Introduction to Internet of Things
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Lecture – 50
Connected Vehicles – II

So, now we are going to continue with our discussion about connected vehicles in the second part of the lecture on connected vehicles we are going to talk about the intelligent connected vehicles. So, intelligence means that it comes with lot of implementation of different types of software different things can be performed intelligently different inferences predictions etcetera, etcetera based on the data that is obtained either from the hardware; that is embedded or from the historical data that is collected from the from the site from the different vehicles on the site and what people have you know send the different vehicles have sent in the past.

So, based on that historical data, different types of inferences can be done so that intelligent decision making can be done. So, here basically you know when we are talking about intelligence of any kind we are talking about the use of software. So, intelligent software the software basically uses different types of analytics different types of machine learning methodologies and so, these that will be applicable on top of the data that is collected and the data that is collected is from the different sensors and these sensors the actuators and so on; get together are the down devices the base devices the physical devices which basically help in the procurement of this information.

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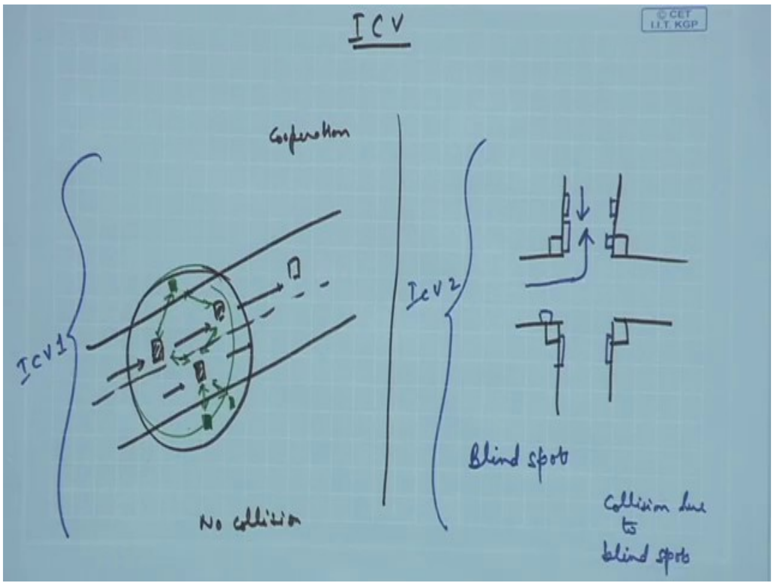

So, let us consider a particular scenario like this for intelligent connected vehicles let us consider 2 scenarios in the first scenario we have a road on which there is a vehicle and all these different vehicles are also moving on the road and then there is a passerby. So, all these different vehicles and we are considering a very simple configuration like this. So, what happens is when this vehicle these vehicles are moving on the road and let us say that this is the lane and there is a vehicle which is trying to pass this particular vehicle. So, you know it might be possible to come up with a scheme through which cooperatively these vehicles will help each other. So, that there is no collision between them.

So, there has; these has to be made possible with the help of enforcement of or enforcement or implementation of some scheme which is based on cooperation between the different entities cooperation between the different entities. So, in this particular example we were talking about this vehicle this vehicle and this vehicle cooperating with each other in order to avoid collision and that would be made possible with the help of the data that is collected from the individual sensors in these different vehicles from the from the information that is obtained from the different roadside units from the different let me denote the road side units as solid blocks.

So, from this from this data from this data this data and also the data like this. So, all these information would be collected together there would be some kind of a cooperation enforcement scheme may be using cooperative game theoretic approaches or something like that 2 come up with schemes or to come up with decisions on driving. So, that these vehicles can keep safe distance from each other and they do not collide. So, this is one scenario.

Another one could be let us consider another example where we have let us say it is not a highway, but you know it is a city intersection like this and typically as you know that in the intersections you have different blind spots maybe due to different buildings in the corners or maybe there is a parked let us say that here we have you know these are the different buildings in the corners of an intersection or maybe there is some parked vehicle over here these are the different parked vehicles.

So, what might so happen is these vehicles these parked vehicles they often create blind spots blind spots and due to blind spots what might happen is a vehicle that is coming from this place and if they want to turn this way and another vehicle that is coming from this way they might collide because these vehicle cannot see this one this one cannot see these and they might collide. So, similar kind of other types of scenarios can also be you know thought of thought of involving blind spots and so how do we avoid this thing.

So, here also these might happen is again there is collision due to blind spots and intelligent connected vehicles can help in this scenario as well. So, these can cooperate. So, there other vehicles that are there and the sensors in them like in the case of this particular scenario they all can cooperate with one another in order to help these 2 vehicles. So, that they do not collide with each other. So, we have one scenario of ICV and the other scenario of ICV intelligent connected vehicles. So, let us look ahead and see what is there for us further.

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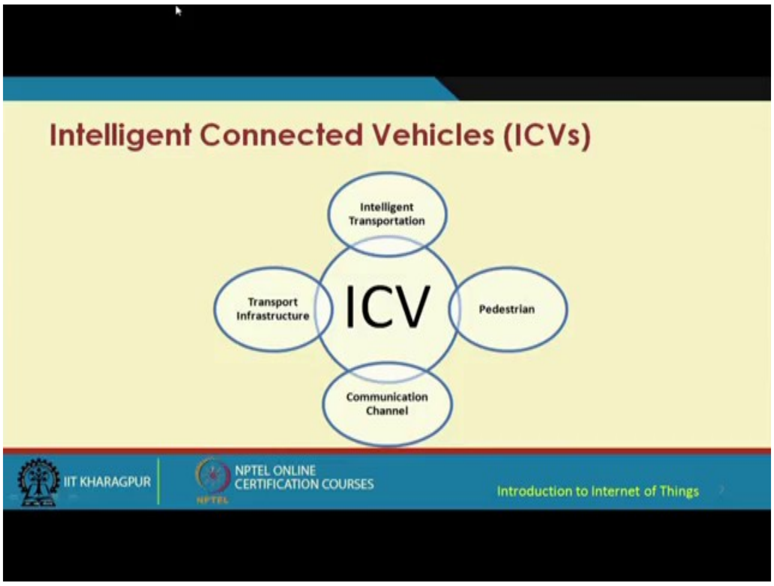

So, when we talk about intelligent connected vehicles we are talking about intelligent transportation which we have already discussed the different transport infrastructure the communication channel pedestrians all coming together interconnecting them in an intelligent fashion to fulfill certain objectives the different use cases.

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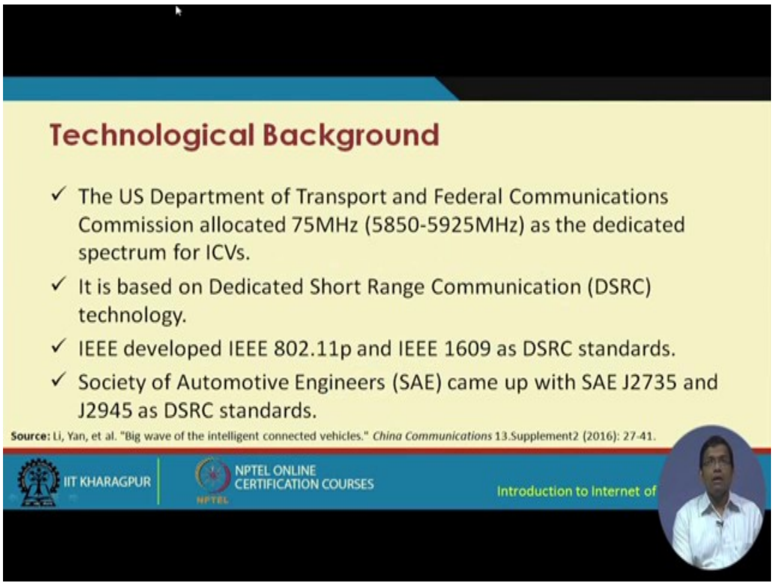

So, let us look at some technological background about ICV. So, the US department of transport and federal communications commission allocated 75 megahertz in the band 5850-5925 megahertz, so, this 75 megahertz band as the dedicated spectrum for internet intelligent connected vehicles. So, US has already done it. I for ICVs they have a separate allocated 75 megahertz band and these particular thing for ICVs, it is supported by the DSRC technology that we spoke about in the first part of intelligent of the connected vehicle's lecture.

So, in the first part we talked about the 2 types; one is the DSRC communication technology the other one is the wave communication technology. So, basically for this part basically the 75 megahertz communication for ICVs there is that DSRC that is commonly used and IEEE concurrently has also come up with this protocol 802.11p and the IEEE; IEEE 1609 as 2 different standards for DSRC implementation. So, 2 different standards 1 is 802.11p not the simple not the standalone 802.11 protocol the standard. So, p the 11p and 16.0 sorry; 1609 IEEE standards are also used for ICV implementations and the society of automotive engineers came up with the SAE J 2735 and J 29452 different standards by this particular society.

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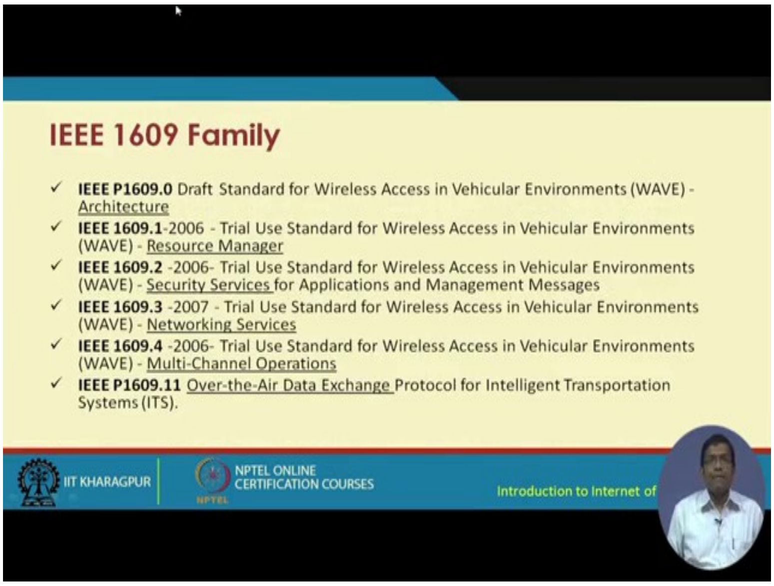

So, 1609 is for automotive connections automotive connections interconnected vehicles. So, these standard and the different drafts I am going to go through. So, P1609.0 this is a draft standard for wave architecture and this wave architecture I already told you before wave protocol. So, the wave architecture is basically drafted in this particular a in this particular document the P1609 draft then the 1609.1-2006; these basically takes about the trial use standard for wave from a resource manager point of view .2-2006 is the trial use standard for wave with security services for applications and management of messages .3-2007 is the trial use standard for wave consisting of different networking services .4-2006 is the trial use standard for wave with multichannel operations and P1609.11 is over the year data exchange protocol for standard transportation systems for intelligent transportation systems the ITS.

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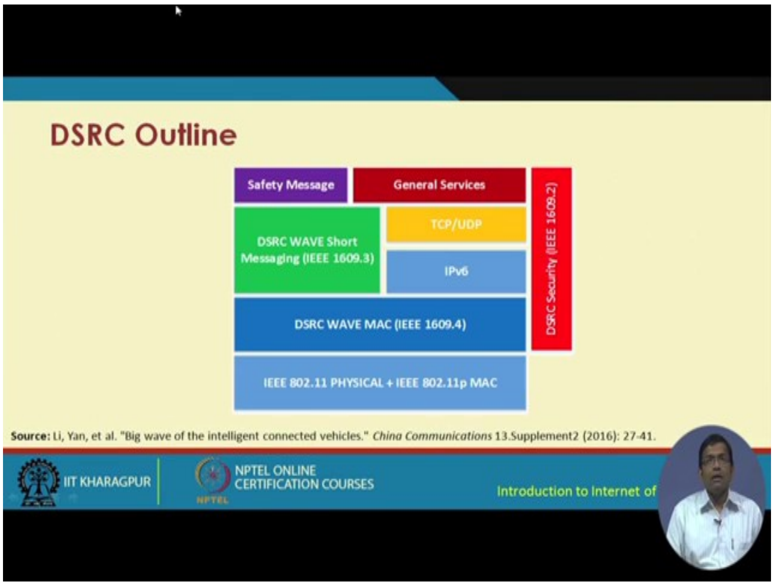

So, DSRC protocol if you look at it looks like this as shown in this particular figure we have at the very bottom the bottom layer is not just the physical. So, it includes the 802.11 physical and the MAC of 802.11p these 2 are at the very bottom then we have the 1609.4 which is the DSRC WAVE MAC and then on top we have the DSRC wave short range messaging protocol 1609.3 and also the regular IPV 6 and TCP IP; TCP UDP as the transport and the different applications such as safety messaging general services etcetera on the very top the security is something that cuts across vertically across all these different layers. So, security is drafted in point 2 IEEE 1609.2.

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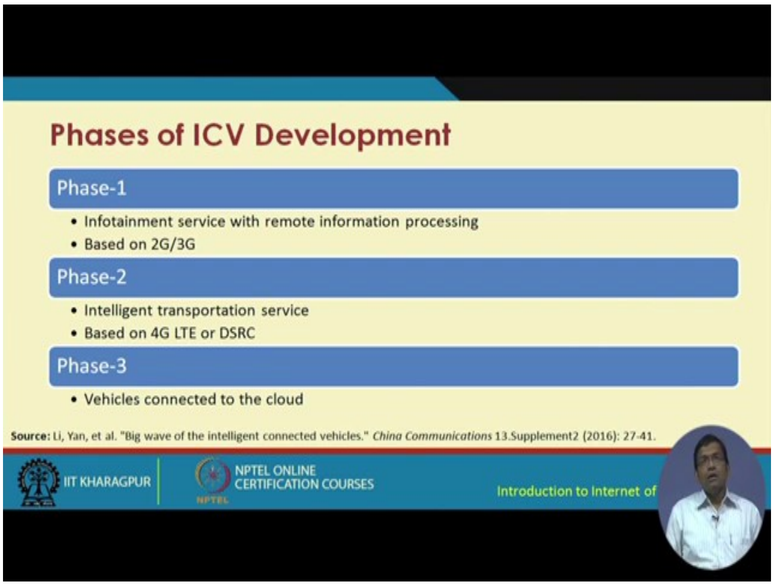

Now, the phases of internet sorry intelligent connected vehicle development in phase one it was considered to have you know facilities for infotainment service availability with remote information processing and that was based on the 2 G, 3 G technology phase 2 basically included 4 G LTE or DSRC and here the focus was on intelligent transportation service and phase 3 basically was to connect all these vehicles to the cloud that was the phase 3.

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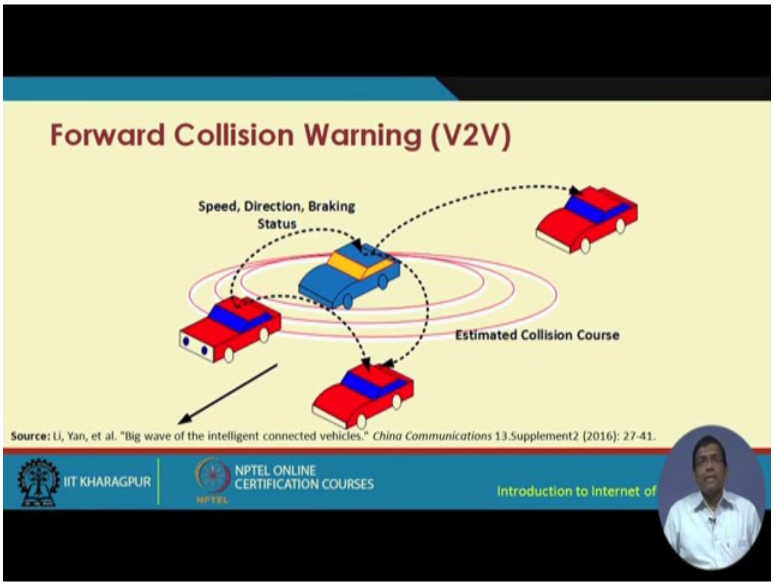

Now, let us look at some ICV scenarios forward collision warning scenario. So, we have these different vehicles which are running on the road we have this vehicle and these 3 different vehicles and this particular vehicle. So, they all would be you know having this information with respect to the speed the direction the breaking status and. So, on and based on these they can cooperatively estimate the collision course you know. So, that they do not collide with each other then this is an example of the existence of blind spot across you know blind spots on the road.

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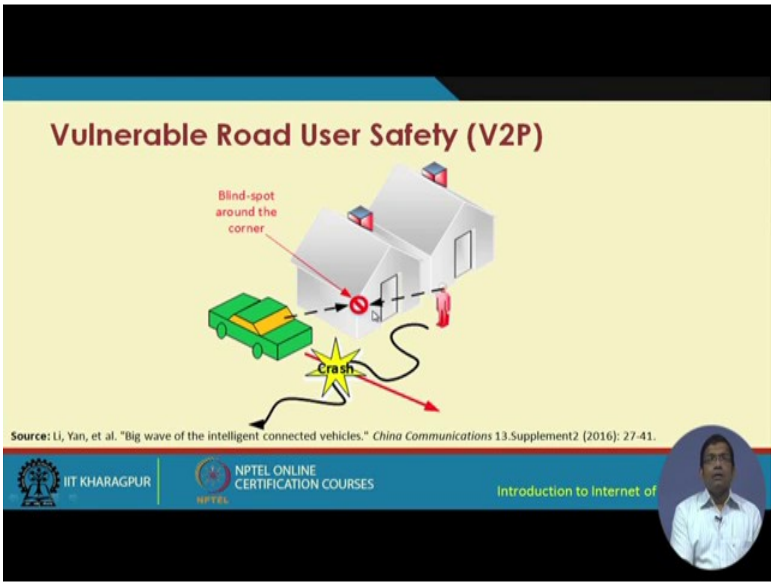

So, you know in particularly blind spots exist in the corner as I was telling you at the very outset for a different kind of scenario. So, it might. So, happen that a particular vehicle would be coming when there is a human who is trying to pass. So, this vehicle was supposed to come this way this human was supposed to walk on the pedestrian; you know on these pedestrian road. So, when they try to cross there could be a possibility of crash crash between the vehicle and the human who is trying to cross because and this was happening because they were not within line of sight of each other and because of the existence of this particular building on the house on the corner.

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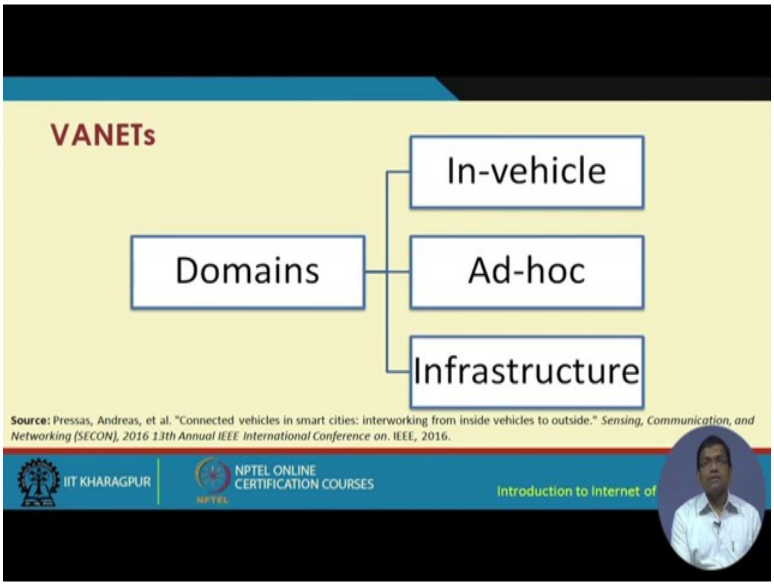

So, you know. So, taking care of this kind of scenarios these V2P scenarios vulnerable road user safety scenarios was something that was considered in the intelligent connected vehicles vehicular ad-hoc network is at the core of ICVs. So, when we talk about vehicular ad hoc networks we are talking about 3 different types of communications at least number one communication inside the vehicle inside every vehicle there are lot of sensors there are lot of actuators there are different types of other embedded devices there are these different transmitters receivers and so on.

So, in vehicle communication is one, then comes the ad hoc communication ad hoc communication is with without the help of any infrastructure these vehicles would be able to communicate with one another. So, vehicle to vehicle communication may be directly or via some intermediate vehicle which will act as a relay of the messages. So, vehicle to vehicle communication either directly or through relays and the infrastructure based communication may be with the help of road side units or mobile towers and so on.

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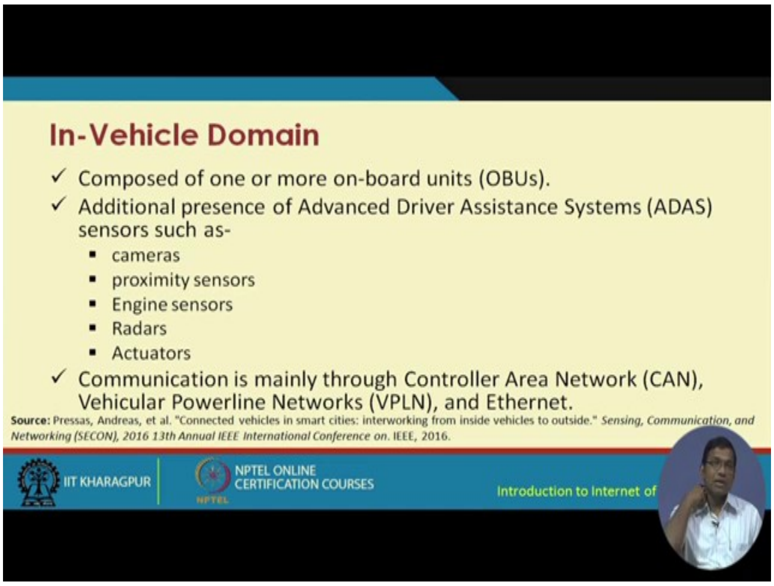

So, these are the 3 different domains of vehicular communication in-vehicle communication ad-hoc communication and infrastructure based communication. So, in vehicle communication for that there are different OBUs the on board units that are basically fixed on the vehicles. So, these vehicles they have each of these vehicles they have one or more OBUs the on-board units they also have something known as the ADAS unit advanced driver assistant system unit which has different sensors such as cameras proximity sensors engine sensors actuators radars and so on, the communication is mainly through controller area network vehicular power line network and the Ethernet. So, these are 3 typical typically used communication equipments communication facilities communication networks that are used.

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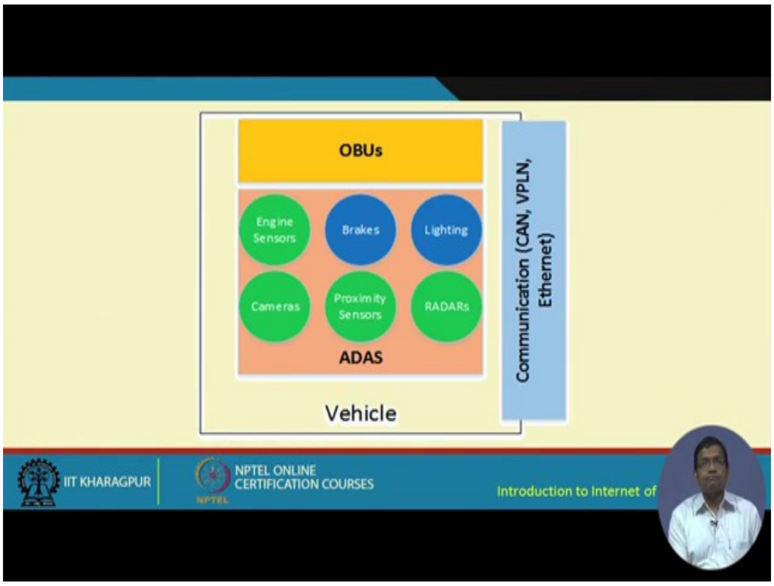

So, what we have is something like this; this is the whole vehicle this is the whole vehicle and in the vehicle we have these OBUs the onboard units the ADAS comprising of different sensors engine sensors brakes lighting radars proximity sensors and cameras and these are all connected with each other with the help of different communication technologies like controller area network VPLN and Ethernet.

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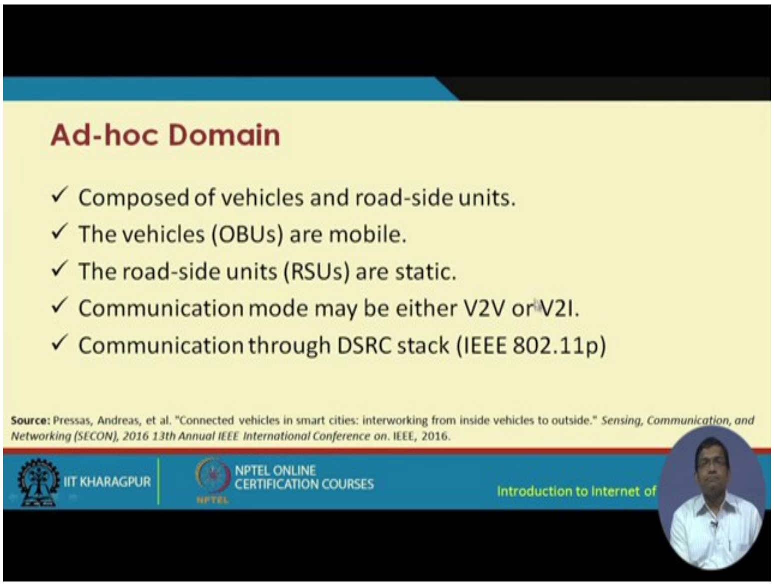

In the ad hoc domain again we have these OBUs, but we are considering OBUs which are mobile and these vehicles basically can talk to each other and also with the road side units the

RSUs, but these road side units are considered to be static in this particular architecture. So, the communication mode may be either V2V orV2I and the communication is done through the DSRC stack using the 802.11p IEEE standard.

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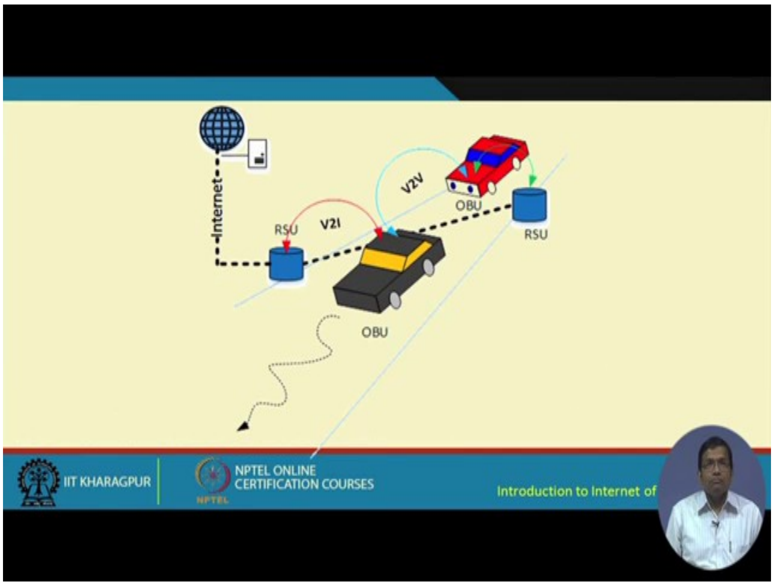

So, let us consider this particular scenario of these vehicles moving on the roads. So, each of these vehicles they have their own different OBU like this every vehicle has one or more OBUs and these RSUs road road side units and it is possible to have different types of communication either vehicle to vehicle communication like this or from vehicle to RSU communication vehicle to RSU communication. So, this is V2V and this is V2I vehicle to infrastructure because RSUs are fixed infrastructure on the road sides.

So, that is the reason this is known as V 2 I infrastructure and it is also considered in the case of VANETs in the case of intelligent connected vehicles is that these RSUs are connected to the internet RSUs the road side units are also connected to the internet. So, basically the RSUs have the internet connectivity.

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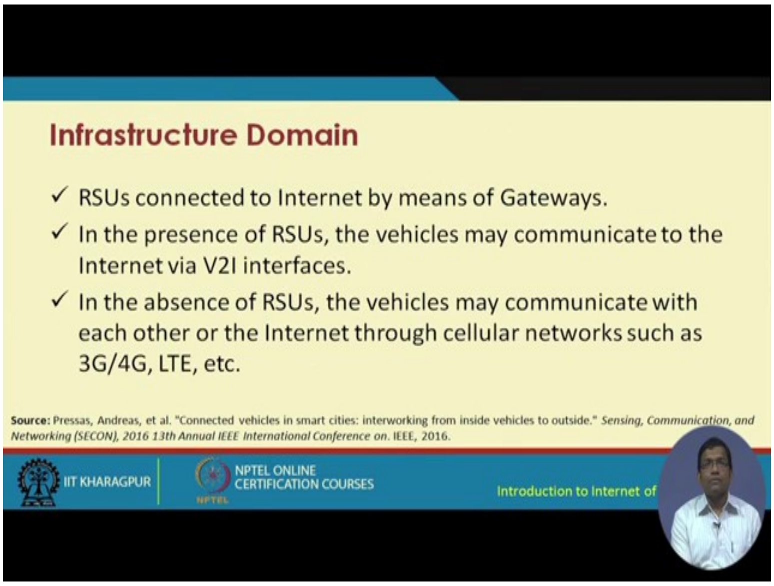

And this is how this internet connectivity is used is provided to these different vehicles on the road. In the infrastructure domain the RSUs basically are connected to internet by means of gate ways in the presence of the RSUs the vehicles may communicate to the internet viaV2I interfaces. So, when the RSUs are present it is going to be the vehicles are communicating to the internet via the V2I interfaces whereas, when the RSUs are not present the vehicles communicate with each other or the internet through cellular such as 3G, 4G LTE.

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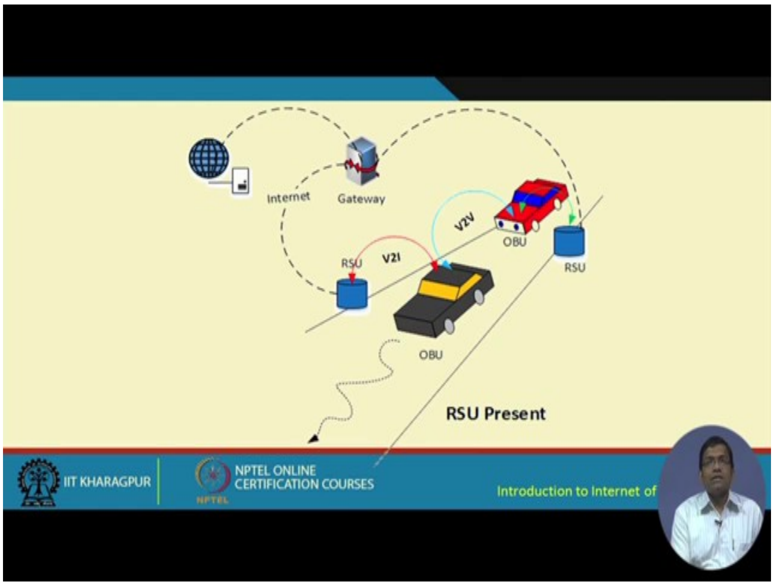

So, these are the 2 scenarios that are depicted over here that I just mentioned here is a scenario of the RSU being present and when the RSU is present you know. So, RSU has the internet connectivity via the gateway and that internet connectivity basically helps to have V2I and V2V communication.

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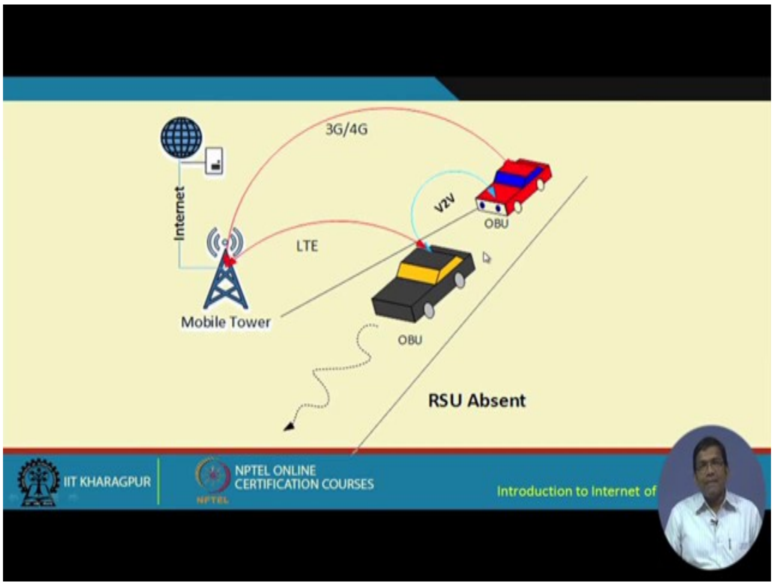

And this is the scenario of the RSU being absent and here basically you know if the RSU is absent what is suggested is to take help of the existing infrastructure of cellular communication like 3G, 4G etcetera and with the help of 3G, 4G LTE you know these vehicles they would be able to communicate with each other.

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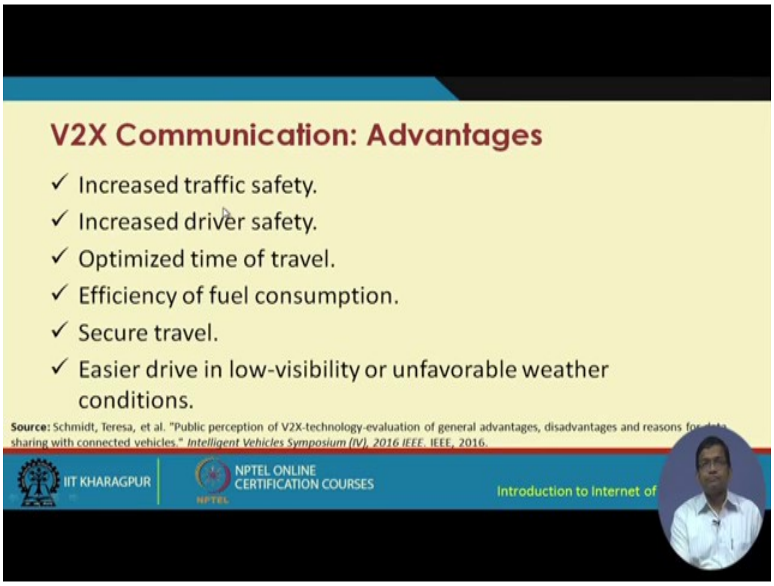

Now, what are the advantages of V2X communication? So, we remember in the last lecture previous lecture we spoke about the V2X; that means, vehicle to everything vehicle to anything basically communication what are the advantages it number one increases the traffic safety increases the driver safety optimizes the time of travel because you know if you if everything is connected together you can calculate your systems onboard systems can calculate that from 1 point to another; what is the optimized time of travel what are the different you know possibilities for different roots etcetera and how the travel can be made and the efficiency of fuel consumption and secure travel security secure you know. So, because you know it is all connected together and you know you can secure you know you know that; what is the way to travel from a point A to point B in a secured manner; fuel consumption likewise can be you know reduced. So, efficient fuel consumption easier drive in low visibility or unfavorable weather conditions.

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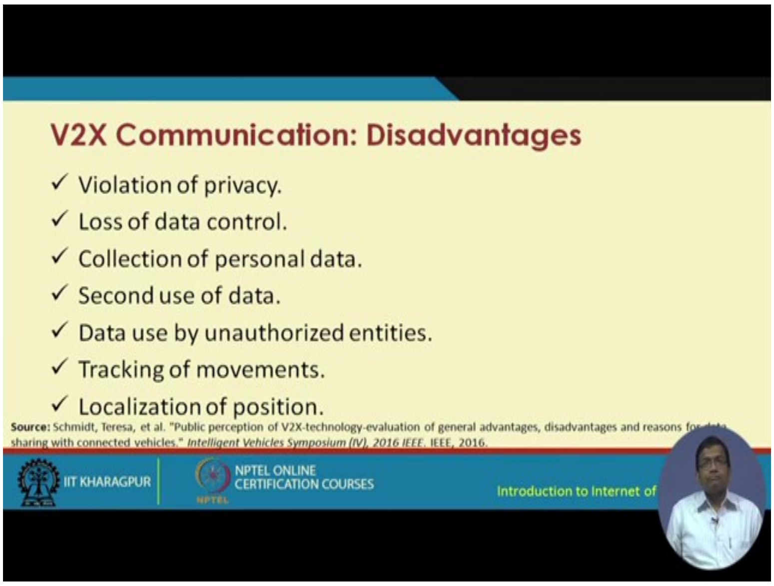

The disadvantages include violation of privacy loss of data control collection of personal data secondary use of data secondary use of data is interesting secondary use of data means these data that is floating all across you know. So, what is going to happen to it who is going to use it you know, so, whether there would be a non intended use of the data. So, secondary use of the data data use by unauthorized entities very similar and tracking of movements of the vehicles is made possible.

So, you know it is possible that you know one can get all these different vehicles who are connected together through that if there is some kind of a security leak or something like that the positions and the movement patterns and futuristic predictions of about these vehicles can be made and these you know. So, that basically is not a very good thing if there are some vulnerabilities that are there tracking of the movements and localization of the positions of these different vehicles are the other disadvantages.

So, with this we come to an end of the second lecture on connected vehicles. In fact, we have spoken about connected vehicles in the first lecture and the second lecture as well we have seen the different different advantages and disadvantages of connected vehicles intelligent connected vehicles the different architectures the different standards that can be used and the only thing that is required is from understanding about one of these things and whatever we understood as part of the module one and module 2 as well implementing those and coming up with a platform to enable this kind of architecture.

Thank you.