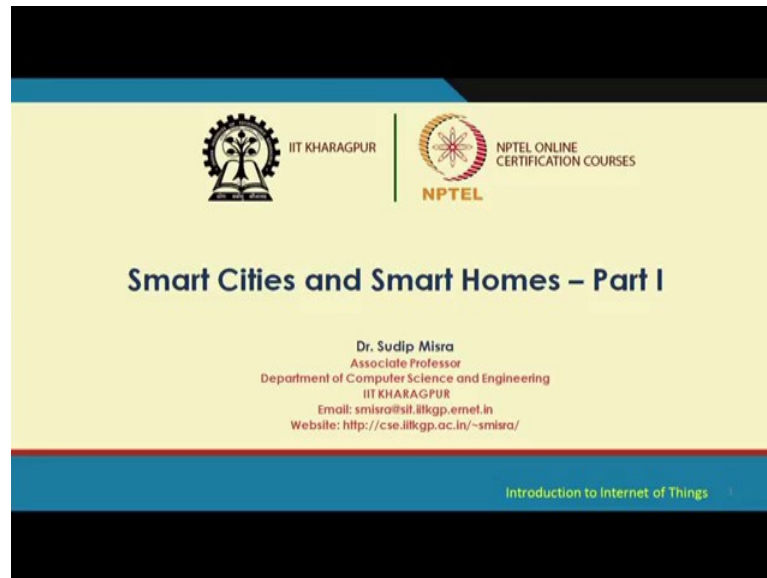**Introduction to Internet of Things**
Prof. Sudip Misra
Department of Computer Science & Engineering
Indian Institute of Technology, Kharagpur

Lecture – 46
Smart Cities and Smart Homes – I

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This lecture is on smart cities and smart homes and here we are going to talk about how IoT can help in building the smart cities and smart homes as you know that throughout the world and even in countries like India, there is a lot of focus on building smart cities. Of course, the scope of smart cities in each of these different countries is different and the scope again depends on the priority areas of each of these countries and their government. Now for instance in India, since the last few years, there have been a couple of cities that have been identified and phase wise these cities have been given funds to build or to transform them as smart cities.

So, when we talked about smart cities; what is it. So, in addition to the regular infrastructure that is there in any city for example, the urban infrastructure consisting of office buildings residential areas hospitals schools transportation police and so on you also need something in addition to make the cities smart. So, what is this in addition let us talk about. So, smart means what smart means that it is in terms of the services that are given to the respective stake holders of these cities. So, citizens are able to do things

in a better manner in an improved manner then usual and how is that made possible that is made possible with the help of nothing, but the ICT technologies information and communication technologies which also includes electronics embedded electronics different other advanced topologies in electrical in a electrical sciences and so on. So, computers electronics put together can make these cities smart.

So, let me just take an example at the outset.

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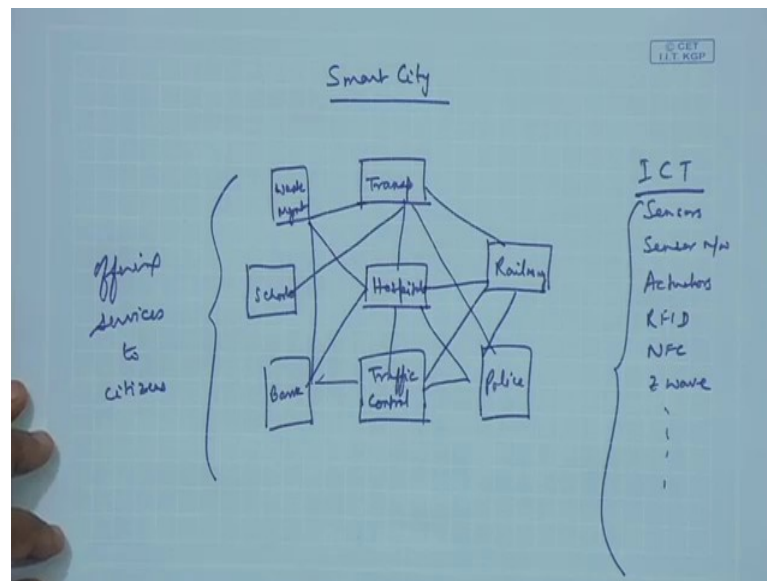
So, first of all let us consider any smart city. So, if we are talking about a smart city we need to have the basic components for example, transport there has to be a railways there has to be hospitals there has to be schools there has to be let us say traffic control traffic control waste management waste management banking then.

So, like this these are some of the different things in a smart city right and one thing I have missed which is very much essential is the police. So, as you can see that we have to transform all of these different components of any city to be smart. So, for which the technology is that we have studied. So, far in the previous lectures will have to be taken help of. So, definitely will have to take help of sensors sensor networks sensor networks then actuators then the different other communication technologies RFID, NFC, ZWAVE and so and so forth. So, many different things that we have covered in all these previous lectures of this course on IoT, so, all these will have to be used in order to make
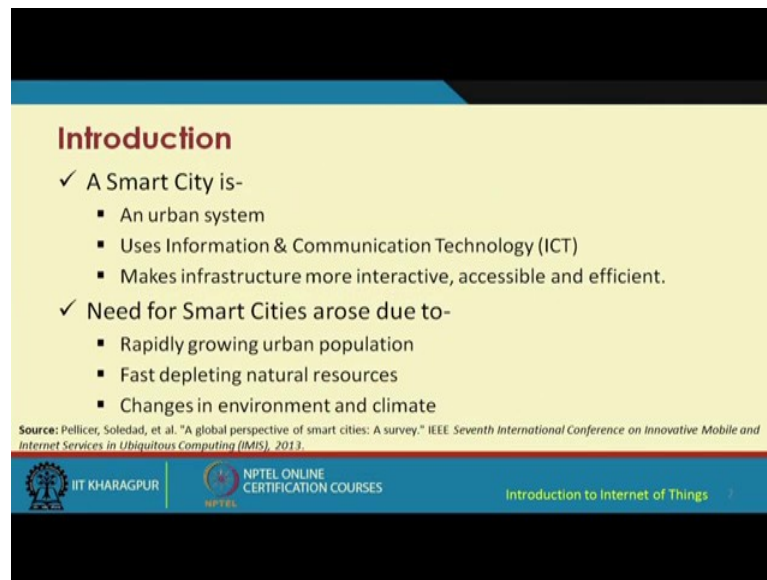
this transformation. So, these are the different ICT information and communication technologies that will have to be used right.

So, what is going to happen is in an IoT environment there has to be lot of these interconnectivities that have to be there? So, for you know although I am drawing these lines almost like randomly, but there has to be you know there has to be connectivity between all these different types different blocks and so on for different good reasons and the reason could be like offering different services to citizens. So, services means that in a smart way people would be able to do different things for example, if it is a health care facility.

So, from very easily you know if something goes wrong let us say let us say with the school child in during the school hours very easily the hospital can be contacted not over telephone any longer I mean of course, the telephone connectivity the traditional ones would be there, but in addition you know there would be smart messaging and so on the ambulances would come there would be continuous monitoring over the ambulance of the child who is being transported to the hospital from the school parents would be automatically informed about the status and so on.

So, many things would be done seamlessly automatically and these are the different services that are going to be offered and normally these services would have to be offered for those or to those who have subscribed for these services only to the subscribers these services would have to be offered. So, whether it is on a paper you know on a on a payment basis or it will be free that depends on the implementation in the smart city, but generally offering different services advance levels of services to different citizens is one of the most important core objectives of the development of smart cities.

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So, let us move ahead and see that what else is there for us. So, as I was telling you before that in a smart city you have an urban system which uses different ICT tools information and communication tools which makes the infrastructure very interactive efficient and accessible in an easier manner then before you know it; it should be you know easily accessible infrastructure and the need for smart cities arose due to different things.

So, first of all the there is an ever growing urban population throughout the world it is not limited to any country, but throughout the world there is an there is a rapidly growing urban population and at the same time the natural resources like coal you know and you know. So, in so many different natural resources that we all use these are depleting at fast rate. So, and at the same time there is change in climate change in environment all throughout.

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So, all these basically necessitate the building of smart cities using advanced ICT tools. So, let us draw some analogy when we talk about a human when we talk about a human humans have the skeleton the skin the organs different types of organs brains nerves sensory organs cognition and so on in the smart city as well in the same way has as a human has a skeleton skin and organs smart cities or rather any city rather any city has buildings industries people transportation logistics hospital police banks schools. So, these are there, but on top of that if there is a human with skeleton skin and organs, but no brains no nerves no sensory organs no cognition. So, you do not have you know life in that human you do not have any life in that human.

So, same analogy can be drawn you know analogously we can say that in a smart city if you do not have embedded intelligence communication networks sensors tags software embedded in these different components and infrastructure of the city the existing cities then it also does not have any life. So, to bring in life to the existing cities having buildings industries transportation police banks etcetera, etcetera you need to embed ICT which includes ubiquity in embedded intelligence digital communication networks sensors actuators tags different software doing different things in a smart way making these different devices to act in a smart way and so on.

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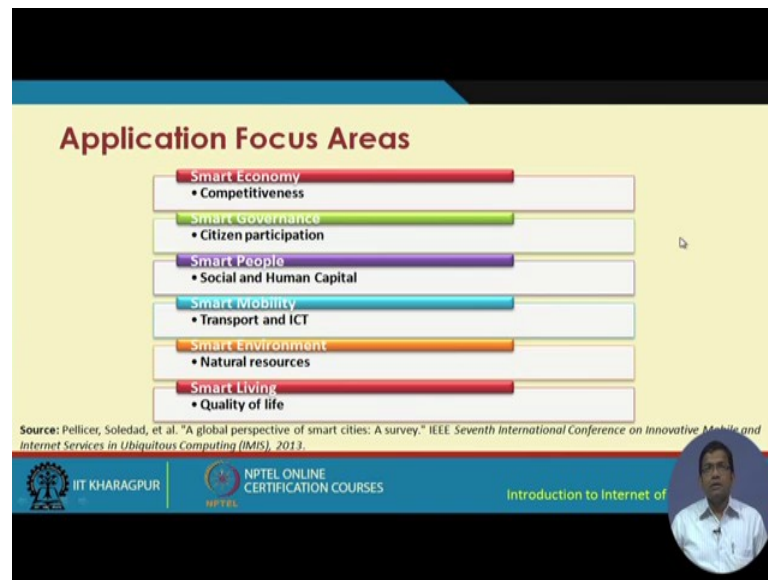
So, these are some of the application focus areas we have smart economy. So, because of the ever increasing competitiveness you need to improve you need to improve your infrastructure the economy to make it smart. So, I will talk about that in more detail shortly now you need to also improve the citizen participation in any good governance in any good governance you need to improve you need to increase the citizen participation and how is that possible you need to take help of the ICT tools.

Social and human capital you need to make the social and human capital also smarter by giving them different technologies different tools the ICT tools then smart mobility to improve the transportation with the help of ICT with the help of ICT you know making the transportation smart mobility natural resources. So, smart environment you know. So, basically you know you need to make your environment smart there should be less you know harmful or toxic gas emissions or other sorts of waste disposals you know these would be a reduced and these should be done in a smart without basically effecting the environment that way conserving the natural resources smart living which would improve the overall quality of life of the citizens. So, these are some of the application focus areas of smart city.

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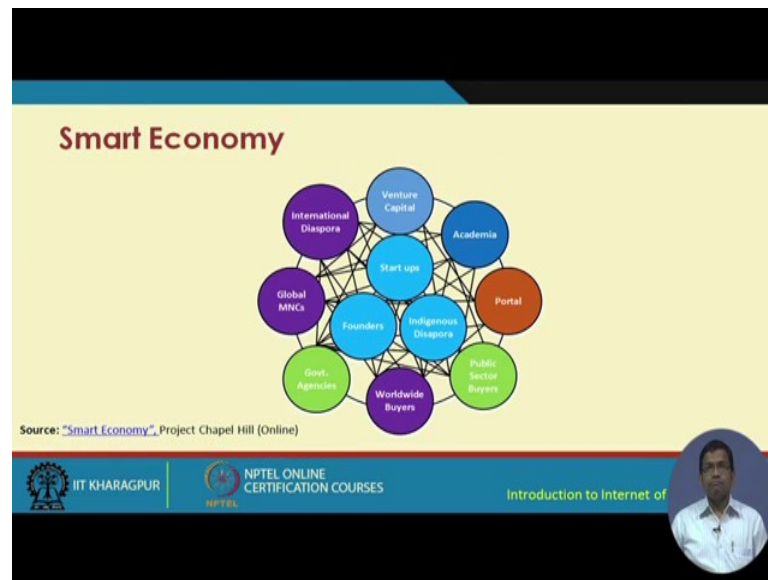
Now, when a when we talk about smart city one of the most important things is smart economy. So, the economy has to be improved over what already exists. So, let us say that in any economy what do you need in addition to the existing economic infrastructure like industry of different types and different other economic domains including even like schools hospitals etcetera, etcetera you also need to improve the economy by including by involving the growth of startups then indigenous Diaspora and different founders of different technologies all of these have to be there and they have to be interconnected they have to be interconnected with different other components for example, a venture capitalist a venture capitalist have to be interconnected with them the international Diaspora along with the indigenous Diaspora then academic academia then public sector buyers worldwide buyers government agencies global MNCs and so on.

So, they all have to be interconnected inter networked together not just at the connectivity level, but. So, that this connectivity has to be there. So, that you know different types of information different types of services are made available to each of these different components in a smart manner. So, they should be able to get these services whenever they need you know whenever there is an useful use case you know from the different components they would be participating in order to improve the quality of fulfillment of the use case.
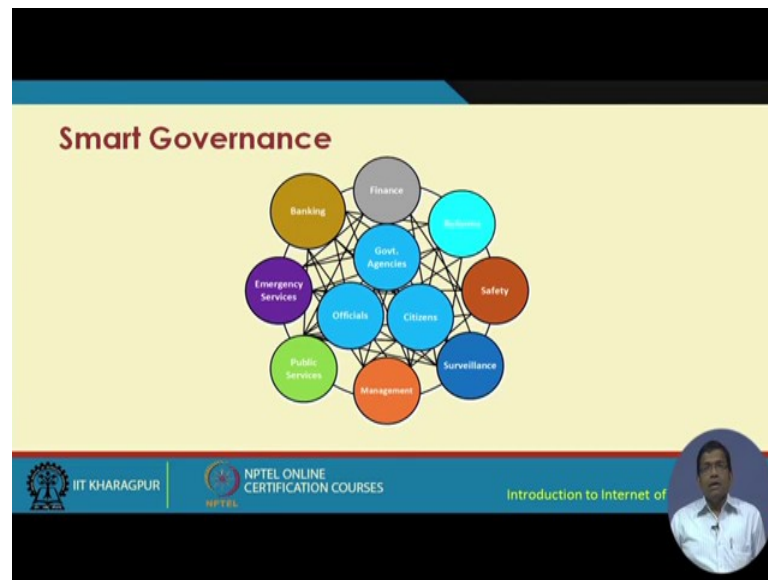
Let us talk about governance in governance there is at the core the government bodies the government offices and at the same time the citizens. So, these government agencies citizens and officials government officials these are all core to any governance or any government body now in addition you have all these peripheral ones like banking finance reforms safety surveillance management public services emergency services and so on.

Now, in a you know in a regular city what happens is typically traditionally they all they function sort of in isolation there is some minimal connectivity between them, but these are not a smart connectivity with the help of these ICT tools. So, in smart governance what is going to happen is they all are going to get connected they all are going to get connected. So, let us say that the officials are not only going to get connected to these government agencies and citizens, but also to the public services to the emergency services to the banking to finances you know surveillance citizens you know. So, all these different types of interconnectivities are going to be there. So, you have to make it possible in order to build a smart government system.
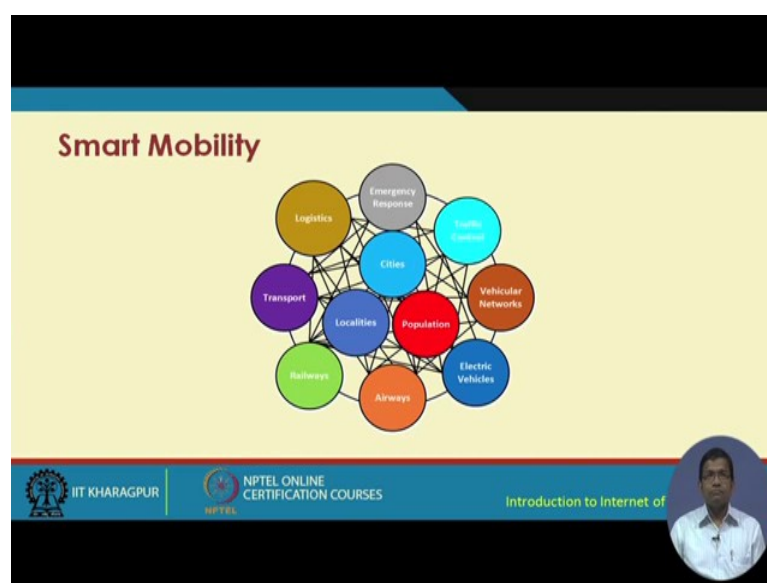
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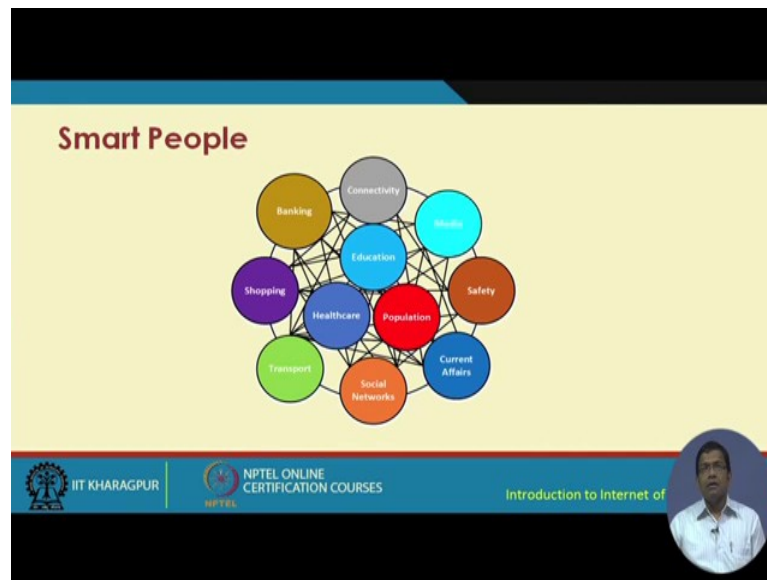
Let us look further ahead and see what is there in for us. So, we have the smart people. So, when we talk about the citizens you know education health care population overall is at the core of the; in of any city. So, and at the same time peripherally we have the transportation the shopping banking connectivity media safety current affairs social networks these are also like peripheral things. So, they all again have to be interconnected. So, that from any component it; it should be made possible to access information from other components of course, there has to some kind of policies of data you know floating across, but generally this has to be made possible. So, that the citizens get the information the citizens get the services from any of these components whenever they need and that has to be again identified in a smart city that has to be that need has to be identified intelligently with the help of cognition with the help of the different software the intelligence that is embedded in to the system.

Smart mobility likewise we already have a addition to the population we have the cities the localities and so on. So, you need to have interconnectivity with the other peripheral components like vehicular networks transportation logistic emergency response railways airways you know electric vehicles and so on. So, these sort of because let me just talk about use case with respect to this. So, let us say that I want to go in a city from point a to point b not just in the city we can even go from one city to another city as well one city to another city.

Now, what should happen is that the information should be made available in such a way I am just giving a simple use case that let us say that I want to book a train from city x to city y or point x in a city to point y in a city and let us say that the road that I am going to take is going to be very much congested or it is going to be very expensive that particular root is going to be very expensive or maybe you know there are you know there are different.

Other reasons for which you can consider the alternative options the alternative options would be that very easily instead of taking a train one could also get other options like taking a bus you know or taking another you know electric vehicle or you know and so on and these again the bus the train etcetera these also have to be connected with the police the police and the emergency vehicles. So, emergency vehicles because for obvious reasons if there is some kind of an accident etcetera, etcetera under that the

emergency response team should be able to get information on the fly you know. So, whenever it is required they should be able to get information and then the action also has to initiate with the help of these tools in a smart manner.
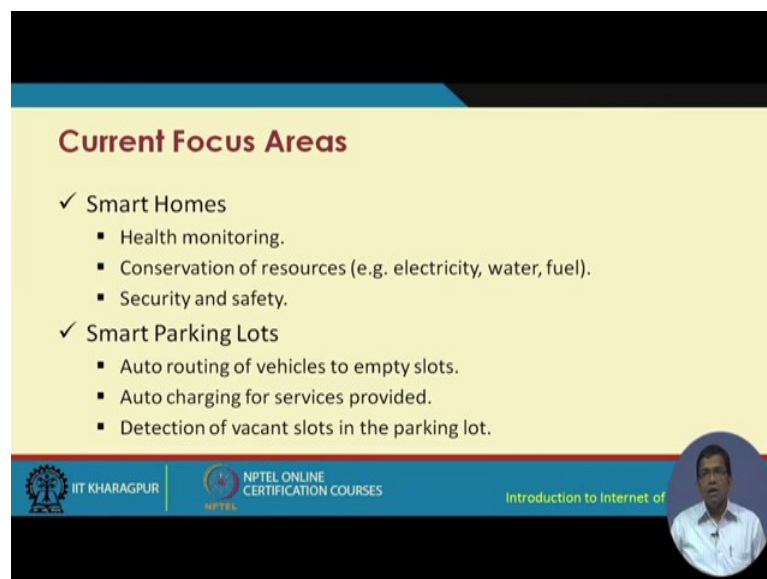
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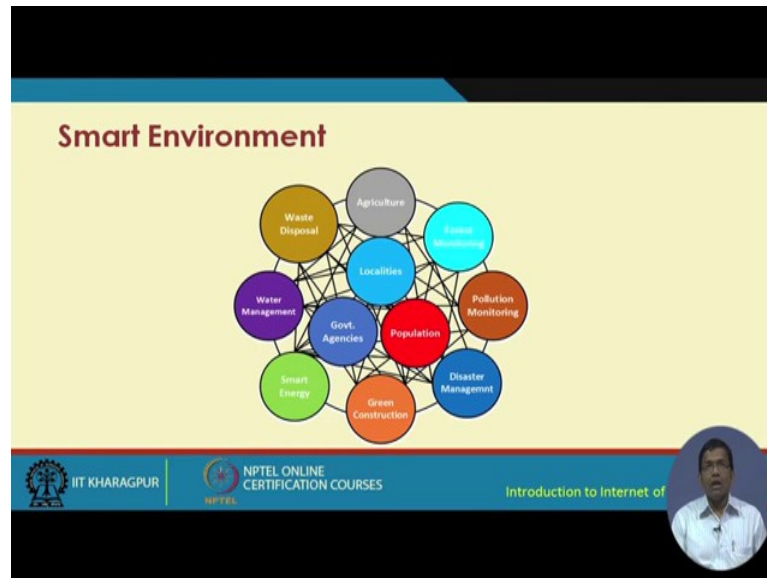
Then the we have the smart environment where in addition to the government agencies localities population there, there are components like waste management waste disposal you know agriculture you know forest monitoring pollution monitoring disaster management green constructions smart energy these all these different components inter internetworked together interconnected.

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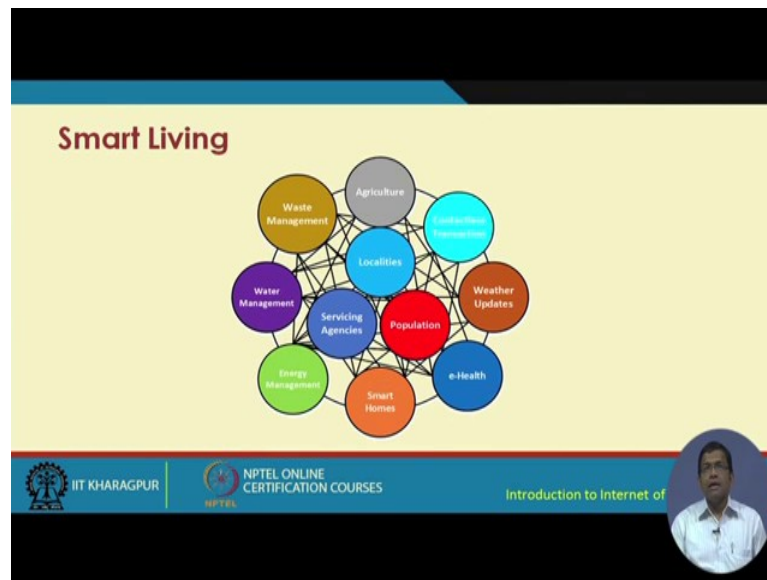
Together in a smart living kind of scenario you we have this we have the localities population serving servicing agencies these interconnected with all these different other peripheral components as you can see in front you in this particular slide.

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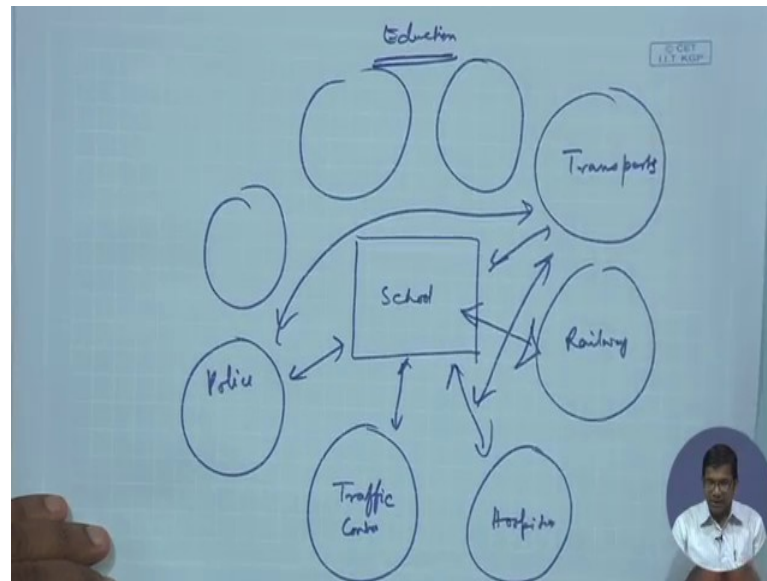
So, let me just give another example before we go further ahead let us consider a smart city where we have a school; we have a school. So, apparently or rather traditionally in a school in any school what you know the school specifically function in isolation the school specifically function in isolation in the sense that you know they do not really have to interact with the other components of a city that much, but in a smart city what is going to happen is we have these other components like transports railways we have the hospitals we have traffic control we have the police we have did I say hospitals; hospitals I have already said like this actually we have different other things in this smart city.

So, you know what is going to happen is if you have this kind of inter connectivity or even between police and transport you know schools and hospitals; hospitals and transport you know railways and this thing and like this then let us say that when a school child from his home he wants to come to a school he has information about the different forms of transport that he can take and let us say in an un event in an you know in a in an emergency in the road while going there is some kind of accident or whatever then correspondingly the police has to be informed and also the traffic control also has to take over and also the hospitals have to be informed.

So, that the child can get health facilities on the road and the same thing can happen inside the school as well once this once the child is inside the school the same thing can happen. So, as you can understand now. So, this was from the education sector school

education sector like this actually there are different other reasons why smart cities have become very popular.

Now, we have the different focus areas we have smart homes smart parking lots in a smart home situation we need to have I will talk about smart homes in more detail later on, but in a smart home situation we have the health monitoring done in a smart way at home this you know the medical data made available to the doctors whenever there is a health criticality the corresponding house physician would be informed the physician can take requisite action based on the severity of severity or criticality of the of the health of the patient.
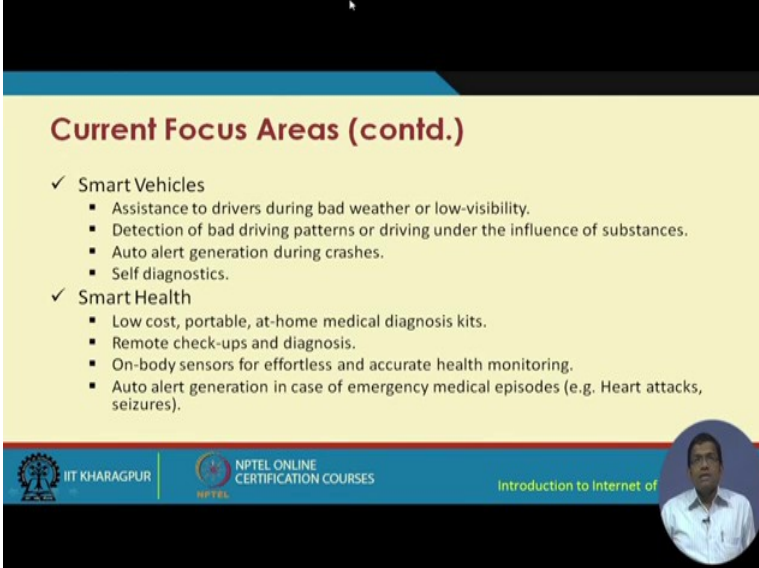
So, smart health monitoring then conservation of resources with respect to electricity water fuel you know. So, you know we should we can have a smart home where you know the water tap will be turned off if you know it is automatically it will be turned off may be with the help of ICT tools whenever it is not being used may be accidentally if I have turned on the tap the water tap it will be turned off similarly with the fuel consumption or conservation as well and like that and security and safety is very much paramount in a smart home security and safety for obvious reasons I do not need to elaborate on these, but safety at home security at home you know prevention of burglars from breaking into the house and so on. So, like that actually there are different other types of benefits of having a smart home.

Smart parking lots is very interesting smart parking lots is very interesting because you know. So, what happens is we all have experienced that when we are in the city and particularly when we are going in to the downtown areas or the central areas of a city typically parking is a huge problem. So, sometimes it might so happen that in some places you do not have any parking spot at all and maybe there are few other parking spots parking lots in the city which are vacant or relatively vacant and how do I get this information until I physically go there and get this information get this information, but you know that is basically infeasible.

However, if we have a smart parking solution in a city then one can one can from the mobile device inside the car one can get access to this information about which parking lots are available which ones are not and dynamically that information can be updated and made available to the users and other things like autorotation of vehicles to empty

slots empty parking lots. Auto charging for the services that are provided detection of vacant lots in the parking lot and so on.

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Smart vehicles with respect to assistance even to drivers during bad whether if there is a bad whether condition the low visibility condition the vehicles would be assisted about the you know how to drive ahead you know what are different ways the roots that can be taken from a particular point to the destination and so on detection of bad driving by patterns or driving under the influence of substances you know. So, the vehicle should be alerting the user of the vehicle driver and not only the driver may be the other corresponding stake holders like police or you know the respective dignitary bodies the authorities and so on auto alert generation duration crashes if there is accident auto alerts will be generated will be sent to the police the emergency personal and so on.

Self diagnostics of the vehicle you know if there is something some component going down something is going wrong with the engine or you know any of the other components of the vehicle you know. So, automatically it will diagnose and that information would be made available to the user of the vehicle similarly smart health low cost portable at home medical diagnostic kits be made available remote checkups and diagnosis would be made possible on body sensors for effortless and accurate health monitoring would be made available for use by the patients who need this kind of care.

Auto alert generation in case of emergency medical episodes like heart attacks seizers etcetera automatically the emergency persons in the hospital will be made available and that again is on the basis of subscription there might be several different several different hospitals with which the patient might get connected, but only to the hospitals with which the patient has a subscription you know. So, they will be getting notified and the emergency vehicles are going to the ambulances going to come to the home of the patient automatically without even having them to be informed.

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Pollution and calamity monitoring for whether or manmade based calamities alert generation in case of above threshold pollutants in air or water. So, on you know. So, nowadays actually we have all these air monitoring systems water monitoring systems these are in different isolation isolations basically this is monitor continuously we have the air quality index being monitored indifferent cities of our country. So, similar kind of thing is going on in different other countries as well. So, this sort of information from any point if I want to let us say from Kharagpur, I want to go to another place let us say Delhi. So, before I travel you know I can check that what is the air quality of that particular city; that means, Delhi and then I can make a decision about whether I should go there or not may be even better would be if I can get an advisory about whether it is safe to travel to Delhi because of this air contamination the air pollution and so on.

So, this is just an example like this actually these can be similar kind of thing can be done with respect to pollution and you know environment monitoring in a in any city smart energy like smart metering systems you know smart meters programmable meters through which you can do different things at your homes you know have differential usage being monitored and build accordingly in a smart grid smart energy kind of environment smart energy are allocation and distribution system incorporation of traditional and renewable sources of energy in the same grid.

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So, these are the different components these are the different benefits of smart energy; smart agriculture likewise automatic detection of plant water stress monitoring of crop health status auto detection of crop infection auto detection auto application of fertilizers and pesticides scheduling harvesting and arranging proper transfer of harvests to warehouses or markets. So, some of these actually as you will see in the case studies when we talk about case study on agriculture you will see that we are already implementing these in our lab in the swan lab of the department of CSC at IIT, Kharagpur we are already implementing some of these different things for smart agriculture we have projects by which the agricultural field are monitored with the help of censors and different other ICT tools and that information about the field cognition is made available to farmers so that the farmers can decide accordingly about what to do next.

So, like this auto application of fertilizers is also possible and air born application of fertilizers with the help offspring or pesticides with the help of autonomously automatically you know this sort of thing is made possible in a smart environment smart city.

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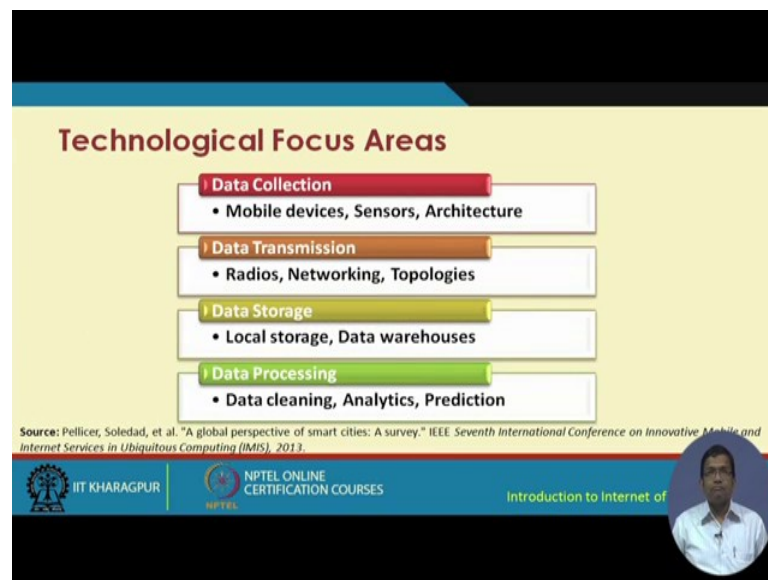
So, different technological focus areas include data collection with the help of mobile devices sensors and architecture I do not need to elaborate on these same thing I also do not need to elaborate on the need for the transmission of the data after collection of data through the above means with the help of radios networking topologies and so on different types of topologies communication and networking topologies consideration of those different topologies then the data that is collected and transmitted have to be stored locally and then remotely and as well in the form of data warehouses you know cloud storage and so on and they also again have to be analyzed to first of all cleaned analyzed and predicted.
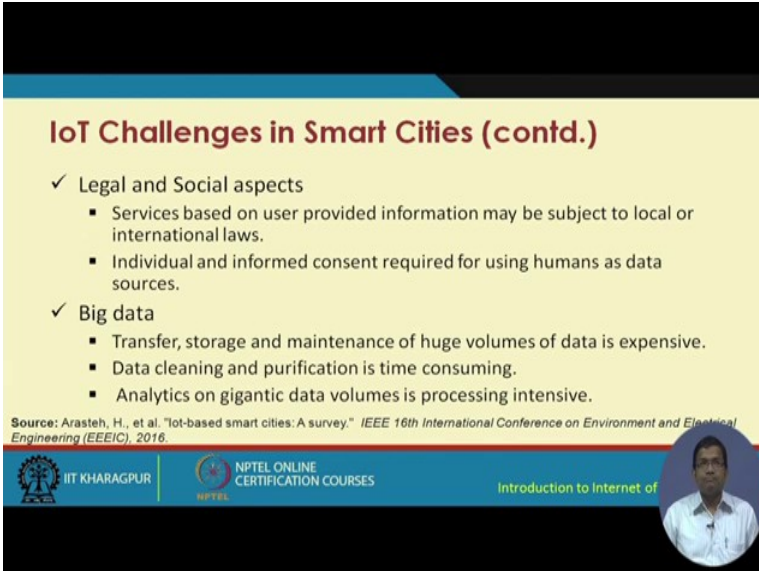
So, there are different IoT challenges in smart cities security and privacies one. So, because you know all these different infrastructure are made available to all different types of citizens. So, you know you expose yourself to different types of attacks the government officers there are different files etcetera you know you make yourself vulnerable to different types of attacks privacy leaks and so on when you open up more and more. So, that also has to be taken up concurrently while building smart cities and the same thing exposure to vulnerabilities multi tenancy of you know. So, the same devices are basically you know accessed by different tenants by different users and that multi tenancy basically induces the risk of data leakage the risk of data privacy leakage security data security and so on.

Heterogeneity integration of varying hardware platforms and specifications is a very you know important challenge and when we talked about IoT interoperability we spoke about some of these issues integration of different radio specifications integration of various software platforms and accommodation of varying user requirements are some of the different other heterogeneity and interoperability issues in IoT and we already spoke about this thing in detail in the lecture on interoperability of IoT in this in this particular course.

Reliability unreliable communication due to vehicle mobility is not good similarly device failures can happen and that has to be taken care of large scale deployment also has

different challenges. So, there would be delay due to large scale deployment itself delay due to mobility of deployed notes and the distribution of devices can also affect the monitoring tasks.

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There are legal and social issues as well for example, services that are based on users user provided information may be subject to local or other national and international laws and that also has to be taken care of in a very smart way individual and informed consent is required for using humans as data sources big data issues are there you know huge volumes of data coming at high speeds and you know different types of vary various types of data media you know text data and so on.

So, these have to be clean in a purified and that is a time consuming process and then data it also has to be analyzed you know in real time to make sense out of it and the corresponding actuation has to happen.

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So, big data issues are there big data in a real time environment is a very important and difficult challenge sensor networks you know we already spoke about sensor networks in detail earlier the deployment of sensor networks in a smart city comes with different-different challenges. The choice of different sensors for sensing is also very crucial energy planning is very much required different devices consuming different energy levels how you are going to schedule how you are going to do the duty cycling these are all different issues in sensor networks.

So, with this we come to an end of the smart cities you know smart cities and smart homes focusing on smart cities specifically in this particular lecture we have seen that there are different good use cases by which we can understand that smart cities is very much required and nothing else other than IoT and IoT constituent technologies can help in the building of smart cities and that is why there is so much of up search on not only research, but also deployment and investment on building smart cities throughout the world and there is lot of opportunity that is ahead in the building of smart cities and we are going to go through some of these different opportunities we have already seen the different challenges ahead some of these different other opportunities we are going through going to go through in the next lecture.

Thank you.