything packaged together is helping in the transformation to the fourth industrial age which is Industry 4.0.

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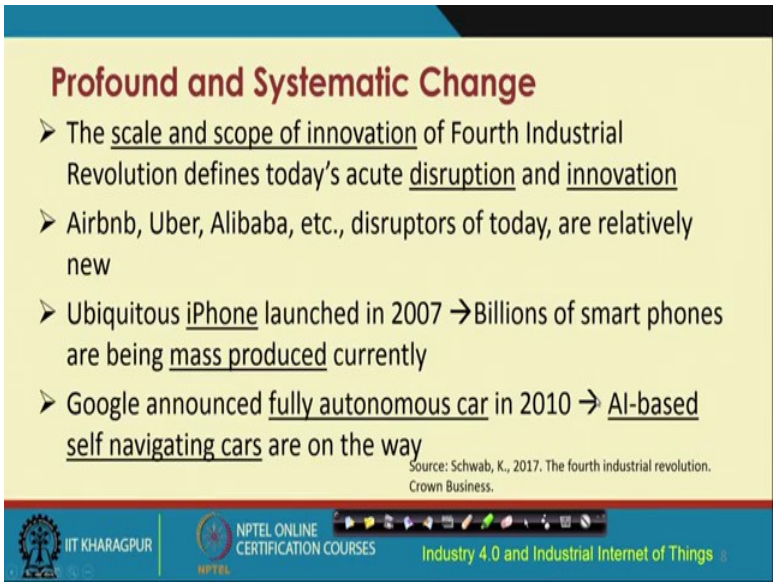

There has been some profound and systematic change in the fourth industrial revolution. This change has been in innovation disruption; disruptive technologies have been introduced. And this disruption and innovation has happened in both the scale and scope. The scope has increased manifolds, and has increased.

The scale and scope of innovation of fourth industrial revolution has basically defined today's acute disruption and innovation in technologies and the transformation of industries accordingly. Companies like Alibaba, companies like Uber, Airbnb, Amazon and Flipkart in India, so all of these companies are essentially transforming the way the operations, delivery, have been carried on in the past. Everything has changed the way things are happening at present.

These are using different state of the art technologies such as cloud, sensor networks, technologies such as drones, networked drones and many different other technologies are being used in order to transform the industries and their operations. So, these are newer ways in which these companies are working.

For example, iPhone was launched in 2007, but since then only within few years, billions of smartphones are being mass produced at present. So, you see that how this disruption and penetration of these technologies are happening and how fast they are happening and in what scale they are happening right. So, these are all like different phenomena that are

happening in terms of change, systematic and profound change, that are happening in this fourth industrial age.

Take the company Google we all know how Google is transforming the world at present. In 2010, as many of us know just still few years back, Google basically announced the fully autonomous car. And already we have seen that self navigating cars, fully autonomous cars are already in the roads. But what is very important also is the increase in the use of technologies such as artificial intelligence and machine learning, that is making these kind of newer technologies, a reality.

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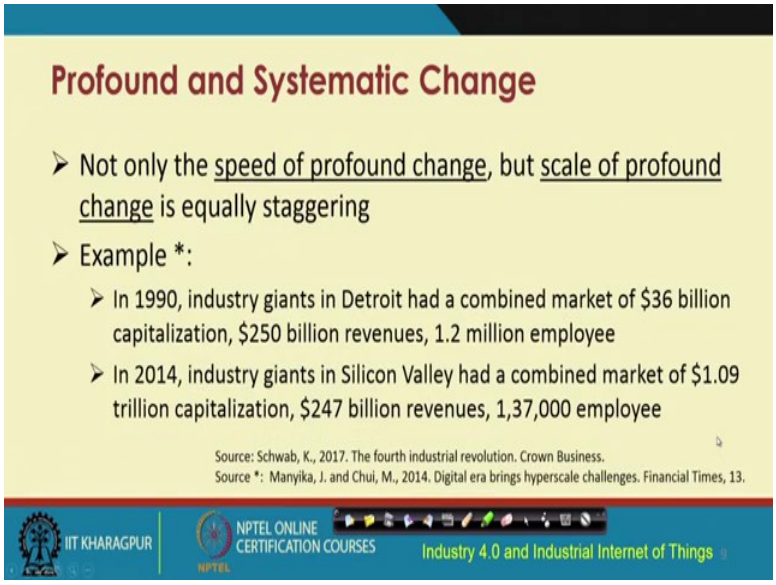

So, not only the speed of change, but also the scale of change, the profound change, both are very equally important and are increasing in rapid pace. So, like going back to the 1990s, there were different industry giants in the Detroit area, in US, which had a combined market value of 36 billion dollars, in terms of capitals. Their overall revenues were in the order of about 250 billion US dollars and the number of employees working in that area was about 1.2 million.

In 2014, if you look at in the Silicon Valley, the different industry giants together had a combined market of about 1.09 trillion dollars. So, the capital has increased manifold. On the other hand, if you look and compare with these industry giants in the Detroit area in 1990s, in the Silicon Valley area, the number of employees was only 1,37,000. There

is a drastic reduction in the number of manpower that is being used in the industries, 1.2 million employees to 1.37 lakhs employees being used.

On the other hand, capitalization has increased manifold. With the reduced number of workforce, we are able to increase the number of the value of capitalization and growth of the industries. Consequently, the revenue that is obtained from the different sales has also increased.

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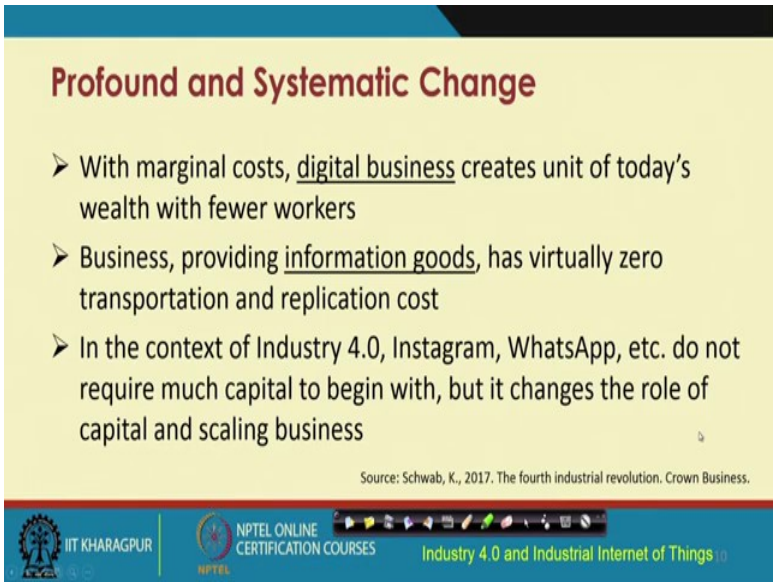

With marginal costs, the digital business creates unit of today's wealth with fewer workers. We are able to increase the wealth, but with the use of fewer workers and that has been possible with the introduction of digitization.

Business provides information goods, which has virtually zero transportation and replication cost. Consider companies such as Instagram, WhatsApp, Facebook, Twitter. They are able to supply information-centric products, and goods. There is almost like zero transportation cost involved and that is unlike the manufacturing industries which have lot of capital goods, lot of transportation costs are involved, shipping from one location to another, and logistics. The transformation to the introduction of digitalization and advanced IT and different other technologies is making the scaling up a possibility in this Industry 4.0 revolution.

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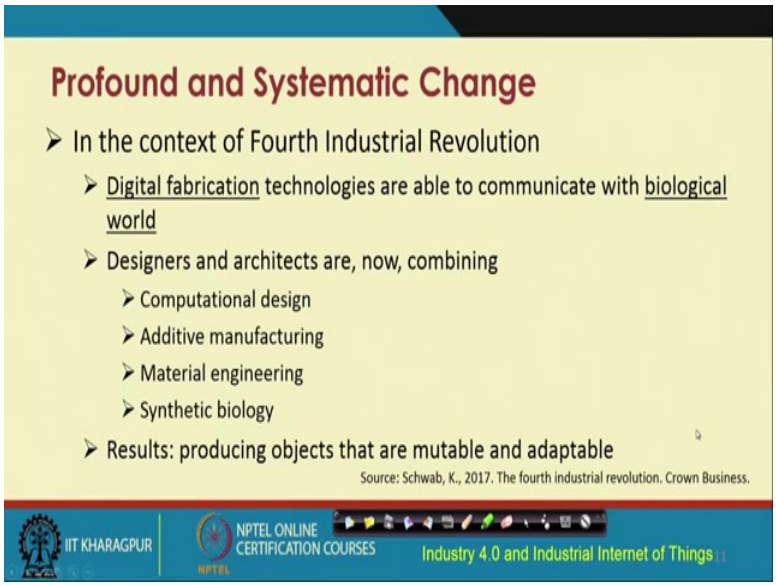

In this context of Industry 4.0, digital fabrication technologies are able to communicate with biological world. Now, it is possible that through the advancement in technology, it is possible that we can have different sensors inside the physiological systems.

These sensors and different other advanced technologies are able to communicate with the outside world that means outside the human beings. This is now possible that remotely signals are send to the human body to perform certain physiological operations within a human, without basically having the human go through or rather the human being or the patient being able to know what is actually happening. These things are possible with the introduction of all these new technologies. Consequently, transformation has been possible in this fourth industrial revolution, transformation of the biological systems, and physiological systems.

Now, it is also possible to manipulate the way biomolecules within a human body operate. It is possible to sequence the different genes in the body. It is also possible to manipulate the DNA within a body. These things are possible due to profound change with the introduction of all these different technologies, IT, biotechnology, nanotechnology, and quantum technology.

So, designers and architects are, now, combining, computational design, additive manufacturing, material engineering, synthetic biology and so on. Consequently, they are able to increase the number of production of the number of objects. These different

technologies will be used in order to increase the production of number of objects and these objects are also being produced, because of the use of these different types of technologies. It is now easy to mutate these products, and have these products adaptable to different changes in the environments of their operation.

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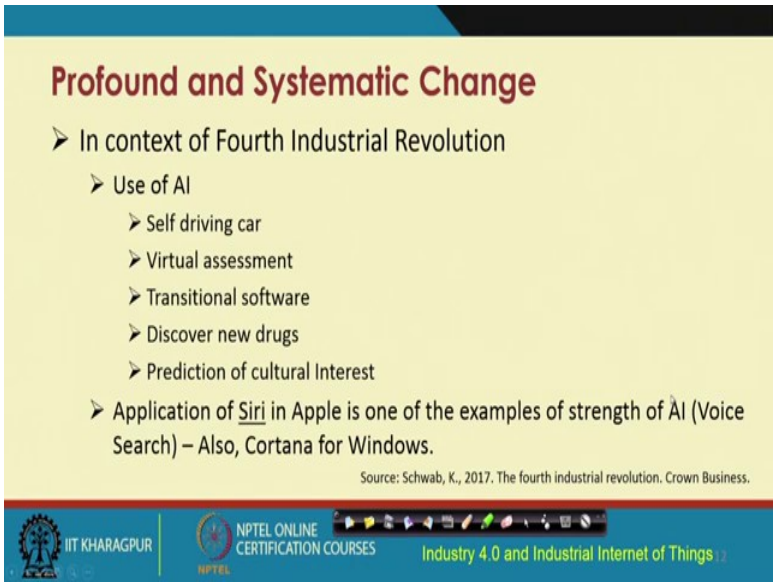

In the context of the fourth industrial revolution, use of AI or artificial intelligence, machine learning, also has made it possible to have self driving cars, virtual assessment, transitional software, discovery of new drugs, and prediction of cultural interest, have been made possible with the use of artificial intelligence.

Everybody knows about the application Siri. Siri basically is nothing, but an application of voice search, it is an Apple product, which basically uses artificial intelligence techniques in order to have and in order to perform voice search. Somebody speaks and this application will automatically recognize the voice and make searching in the internet possible. And it is very similar to the Cortana by Windows. This is basically the voice search with the introduction of use of strength of AI machine learning.

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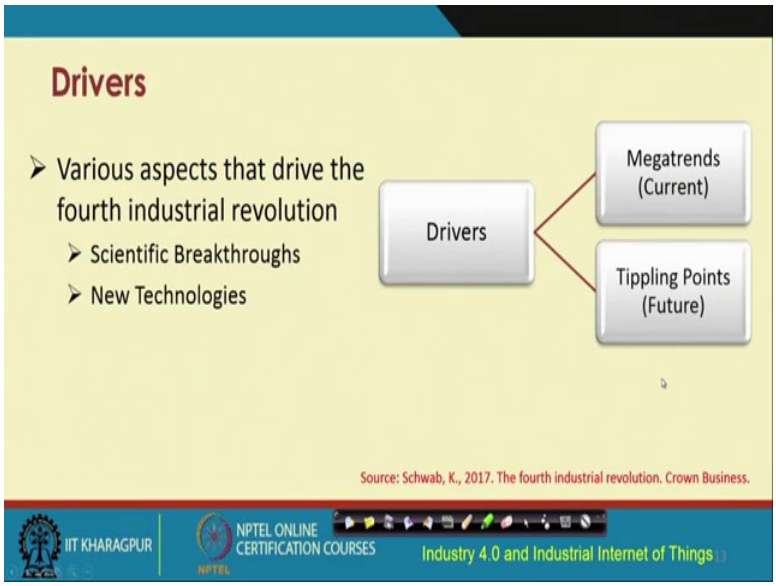

So, there are different drivers. These drivers are basically driving this change. Change in terms of scientific breakthroughs. Introduction of newer technologies, current transformation in terms of changes in the megatrends are happening, future transformation, the tippling points, everything are happening at present with the introduction of all of these technologies.

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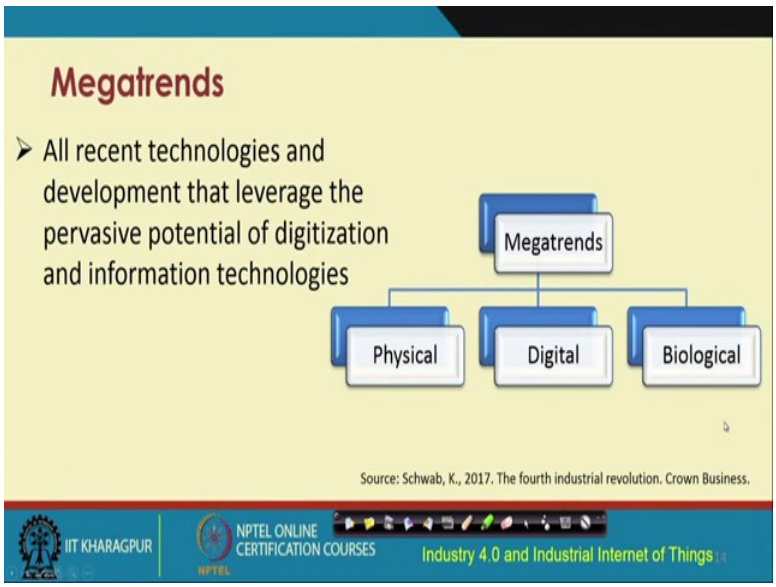

These megatrends are due to the introduction of recent technologies and using or leveraging the pervasive potential of digitization and information technologies. In terms

of physical transformation of machinery, manufacturing machinery, digital transformation, in terms of the introduction of IT, biological transformation through the introduction of biotechnology, biotechnological systems, all of these are newer megatrends are happening at present.

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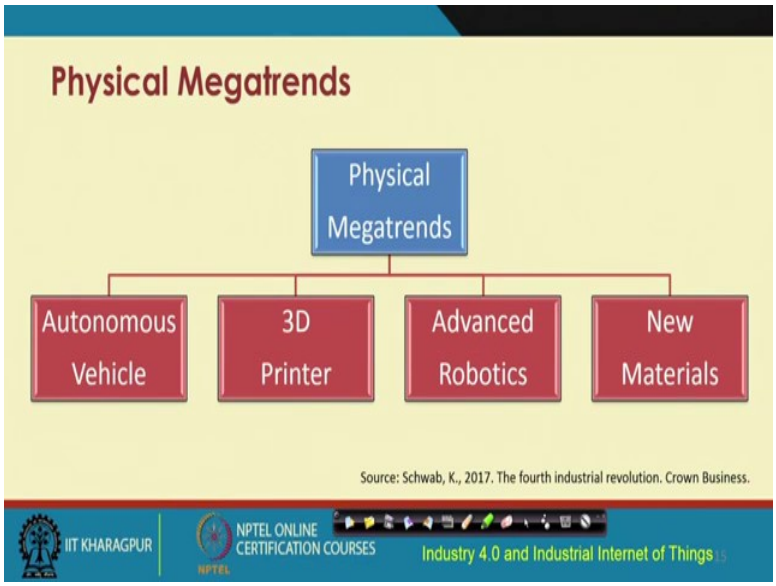

In terms of the physical megatrends, we have now autonomous vehicles, 3D printing, advanced robotics, connected robotics, new materials, lightweight materials, cheaper materials, and stronger materials.

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Autonomous vehicles are already in place. We now have autonomous trucks, autonomous drones. Drones are basically autonomous self-driven, airborne vehicles, where there is typically no pilot or any kind any kind of human pilot or machine pilot. Aircrafts, driver-less aircrafts are a reality now. And also driver-less boats and many other like particularly in agriculture people are now talking about use of driver-less, driver-less tractors right. So, all these are possible with the introduction and use of artificial intelligence and advancement in robotics.

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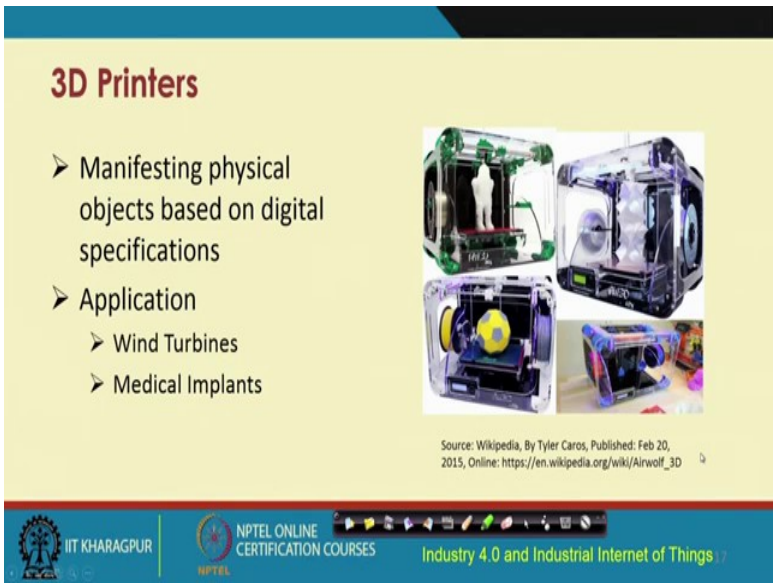

3D printers, basically, give any shape these machines 3D printers. They will manufacture a particular product according to the specified shape. 3D printers have applications in wind turbines and medical implants.

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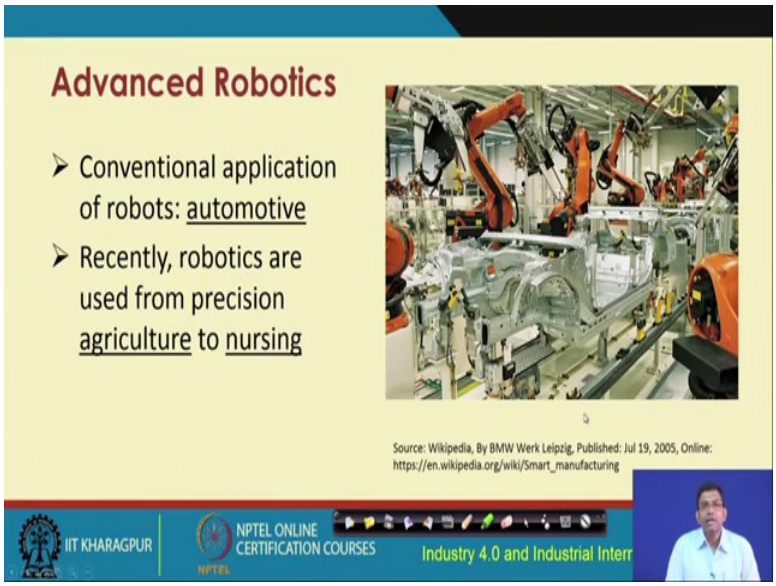

Advanced robotics, different robotics, robotic equipments, connected robotic equipments are being used in the automotive industries. Robots are also used in medical domain for robotic surgery. Robotic surgery is basically something that is happening worldwide. Robots and their use in agriculture robots and their use in nursing. Connected robotics is something that is quite common now in automotive industries in agricultural fields. We ourselves have developed some robots, which will go and plant some seeds in the agricultural field. So, these are all these advancements that are happening in different industrial fronts with the advancement of robotics and connected robots.

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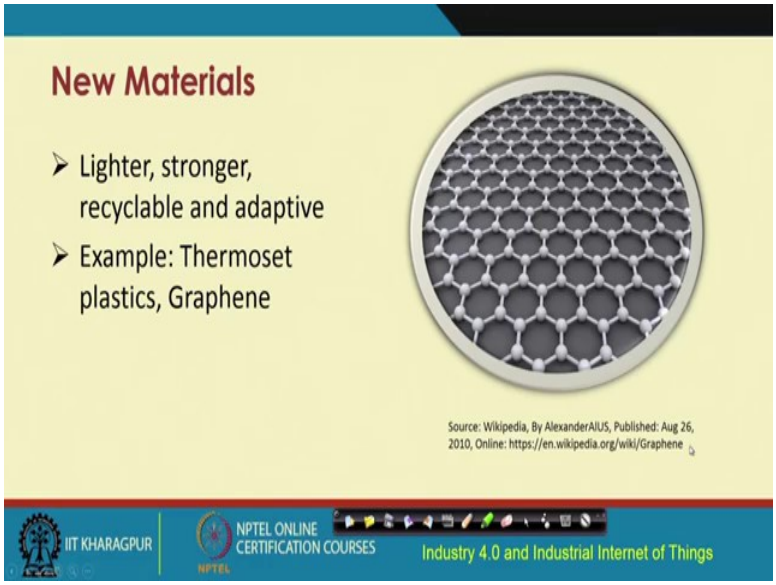

Newer materials, lighter materials, stronger materials, materials that are recyclable, recyclable plastics are basically a reality now. Use of nanotechnology, Graphene, carbon, nanotubes these are also making these materials lighter, stronger, having different advanced properties for being used in different application domains such as aviation industries, for different other manufacturing industries.

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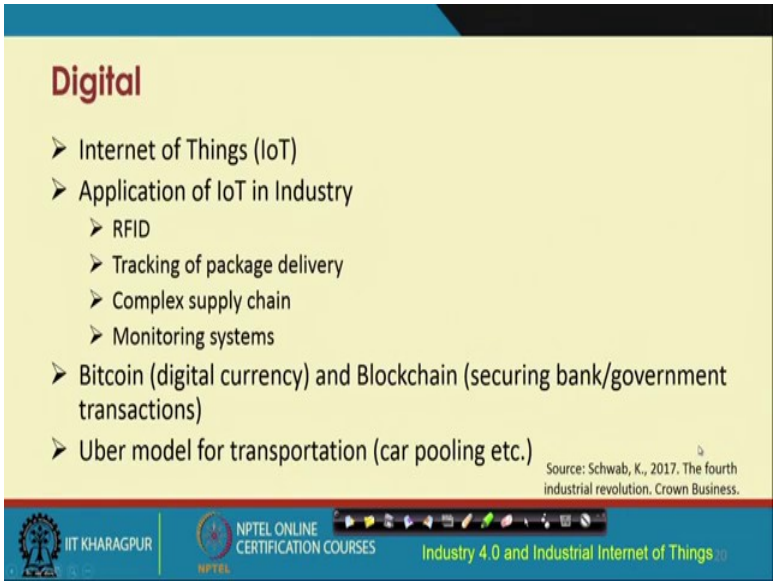

This digital transformation has been happening. The introduction of sensors, connected sensors, connected actuators. These are all about the use of internet of things. Sensors being used RFIDs, NFCs, tracking of package delivery, typically by courier companies this is quite common. Complex supply chain, monitoring systems are all a reality in this fourth industrial revolution.

We have all heard about use of digital currencies. Bitcoin for example is one such, and use of Block chain, for securing bank transactions and government transactions and so on.

Companies such as Uber are transforming the models of transportation. Car pooling has increased the revenues that are earned by these companies. So, the reduction in fuel consumption overall and also consequently reducing the pollution in the environment through the use of car pooling, reduction in fuel consumption, increase in revenue, making everything very smart in the sense that have all of these different cars and vehicles connected to each other. Instantly, which car is where, and what is the

availability status, and protecting the environment from unnecessary pollution all of these things are now possible.

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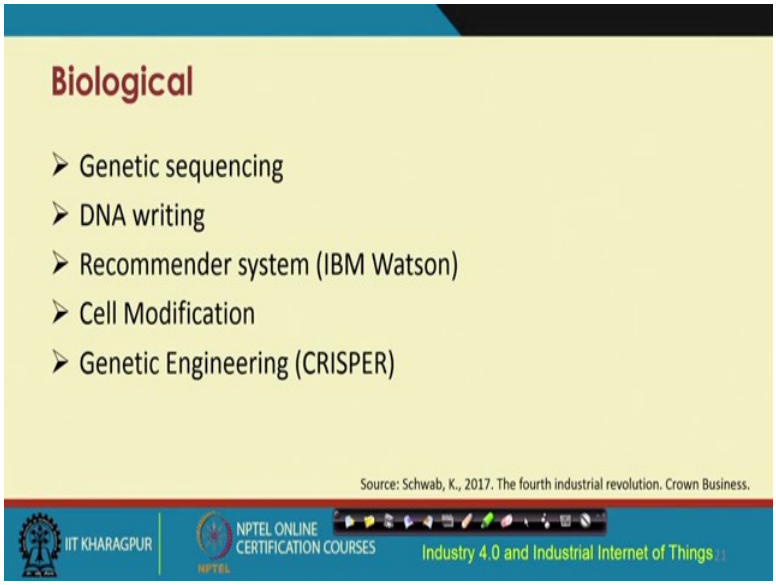

Biological transformations adoption of different technologies such as gene sequencing, DNA writing, recommender systems, so recommender system in the physiological domain is about like if you tell some of the molecular level, composition of a human being then what is the best precise drug that should be administered to that particular human that recommendation can come in through the use of different advanced systems that have been produced now. Cell modification is possible now, and also advanced genetic engineering is a reality.

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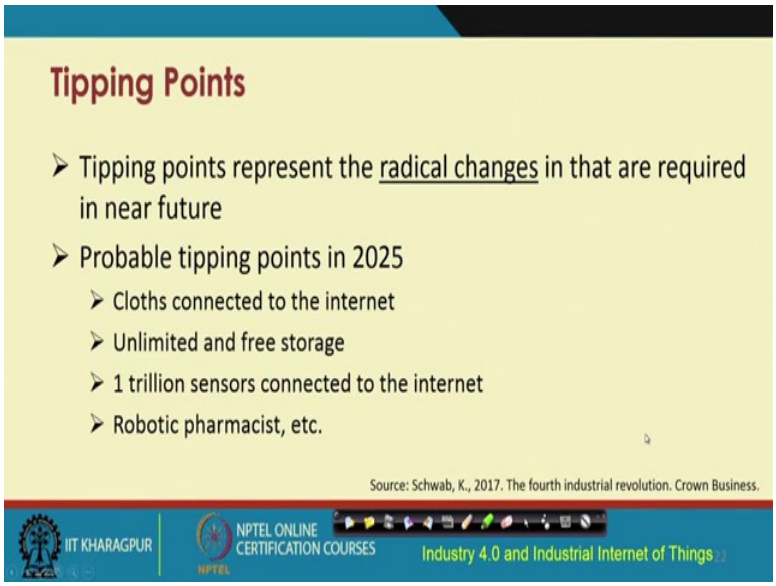

Tipping points or the changes that are coming in the future. So, basically by 2025, it is expected that we will have the different clothing, the different fabrics, connected to the internet. There would be unlimited and free storage available to everyone. There would be trillions of sensors connected to the internet. And we are going to have a world, where there would be some robotic pharmacists, which is going to help in the pharmaceutical industry.

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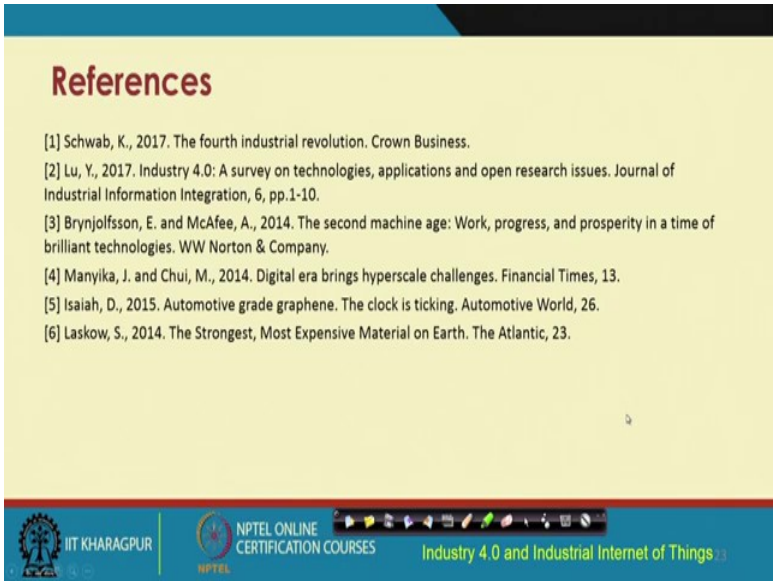

With this we come to an end of the fourth industrial revolution lecture. We have understood, what is this fourth industrial revolution, what were what were the previous three industrial revolutions that we have seen. And in this fourth industrial revolution age, what are the new things that have come in technologies such as self driving cars, technologies such as AI enabled Siri.

Technologies such as connected robots, standalone robots, smart robots being used in different application domains such as agriculture, medical industries, manufacturing industries. Technologies that are going to come in the future and people worldwide are lot of research words that are going on in different labs in the academia and in the industries R & D industries. All of these things we have gone through. And we have also seen how these transformations are happening gradually and what is the benefit of all these transformations that are happening.

So, with this we come to an end, these are some of these references that you might want to go through if you are interested to know further about any of these. There are many more references that would be there if you search in the internet or if you look at relevant books like the ones that are listed over here. With this we come to an end.

Thank you.