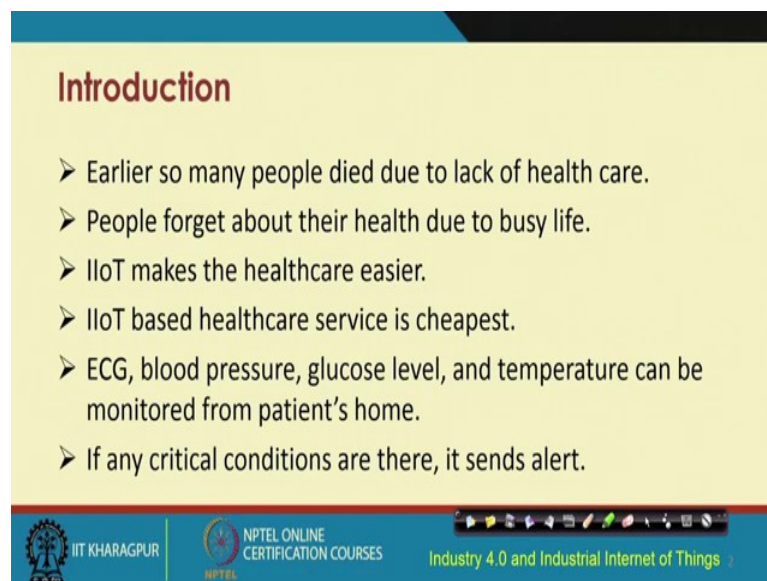**Introduction to Industry 4.0 And Industrial Internet of Things**
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Lecture – 51
IIoT Applications: Healthcare

The next example that I am going to give you of IIoT implementation is from the healthcare industry. IIoT implementation in healthcare is quite pervasive; there are large number of different IIoT implementation solutions in the healthcare industry that exist at present. So, I am going to give you the highlights of how IIoT can help in transforming present day healthcare and making healthcare much more affordable, much more efficient and much more autonomous.

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So, before I do so, let me give you some points of introduction. So, healthcare now a days have improved. Earlier days, people used to die due to lack of healthcare. People used to forget about their health due to busy life and this as also happened in the recent past. People basically tend to forget about their health and taking care of their health due to busy life and so on. Additionally, the number of diseases have also increased in the recent times. So, however, we have our IOT solutions, we have our IIoT solutions that could be used to alleviate some of the problems that are encountered by people with

respect to health. So, IIoT solutions can help in making healthcare easier, affordable and so on.

There are different sensors such as the ECG sensor, blood pressure sensor, glucose monitoring sensor, temperature sensor etc. that are currently available in the market, that can be that are those are cheap affordable and can be procured can be purchased by the patients themselves for monitoring their health conditions at their homes or those could be also purchased by different healthcare facilities hospitals and so on. So, these systems would be further developed, these devices, these different sensors would be internet worth so that if any patient has a critical condition, different levels of alerts would be sent to the healthcare facilities or hospitals to which this patients are registered.
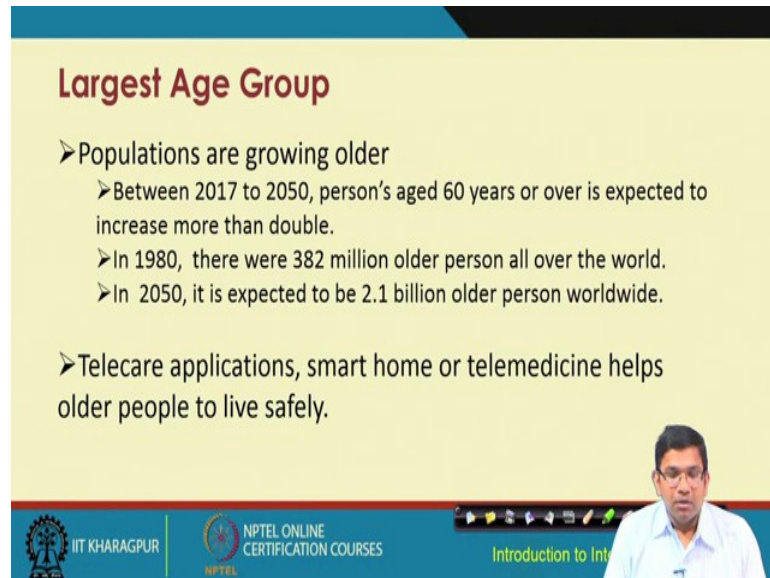
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There are different healthcare challenges with respect to their implementation of IIoT. Populations are ageing all over the world; different diseases are increasing; expenditure of hospitals and medical clinic are also increasing. These are some of the generic healthcare challenges, but from an IIoT perspective as well. Catering to this going requirements is also a challenge; scalability of IIoT solutions will have to be taken into account both in terms of numbers, but not only in terms of numbers, but also in terms of diversity. Catering to different types of diseases; catering to different types of hospitals, different types of medical clinics having different facilities.

So, all of these challenges, the generic healthcare challenges also have implications on the IIoT implementations in the healthcare industry.

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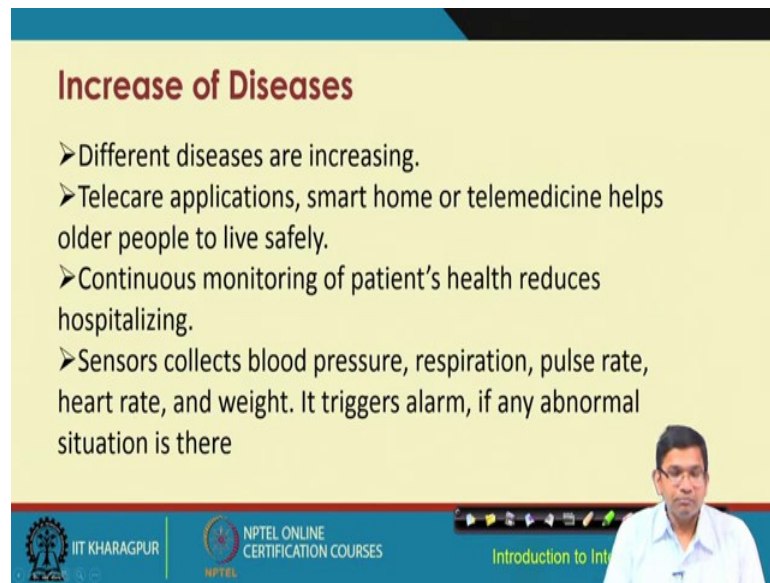Looking at the age groups, populations are growing older, between 2017 to 2050; the persons aged 60 years over are expected to increase more than double. In 1980, there were 382 million elderly persons over the world, in 2050 that number is going to grow to 2.1 billion. So, you see that 1980, it was only 382 million elderly persons all over the world and by 2050, this particular number of elderly persons is expected to grow to 2.1 billion, worldwide. So, this is a huge number. We have a growing population and growing population also will invite taking care of their health. Elderly people monitoring their health condition etc. efficiently will have to be done. So, Telecare applications, smart phone or telemedicine basically can help elderly people to live safely.

So, you can have telemedicine solutions being deployed being implemented in the homes of these elderly persons so that the doctors can remotely monitor the condition of this elderly people from their home. Not only elderly people, I took the example of elderly people, but this also applies for the other population as well; other parts of the population as well.

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Additionally, the number of diseases are also increasing. Not only the number of diseases, but also the types of diseases are also increasing day by day.

So, you need to have suitable efficient large scale monitoring system that will cater to this particular problem and addressing that problem. So, now a days, we are talking about having Telecare applications, smart phone applications, and telemedicine applications for elderly people. We are also taking about these kind of solutions for catering to the other segments of the population. So, that continuous monitoring of patients health can be done and this can also help in reducing the number of cases of hospitalization.

Sensors can collect blood pressure, respiration, pulse rate, heart rate data, weight data continuously and as and when required, if any alarm has to be triggered this can be done this can be done in a much more efficient manner and this can be done if any abnormal solution is detected or any abnormality is going to arise in the future, predictively this can also be done.

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So, reduction in the expenditure is required. IIoT based solutions for health care can help in reducing the expenditure; different wearable healthcare devices can help in reducing the cost of health checkup; remote continuous monitoring of patients using different sensors, smart sensors, connected sensors would be made possible. In hospitals and other health care units smart beds can be deployed which can send notification about the patients activity.

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So, if we are talking about IIoT healthcare solutions, let us look at this particular architectural view point. This has been taken from this particular source that is given at the bottom of the slide. So, basically when you are we are talking about IIoT healthcare, these are broadly the different layers in the architecture. It starts from Sensing at the very bottom; Sending the sensed data; Processing the data; Storing the data and getting different information knowledge etc. about what is going on underneath from the data trying to make more sense out of the data, through information processing, knowledge processing and so on. These are all this things that are possible.

So, let me now elaborate this thing further.

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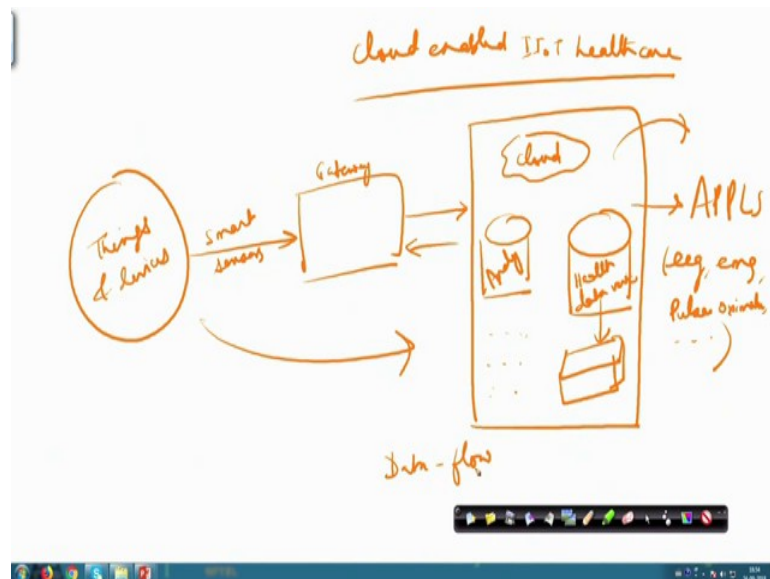
Let us say that we want to have a cloud enabled IIoT healthcare care solution. So, how it is going to look like? Let us look at the dataflow architecture of such a solution. On one end we are going to have all these different things and devices which are going to be typically sensor enabled, i.e. the smart sensors and then, some gateway. So, gateway devices, the data are going to be sent to the cloud platform; IOT enabled cloud platform where different analytics will be performed. Different other analysis for example not just analysis, but may be health data verification can be performed and the data can be stored and the data can in fact, be also processed in a computer or a computational resource in the cloud and so on.

And there is lot of other different things could also be done at the cloud and finally, we are going to have this is two way communication and finally, we are going to have this different applications, healthcare applications which are going to be the beneficiaries from all these analytics on the data that are coming in. So, this different applications are going to run.

So, you know at the application end, different patient data about their health condition such as ECG, EMG, then may be pulse oximeter data and many other different types of healthcare data could be made available after suitable processing suitable analytics and so on through these different applications, different portals, web portals and so on. So, this is going to be the dataflow architecture at very high level for healthcare IOT.

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So, let us look further ahead and see what the benefits of IIoT in healthcare are. With IIoT, one can monitor the patient's health condition remotely. So, remote healthcare is possible. Remote real time continuous monitoring of patients health condition 24x7 is possible. Hospital staff can predict the arrival of a patient in their emergency units; it is also possible to have hygiene monitoring system which can detect the cleanliness of the hospital and the healthcare facility. Medical staff can provide quality medical services with small budget using IIoT. So, these are some of the many benefits that IIoT implementation in healthcare can provide.

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So, nowadays there are different healthcare devices. Wireless ECG monitors are there which can collect bio signals from this ECG devices, ECG sensors; the collected data could be sent to the cloud; medical staffs can analyze the health related data in real time. In fact, you could have some programs which can autonomously which can analyze the data that are coming in and can send alerts. So, one example of a wireless IOT enabled ECG sensor is QardioCore. QardioCore is a device for ECG monitoring; it is a wireless device.
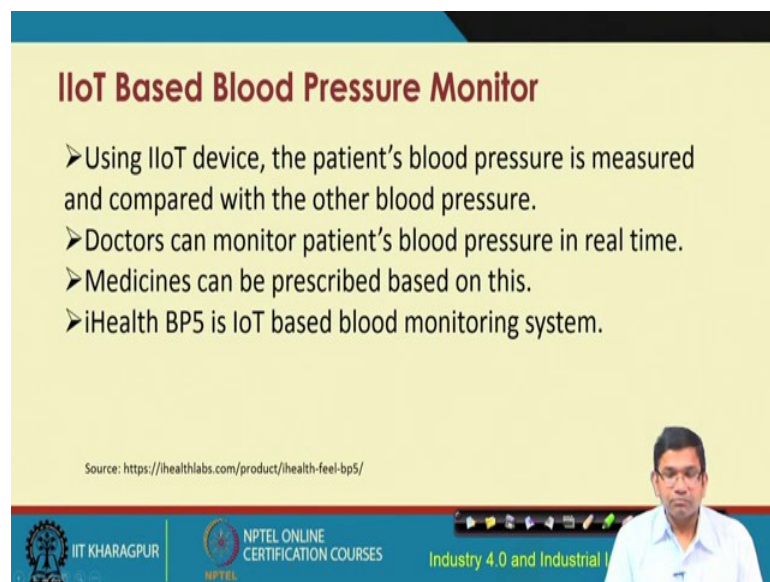
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Similarly, for glucose level monitoring particularly for diabetes patients; diabetes patients typically need to check the glucose level quite often. Particularly, the ones who have higher degrees of diabetes; they have to they are required to check the blood sugar continuously, not continuously but quite often. So, if you have an automated IOT enabled system to which the patients can be fitted, then a automatically the data from this different patients can be made available to whoever can make sense out of the data such as doctors who are treating the diabetes patient and so on and example of continuous glucose monitoring device is the Dexcom. Dexcom devices can help in continuous glucose monitoring.

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Similarly, we have IIoT based blood pressure monitors. Using IIoT devices the patient's blood pressure is measured and compared with the other blood pressures in real time. Doctors can monitor the patient's blood pressure in real time; can get alerts if the blood pressure process a particular threshold and depending on the blood pressure data, the doctors can prescribe medicines to the patients. One such example of blood pressure monitoring system is iHealth BP5.

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Similarly, body temperature monitors, wearable sensors to continuously monitor the human body temperature. This sometimes is very much required particular patients who are suffering from diseases which make the patients vulnerable to sudden increase in the body temperature or sudden decrease in the body temperature. So, there are different body temperature sensors in the market. One such body temperature sensor is by Kinsa. So, they have their smart thermometer which is an IOT based body temperature monitoring device.

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For oxygen saturation monitoring, particularly for asthma patients this is very important, oxygen saturation can be monitored with the help of IOT devices such as Pulse Oxiometer. So, Pulse Oxiometer can help in measuring the oxygen saturation so this Pulse Oxiometer could be integrated with connectivity solutions such as Bluetooth which can send continuously the data of the oxygen saturation level of the patient who is being monitored.

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IOT based contact lenses are also there in the market. There are different IOT based contact lenses which are which also offer Wi-Fi connectivity with smart phones so that the condition of the patient, their eye condition, their sugar level etc. could be also monitored.

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IOT based asthma treatment solutions are already in the market. Smart Inhaler; inhalers are a very essential requirement of asthma patients. So, Smart Inhalers have been manufactured. So, ADAMM is an intelligent asthma monitoring device that has been developed. So, this particular device can keep track of the body temperature, coughing rate, heart rate etc. which are basically preliminary symptoms of an asthma attack.

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Different smart phone based healthcare solutions are already available. So, smart phone devices connected to electronic devices such as sensors can help in collecting the data of

the patients. Smart phone is used to monitor the health of users and detect the diseases. Smart phones healthcare app basically provides low cost healthcare devices which are sort of like diagnostic apps that help in detecting the health condition of patients; can also help in medical communication between the patients and the hospitals and can also offer medical education in the form of tutorials to the patients.
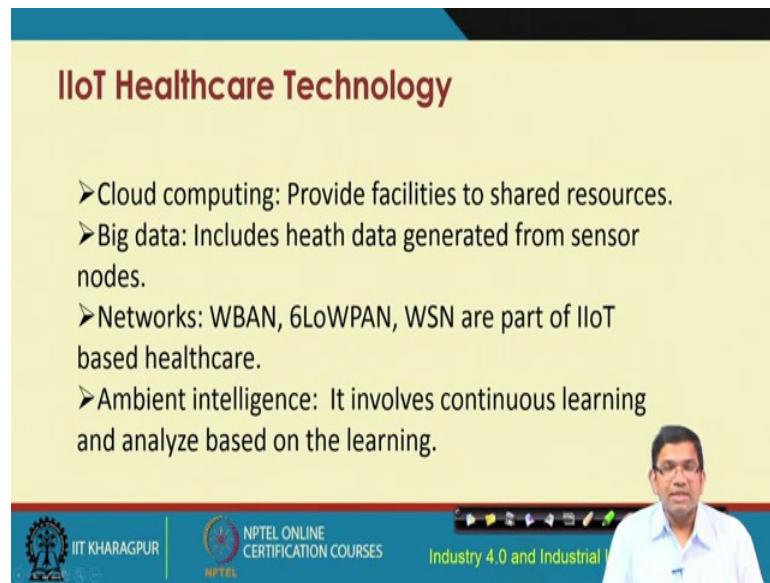
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Health assistant is one such app which keeps track of health condition of the patient. Google Fit is another solution which keeps track of different physical activities of the patient. ECG Self Monitoring is another solution which serves as ECG device, based on the "ECG Self Check" software. Likewise there are different other solutions that I have listed over here and there are many more that I have not listed.

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So, I would encourage you to basically explore the different solutions that are there in terms of healthcare and the IOT implementations in healthcare. Cloud enablement, dealing with big data because most of this data that is generated from these healthcare sensors have the nature of big data. So, cloud enablement big data analytics etc. are very important in healthcare and IOT implementation in healthcare.

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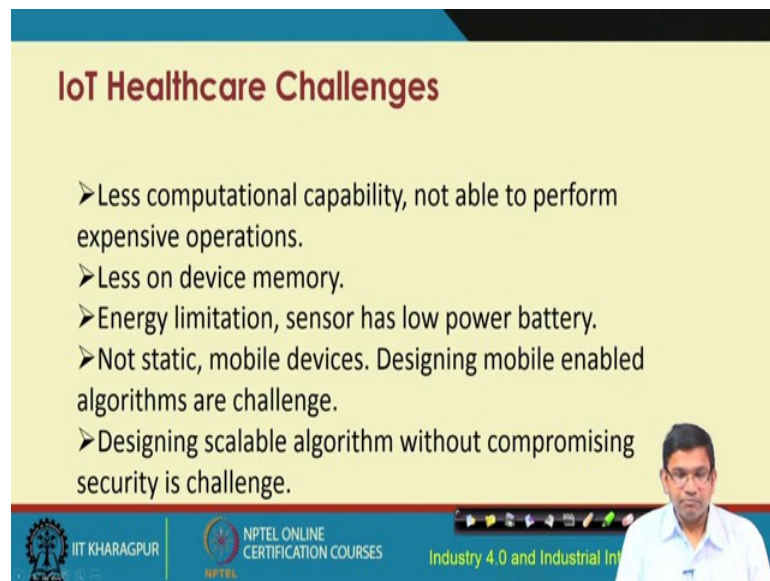So, security is paramount in the healthcare sector. Privacy of the individuals is very important because the data that are being carried forward from one device to another

through a particular communication channel should not be hacked and basically unauthorized users should not be able to get access to the data. So, ensuring the confidentiality of the data, integrity of the data, authentication mechanisms and their implementation and availability of the data are very important in terms of security requirements and their implementations in IIoT healthcare.

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IoT or IIoT healthcare as different challenges; challenges with respect to limited computational capability, not being able to perform expensive operations, challenges with respect to having very less device memory, energy limitation and also taking care of the mobility of these different devices because the patients themselves are mobile.

So, consequently this devices themselves are wearable devices, the sensors themselves are also mobile. So, taken care of mobility of these different devices from a technical point of view is a challenge; both from a communication and algorithmic point of view there are different challenges. So, taken care of all of them are different challenges that basically are important for consideration.

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So, finally, we come to the references. Once again as usual, these are some of the references that you are encouraged to go through. With this, we come to an end of the healthcare implementation or IIoT implementation in the healthcare industry. The different references, we have talked about; different solutions that are there, we have talked about. So, I would encourage you once again to go through these different solutions to get an understanding about how IIoT implementation has been done in the healthcare industry to solve different challenges that plague this particular industry.

Thank you.