Design for Internet of Things
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Lecture - 20
Introduction to MQTT

See, before we get into this detail of any of these protocols, you have to get the philosophy right. Why we want these protocols already there are so many protocols that are there internet in the internet world right. You have HTTTP which is an application protocol very popular protocol that we have all been using, essentially browsers are HTTP clients right. And, so that protocol already exist for moving files bulk file transfers for bulk file moments, you have FTP, and the secure version of FTP is the SFTP that is another protocol. So, like that there are so many protocols which are around. Why one more why not adopt existing ones and use them, why create many more that maybe one thing that may be bothering you.

So, we have to understand that part first that is one thing. Second thing is there is one critical thing that you have to note in the IoT world that is the reason why these protocols are required. Gone are the days where humans were human action or human triggered events was generating traffic on the internet its gone is the machines which are going to generate lot of traffic, it is the machines which are going to consume a lot of traffic. So, data sources and data syncs are essentially machines here.

Therefore, the existing protocols are not suitable to ensure that securely data can be transferred from point a to point b. Without the human in the loop many many times its good not to have human in the loop and you know I just recently read the article, I am sure you might have seen that in the newspapers as well that you know all these voice based command systems are quite popular right you have siri: for instance from apple, then you have products from amazon called amazon echo, which is from amazon.

If there are so many other vendors which provide you solutions where essentially you can talk to the device, and the device will find out get you information and perhaps tell you about whether tell you about cooking recipes and so on and so forth. So, many nice things it does essentially, everything is around voice recognition speech and all of that. So, lot of IoT products in that space. The there was there is also this thing about such

devices which use lot of learning mechanisms behind, and it is a very intelligent device ultimately right because it is able to recognize able to differentiate between different voices and take commands and at able to you know carry out the activity, carry out the command that is been issued by the owner of the device.

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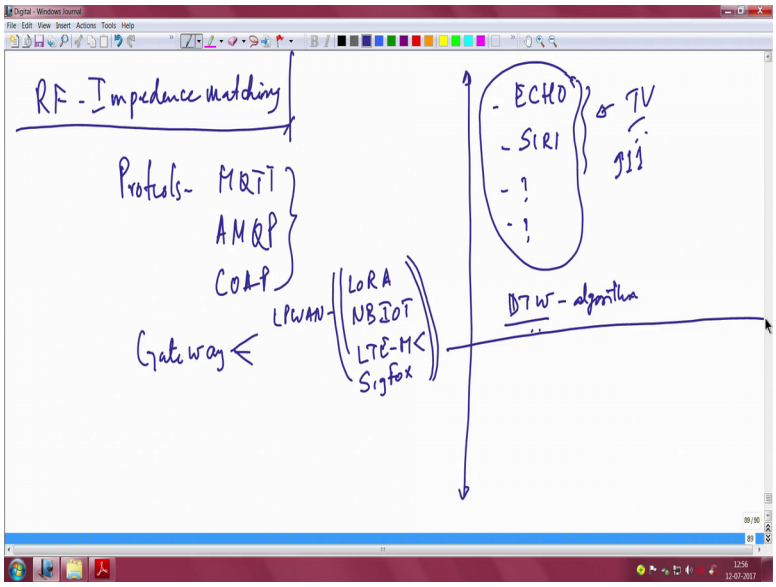

All this is good, but there is also you know all this being you know sort of being trained amazon echo let us put them down. Echo is one such device amazon echo then you have siri which is actually integrated into many phone products, but I gathered there will also have a standalone device and so on. So, many other devices which seem to be coming up essentially based on voice recognition, commands which are based on voice and so on.

Recall, I mention to you about single word a proper recognition command recognition kind of algorithms particularly this dynamic time warping algorithm which I mention to you, when we were discussing about the space on vibration energy harvesting, I mentioned that DTW is something that is a nicely used algorithm. Anywhere that a part the nice thing about these products is sometimes they are unable to differentiate with a by a command issued by let us say a human in front of it or even a television which is just speaking out a command right.

So, that is a real problem for example, if it is a there is a television serial in which you are watching and echo is tune to call a 9 1 1 number for instance, if something like call the police comes up right, then what we will happen? If it is really it does not know that

is actually coming from a television part of a television serial and actually it calls the police. It really turns out that many times you can have this kind of false problems with these kind of devices because they are a little bit dum in that sense. So, it so happened recently that there was a fight in a house and then. So, it just happened that during the course of the fight the device that was there actually heard you know sort of call the Sharif or call the police or something like this and in fact, the people actually landed write in time came back in time to you know sort of ensure that the fight was avoided in the house.

So, such good things also can happen with. So, do you call this a bug on such devices are do you call it like a feature is often a thin line right. So, if it works in your favor, if it works in favors the human. Obviously, it is a nice feature. Anyway all of this clearly indicates that a machine was actually collecting data interpreting understanding having intelligence and calling out you know help and support outside, there it was actually there was a consumer which was also a machine perhaps which altered the police out there and which ask them to call back. So, a machine really receives the data a machine a transmitted data and so on. So, the protocols in the IoT world, we will have to clattered to this this is the key requirement therefore, before we get into the details of any one of these protocols what are those the basic requirements that these IoT systems we will have to support you have to no correctly.

I will put down one by one and I think this is not an exhaustive list, but this just to motivate you before we get into any protocol discussion because protocol is there is a standard you understand the standard very well; this perhaps and RFC which you read thoroughly understand then integrities of the RFC, and then you do a implementation of the RFC you get a protocol in place right. Of course, designing the protocol is one part, but then testing the protocol conformance of the protocol is another story, which are all basically to harden the basic protocol in place to weed out bugs for instance to ensure the correctness of operation of this protocols, to ensure that the expected operation actually happens all; that means, looking at the conformance. Then looking ats vulnerabilities in the protocol where are the holes in the protocol where what are exploits which you know because security has to go hand in hand when you talk about I o t.

So, security exploits vulnerability and security exploits which the protocol has, are all to be you know you know all have to be tested therefore, you may have to do some sort of

protocol fazing for instance are trying out many many test cases fazing or even looking at very specific exploits critical exploits which will you know put holes in to the protocol stack, all that we will have to be done. So, there all another pull at I would say another large body of activity in the IoT world when you want to do. We will not get into that detail because in this limited time we have to get understand the basic protocol first quickly get into a demo, understand how you can use this protocol because ultimate objective is can I use this protocol as it is by now following this course, and building a system around it very quickly right.

So, that is what you must ultimately aim at. So, before I actually get into the protocol, let me put down a few points I would say few requirements. So, I will take a fresh page and I will start with a requirement.

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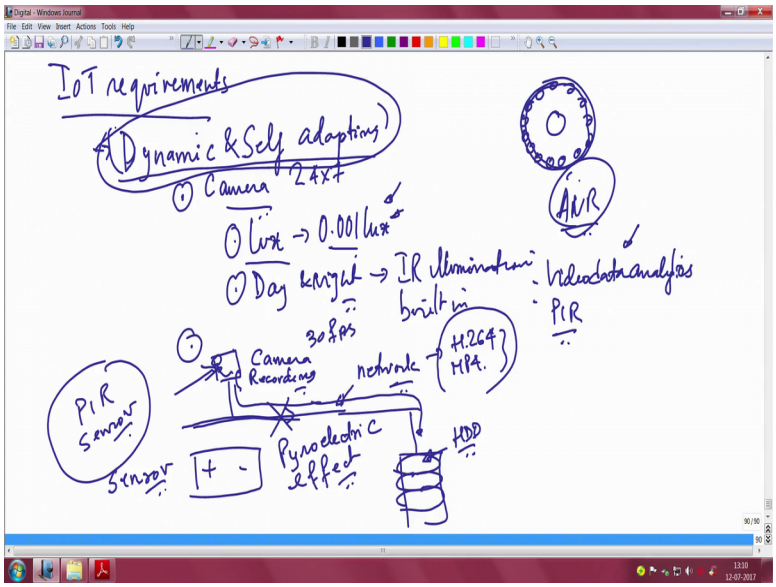

So, I will say IoT requirements, I will really you I have un using this because of lack of better word, but if you do think that there is a better word please do it. First thing is they should be dynamic any IoT system that you design should be dynamic and self-adopting. Big bullet big understanding big name on this it is very simple what actually it means us the following, for example, you take a camera surveillance camera what does a surveillance camera do. So, I will put down an example of a camera what does a camera do.

Camera essentially is a let us take you take a surveillance camera or some camera which we are placed in front of your house, essentially you want 24 bar 7 monitoring of this camera correct which means 24 bar 7 monitoring of this camera. Look at what happens; you have daylight, you have good sunlight during the day and during the evening the whole system becomes dark, you still need good pictures, you do not mind compromising on black and white pictures towards the evening after it is you know after the sun comes down or you may want to enhance the environment lighting so that the camera sensor is able to still take color pictures. So, there is one important parameter called the lux which we descript to describe already when we are looking at energy harvesting and photovoltaic systems and so on.

So, they will be a specification for the surveillance camera that you want to buy. I want to monitor under very low lux right that is the unit. So, you people we will say 0.001 lux is what my camera can provide. Another person we will say I can only provide you 0 0 no maybe 0 0 0 dot 0 1 lux thinks like that. So, this is an important parameter to look at. The other parameter that you will be looking at before you buy this camera sensor is it should work day and night day and night. This is an I would say a insufficient specification if you just go buy all the confusing data sheets of buying a camera, you should ensure that there is for night there is IR illumination built in, illumination built in right. So, IR illumination is built into the system.

So, that if the light comes down if the lux goes to a very small value the IR camera the IR illumination IR l e d's let us say typically you will have the camera, and all round you will have l e d l e IR l e d is around it typically these are all the they I am I am just telling you one camera that I have seen. So, this is the main lens, these are all the supporting l e d's which simply switch on moment the sense that the light is low. Go back and look at your definition dynamic and self-adapting what is it doing its doing all of this it is able to detect that the lux has come down and immediately it says I had to switch on the IR light IR l e d. So, that the area under which I am doing surveillance monitoring, it is able to essentially illuminate IR illuminate the system so that at least black and white pictures can be taken by the camera.

The third thing; that means, the lens should basically remove the IR filter which you do not want in the day right. In the day you do not want the IR light to come in because there is already sufficient light and the visible light itself is good enough for the camera

sensor to pick up the images color images, and in the night if you feel that the illumination is very poor and you are not able to provide equivalent of whatever white light I mean I will be very careful because you cannot beat the whole spectrum of light that the sun gives light; whatever artificial white light that you create is good enough for color pictures that which is also insufficient, then the camera has to switch to black and white and therefore, when it is switches to black and white you need the IR illumination.

So, you actually want the system to have a motor remove the IR filter from the lens directly, either it should do that or keep the lens and switch on that you know artificial white light so that these IR l e d's can be switched off are not used and in fact, the camera is working under normal you know in the night also it is working as though it is like a day camera. Because there is efficient a let us say l e d lighting good amount of l e d lighting good amount of l e d lighting covering a good spectrum such that the camera is able to move back to the color mode all this means here it should be able to do dynamic and self-adopting the.

So, this is a bullet essentially talking about that, you could also be talking about in the same camera system because the camera. So, what is the camera? The surveillance camera essentially the there is an optics right and then there is a cmos or a c c d charge coupled device based sensor which is capturing the image, and then you have essentially image data then you have video data, you have a video stream coming and that video stream has to be compressed.

So, that you may want to transmit over you want encode it in some way, and you want to compress and then you want to transmit the compressed video on the network all right. So, I will say I will just put the camera sensor this is the camera sensor equivalent it is not a full picture, but it is like this is the network. So, directly you are doing let us say 30 frames per second, your capturing 30 f p s; let us say and you are using some compressions scheme encode and compressing scheme, it could be h dot one of the H dot 264; I think 264 is a standard are M peg 4 a systems are any one of these standard compression schemes you want to and you want to send the data on to a central storage device, because you want to archive the video streams.

But that is not going to you cannot be doing it all the time 20 bar 7, you want to start this camera only when there is a human movement across it. So, there are these motion

triggered cameras essentially they will have a P I R sensor, and the P I R sensor we will detect motion and once the motion starts the recording we will start it will it will do the compression and then it will do a transmission on the network. Now I assume that the network fails right.

So, you need a local storage now camera is again got to adapt itself it has to say o I have sent that the network is down I am a switched and put the data back on the local storage how is that going to work. So, there are features which outlook for this camera I think it is called ANR feature, this particular aspect is also called I am just giving you some normally used commercial times called automatic network recording or some I forget the actual expansion, but please do look up that expansion on what this actually stands.

So, there is a feature there that is the key point again it emphasizes the fact that dynamic and self self adapting is a very important feature and this is a very good IoT product you can think of very very good IoT product. P I R sensors essentially are those elements are is basically a sensor which essentially has a its a differentially wired sensor. Essentially, if it is I think I mentioned this one's to you, but just to you know sort of recap it uses the concept in physics called Pyroelectric effect pyro electric effect and essentially come.

And you know very popularly it is also called the passive infrared sensor P I R actually people use it as passive infrared sensor. Essentially it means this that if there is a human the human is emitting a lot of IR radiation all around all the time. If this IR radiation appears in front of the sensor, it says there is a human I mean it says there is motion it would not says its human, it will simply say it is a human it is a there is a motion moment it sensors that there is a motion this camera we will start the recording process.

So, camera recording; lot of research lot of nice things are happening to use the simple P I R systems to essentially differentiate between the motion whether the motion happened due to humans or whether due to other animals, even if there is a dog which cuts the camera it is going to start recording. So, you do not want to get into that you want to build an intelligent system, and its worth investing some amount of time energy and technical effort in order to build multiple P I R systems which can essentially use that as a signature for differentiating use the multiple signals which are coming from these P I R systems, for the purposes of recognizing whether it is a human or a animal which

actually got the witch cross the camera. If there is an animal you do not start the recording; that means, you have added additional intelligence into the camera.

Some amount of analytics as they call video data analytics would mean it is the camera that got the image, for grown through for instance you can open the camera look at the ground truth and then say this was a dog and therefore, I am not going to do it, but the main sensing actually came from let us say P I R right. So, you have a set of P I R sensor from which from algorithm that runs on it, nice classifier for instance between the animal and human and that the classifier says I found that this is a dog and now the and it gives a trigger to the camera and say you go and check whether it is really a dog, then you switch on the camera you identify that this is you get you capture and image and you run a video analytics or a image analytics algorithm, find out that it is indeed a dog and then say if that is a dog I am not going to do any recording, I am going to save on the hard disc space here hard disc space and so on and so forth.

Which is a clear indicator that IoT does require all of this support of this dynamic and self-adapting feature in order to you know actually if you want to make a system, this is a very important requirement.

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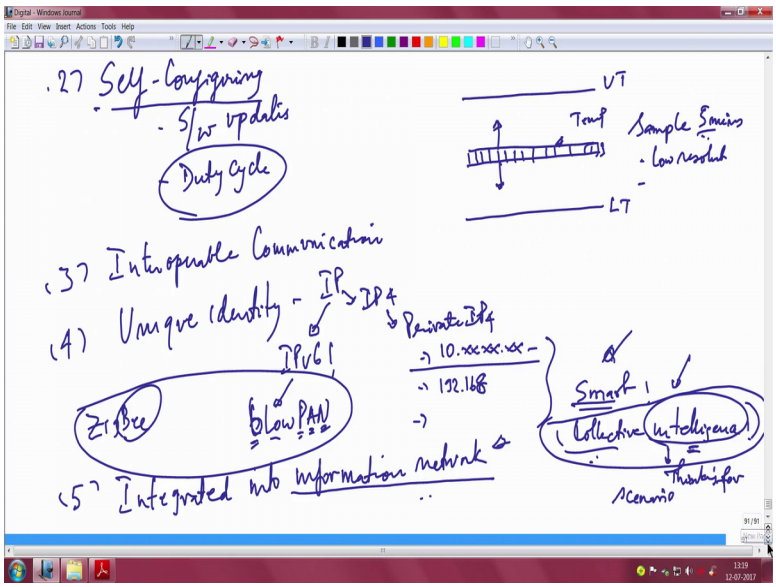

The second thing is self-configuring right the second thing is self-configuring. In other words we talk about software updates and adjusting the duty cycle for sensing for

communication whatever if it is doing some sensing it should be able to let us say adjust its duty cycle, I give you a very simple example.

Let us stay there is a sensor which is expected to monitor the temperature. So, this is the temperature, I am just visually putting it down and there is a band that you have associated this is the band. You are saying and this is lower threshold and this is upper threshold, this is the point where it is supposed to monitor. You are saying as long as the temperature is within this band you sample every. Let us say 5 minutes I am just putting down some examples please 5 minutes and do it at low resolution do not do 16 bit, do not do 24 bit do 8 bit, maybe even 6 bit very low resolution right low resolution and sampling time is very high right is a high sampling time, but when it starts moving up either up or down you want to be a little more aggressive right. How we will you do that unless you are self-configuring you should be able to change the duty cycle of your system such that it is able to monitor much more aggressively.

The third thing is you are bound to live in a world where there has to be interoperability. So, I would put down inter operable communication is a must communication let me complete this. Which means whatever be the vendor whichever is the vendor whoever is the vendor with whatever protocol that he comes up with he should be the sensor should be able to talk to each other there is no way by which you can say I am going to do only this, and this is not going to work. If you do as closed standard you are bound to that vendor right for any further improvements or anything, and it may just turn out that that vendor simply closes a down and closes a shop and then goes away you are stuck with all the equipment that you bought from that vendor it is not going to work. So, you are going to I mean it is hard to you know to get to have success and scalability with that kind of thing.

Therefore you may want to look at inter operable communication. The fourth thing is unique identity right this is like your Adhaar card, one number which is unique to you right that is possible in the world of IoT only if you have I P stack and just not I P stack it has to be I P v 6 only and you cannot have a full blown I P v 6 stack on a small constrained device IoT device where memory is a constrained, size is a constrained, you know you want improve life times yet you want I P v 6 therefore, you must put constrained I P v 6 and if you are using you know mac layer protocol such as zig bee

mac layer protocol such as zig bee and so on; they actually support a protocol called 6 low pan 6 low pan 6 stands for I P v 6 low power personal area network ok.

So, you must be looking at unique identity not I P v 4 anymore, but indeed I P v 6 I will struck it of but I will be a bit more generous because we use this quite a bit also even now. In fact, lot of it is very we are all comfortable with I P 4, and it is restricted to private I P either it is the ten dot x x dot x x dot x x range in the you know classical submit based systems or it is the 192.168 if it is the class b; this is class a, this is class b or I think there is one more 168, 168 is also there I think I anyway this is class a and this is class b. So, it could be it could be the private I P v 4 in the case of I p and in the I p k I P v 6 is indeed it has to be I P v 6 and if it is constrained environment, it has to be and if you are using zigbee kind of modes or zigbee kind of devices for all your sensing and communication protocols then it has to be 6 low pan.

Alright then the other thing is related to fourth or we will let us say the fifth one. The fifth one indeed is related to integrated this is important integrated into information network. Remember what we are saying this is all about information network you take the whole thing we are actually talking about information network systems right; it is just not about you know being doing things smart, it is not about a smart node it is about collective intelligence really, there is this this topic of smart and intelligent are often it is a very subjective thing, but I in my view they are different this is more to do with thinking right you have to deeply think on for a new scenario thinking for a scenario which you have not encountered earlier right.

So, that is something; that means, you are you need intelligence there, but smartness is doing things autonomously and taking care of a few things program things, and you know bringing in a lot of aspects of doing I would say more. You say if you are say you are a smart sensor which means you can do many things on your own, you autonomously sends you do all of what we discussed even with respect to the let us say the camera sensor I mention to you it is doing lot of things by itself, but really intelligence is the fact that the camera sensor caught something the camera system that we discuss caught something which it did not know earlier, how does it react to that situation that will be perhaps much higher order.

And that would perhaps mean it is a really very good intelligent system. In the IoT world I would say that it is very hard to achieve that by a single entity, it has to be a collective set of nodes which ultimately lead you to give you this collective intelligence because this scenarios that emerge when you talk about a collection of nodes towards getting to achieve something, can actually add to the overall collective intelligence of the system.

Therefore it now boils down to building intelligent systems or IoT systems not just which are dumped in terms of being I mean in in fact, smartness is a one part is going a little more than being dumb, but being a lot more intelligence means a collection of devices collectively which are able to do intelligently the intelligently able to meet the required goal right now this is the motivation.

Very small devices smart devices no problem, but at some point in time the smart devices while they are very smart may not have a con may not be able to achieve a bigger goal of being collectively very intelligent they are not intelligent. So, therefore, you need to get all pieces of data collected by each one of these nodes in a transparent manner, and together they will perhaps provide a collective intelligence; together they are able to do a few things, together they are able to achieve things of the required goal.

Let us see a demonstration of the system in small bits and pieces with the small introduction to, the first IoT protocol which is called m q t t message queue telemetry transfer.

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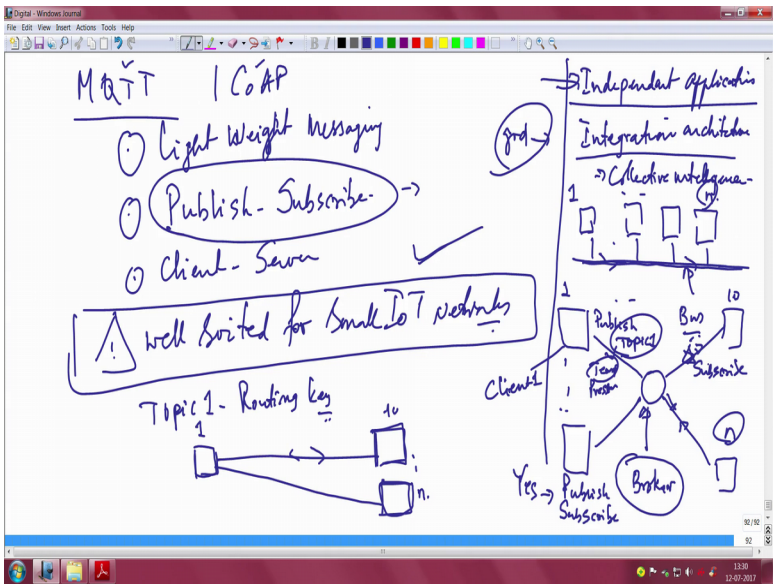

Let me give you some story before we go for the demo; this is basically a very lightweight light weighted sorry this is to rub it out light weight hoops w e i g h t light weighted messaging protocol messaging protocol, it is based on a very important paradigm I think you must spend enough time in understanding the philosophy of this. This is called publish subscribe it speaks volumes about this whole protocol it is definitely client server there is no problem, and I would say very importantly well suited for small IoT networks.

So, design for IoT means design means choices should I use m q t t or should I use something else, you will come to this point at some point or time in time. Well, you are the best judge you have to look at that famous word I keep saying it depends right. So, you cannot be saying it depends, but you have to actually analyze the ground reality what is it that you want to achieve and use that as an input towards choice of whether it should be m q t t or whether it should be another IoT protocol.

Quickly let me summarize the other one is indeed the constraint application protocol called the co app right, should it be this or should it be this well we will see as it goes, but I can tell you this is my take on the system if you are its well suited I would say, for small IoT network you want to start something quickly you want to finish off and you want to test your system thoroughly, you do not want to look at any scaling at the moment you still want use publish subscribe framework architecture please use m q t t, message queue telemetry transfer where to get into the details of this right.

That is one part of the story, now how does it suit the way by which we have been discussing about this important requirement of integrated into the information network is the key right; obviously, we put down all these basic requirement. So, somewhere it should get integrated. Now let me put back this how this architecture is good; basically before you get into this architecture, what are the options that you have you have to put down for integration architecture arti I would say you have independent applications basically, you have independent applications in the one on the one side.

And you want integration architecture. you need a architecture this is what you want this is your goal and you have sensor nodes each one independently monitoring something or the other and it is doing itself right it can be doing think smartly no problem, but you want an integration architecture because you believe in collective intelligence, we

believe in can collective intelligence how does this m q t t fit in? Before we do that look at it this way.

You have different ways of you know getting to this integration; one is you use a bus based architecture you use a bus essentially right you have 1 to n nodes, and this 1 to n nodes essentially are able to you know send data are able to communicate amongst themselves using this network bus it is a common bus this is one way. The second way is you do it with one middle entity and you have entities which are connected to it right I will say 1, this is some 10; let us say this is something and this is finally, n. So, the same n that is here is now going through this middle entity this middle entity is actually called the broker. Now you have nodes which publish and there are nodes which subscribe to these nodes publish on a topic nodes subscribe to the topic and get the data. So, you have publish and you have subscribe, that is why it is called the publish subscribe architecture this is called the broker.

These are clients client this is a client, client one and is goes on like this. So, can a client you may ask questions like can a client be both publish and subscribe can you do both? Yes why not they can be published, they can be publishing and they can also subscribe. They can be subscribing to another topic this is topic one and who initiates the topic who holds the topic everything is held in the broker. So, broker you can see this topic is strange right its written as topic, but indeed this topic is nothing, but the routing key itself, it is like a route. If there is a node n who does not want temperature you will simply not subscribe to it. So, there is no subscription there is no sub subscription to it, but if this node is the also sending out pressure he may want to subscribe to it.

So, pleasure information goes in this direction pressure data, but temperature data we will perhaps not go all though it is coming from the same node. So, very intelligently you loot the data based on the topic. So, topic is like a route. So, I will say topic in very simple terms it is also the routing key. So, that is the key thing and this m q t t actually uses this, but you need to complete the story right you said independent application integration architecture for collective intelligence the first type is a bus.

The second is publish subscribe architecture what is the third well third is pretty pretty straight forward nodes we are denoting as this rectangular block. So, I will continue to use rectangular you can do one to one right. 1 some 10 and this is n, you go on

establishing one two one connections here it is obvious, this node knows to whom he sending he knows to whom he is communicating both ways here you do not need to know that disconnect, they are disconnected so well that this fellow may publish this node may publish at a particular time.

But this node may pick it up at a different time because of certain considerations this node did not come up therefore, you can pick up at some other time. Clearly it is an indication it is an indicator, that the they are not connected with each other. You can have something similar to being connected or disconnected in the bus based architecture, we just puts out the data on the bus who are wants to pick up can pick it up or it can also be that by all. So, so the main difference between this bus based and the broker based is there is no central entity right we can see that the data is available right on the bus. So, if you want to go a meet this goal of integration architecture for collective intelligence, for small networks without connecting the client to the subscriber and the publisher, but passing through a broker seems to work well for small networks.

Let us see a demonstration of this m q t t and then come back and complete the discussion on m q t t right. So, if you recall I was telling you all the basic requirements for I o, I o t's right and we also mention that we took an example of one IoT protocol that we wanted to demonstrate, this is with respect to the camera example I started with. Now what we will do is we will try to connect everything with a very simple demonstration, I which basically we will show you the power of this published subscribe kind of paradigm communication model under which IoT devices can actually benefit from. So, first thing is I will. So, the big story goes like this the demonstration goes like this, first is to see if 1 IoT node which has a sensor called a P I R sensor, actually detects a motion right; that means, a human has entered or an animal has crossed or something the sensor has actually detected it.

So, let us call this by the name where topic in the m q t t as I mentioned is like a routing key, let us give this a name for the topic as motion just the name called motion. Now the pay load that should be contained in this topic the message that goes out should say detected alright. So, let us see how we can first of all detect this motion, and then we can then see how this message can be published right. Now there is a so, it should go where it should go to the broker. I do not have a physical broker and that is the beauty, I

actually have the broker sitting on the cloud and so we will assume that there is a cloud and I will show you a small triangle which says it goes to the to the broker.

And, we can discuss these actual configurations in great detail as we go along and how you can do this all by yourself we just simple mobile phones with you. And that should now be received by another sensor which says there is a motion detected right if the motion is detected what should you do? You now want to now you may want to switch on the camera to actually catch the face of the person who on which you want to start either recording or use it for the purposes of authentication in case it is a door access system.

That should be another senor node, the other sensor node is only interested to know if there is a motion that is detected and it will do its own processing. Go back to the original concept of collective intelligence we mentioned. So, these nodes together are giving as a fantastic level of intelligence for our application. So, now, what we will do is we will a shift you, we will I will let us know focus on the equipment and the simple board which Madhuri we will demonstrate.

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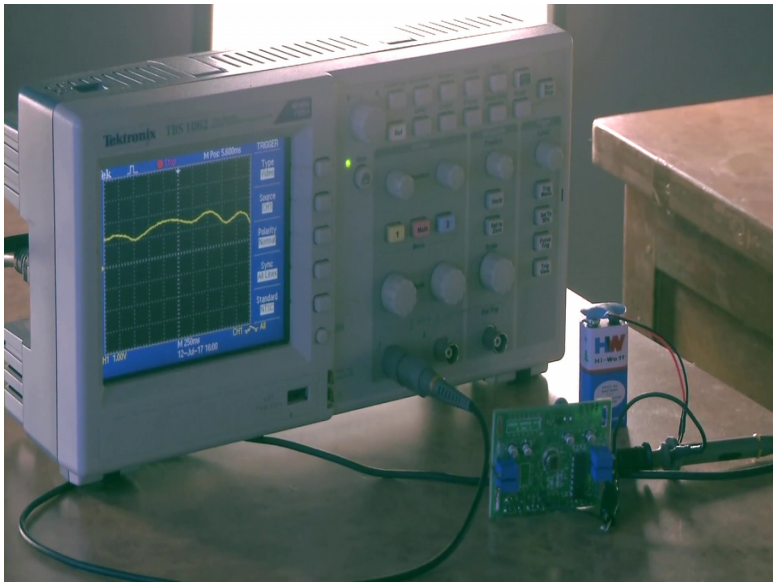

So, what she has done here is, she has set up a P I R system and she has shown a detection. You can see it is a very simple very very simple analogue signal that you can get from this P I R sensor, and let us see if she can actually show you in real time if she can actually capture this signal if there is motion.

So, the way she is going to demonstrate this is, she is going to waver hand in front of this P I R sensor she is going to show you where the sensor is and then she is going to wave in front of it and let see what actually happens on the oscilloscope alright. So, now that is we can see in now the detected captured wave form is reset, now go head where is the P I R sensor? That is the P I R can you use a pencil or something which by which you can point to the P I R system never mind.

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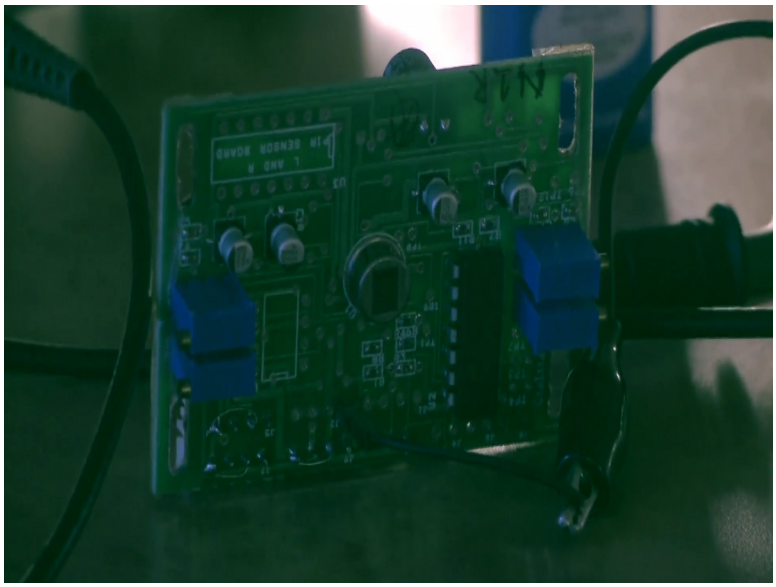


Now, so that is fine is s that is the P I R sensor the potentiometers are for what the potentiometers that you see these blue potentiometers are for adjusting the gain of the potentiometer

Student: Yes.

The gain of the P I R amplifier.

Student: Yes.

So, it is a two stage amplifier that you have here, and then these both the stage gains are being adjusted.

Student: Yes.

And your power this with a.

Student: 9 volt.

9 volt battery, what the kind of current consumption for the sensor.

Student: It is about 1 million amplifier.

Roughly 1 million amplifier.

Student: (Refer Time: 45:40).

Including the electronics.

Student: Yes.

Including the electronic: so you have a two stage op-amp circuit.

Student: Yes.

And then you are getting that signal can you know demonstrate to us.

Student: Yes.

The P I R system very good, right; so you can see that can you wave again and you can you can hold the way for.

Student: Yes.

There was a way from here maybe the time base can be reduced. So, that it is able to go faster yes even lower even lower.

Student: Even lower.

No. So, that you get the full yes let us see now ha good hold it, now you do it again and hold it yes hold it yes. So, this is essentially a very small signal and the voltage levels are very low. So, the trick in P I R sensor essentially is not so much to do with the sensor, but really the optics that goes with it. So, Madhiri we will now demonstrate three different types of lenses that should be accompanied with any P I R system. The first one she has in her hand is a golf ball lens as you can see this is a lens which will allow the detection if and how we will you place it on top, you in a place it on top of the lens system here and then it is able to detect with almost 120 degree angle any motion that happens.

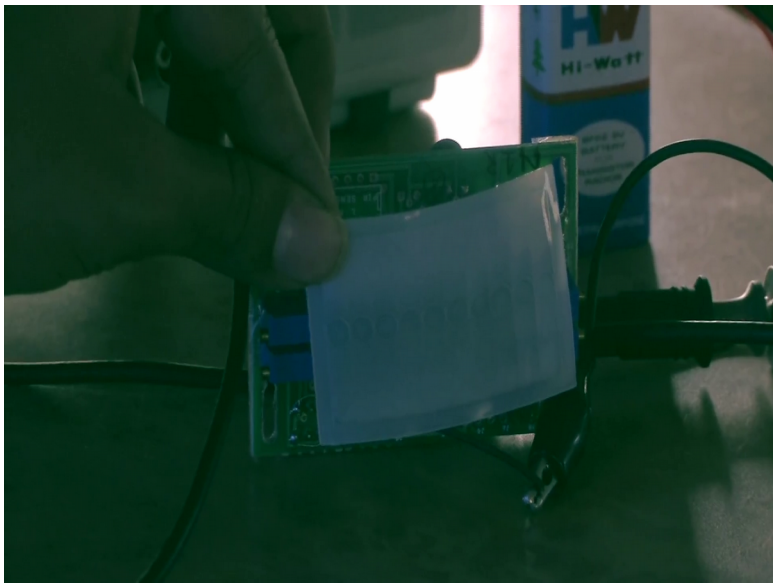
So, this is one type of lens supposing you now want yes its fine supposing you know do not want such a high bandwidth or high a bema width, you can actually going for a spot lens and what Madhuri has in our hand is a spot lens which you will have to actually hold against at a con at a at its focal length.

Student: Yes.

At its focal length so that it is able to concentrate and give us a signal. So, this is like reducing the bema width. Now another type of lens which essentially a most people use this is called a multi lens, what you can see here is a hold against this. So, that there will be the lines that the camera can capture.

Student: (Refer Time: 47:53).

(Refer Slide Time: 47:54)



You can see that the number of lines here, each line is like one detection. So, if she is able to mount this against the P I R lens and if she is able to hold it there and if a human actually walks across there will be multiple analogue signals that appear here, which we will essentially give her a we will shall give you a feel of the number of detections, you will actually get multiple detections which we will give you a nice sine wave as it moves from as the human crosses or a body crosses from either left to right or right to left.

As you can see depending on the polarity of the signal, we will demonstrate that subsequently you will be able to see whether it is a the person has actually cross from the

left side to the right side or from the right side to the left side that that direction is also possible, and the amplitude we will actually tell you what kind of distance from the P I R actually the detection actually happened.

So, this is about the sensor. Now imagine that this information is now going on is now captured into a publisher right who wants to take this data and push it to a broker Abhirami is here.

(Refer Slide Time: 49:13)

And she will show you with mobile phones, how you can actually invoke a simple application on android phones by which such a data which is a topic referred to as motion and payload containing detection detect can actually be transmitted. So, the app here a is referred to has.

Student: (Refer Time: 49:46).

My m q t t which you can download from Google play, and you can see it is a very simple interface.

(Refer Slide Time: 49:47)

There is a dashboard, there is a subscribe, there is a publish and you can also see stored messages there, and there is a simple button for any specific tuning that you want to do and see on top here very carefully, this publisher is actually contacting a broker and you can see right on top the name of the broker it is called broker dot hivemp dot come, essentially this broker which is a triangle here is somewhere in the cloud, somewhere on the internet somewhere on the internet.

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There is no physical machine here that is the beauty is the physically you do not need to have any infrastructure, and if this phone has an internet connection which most often you know phones with 3G, 4G actually are able to do can actually transmit this message which is essentially having a topic name as motion and carrying a the name the payload as detect ok.

So, let see how Abhirami is able to do that and obviously, there is a consumer for this data right. You can see that you do not need humans to do that, that detection happens it comes to this phone because it is interfaced this is like a sensor node you can imagine this to be like a sensor node and let us see how automatically that message comes to the subscriber alright.

(Refer Slide Time: 51:24)

So, all the configurations can be now shown on the subscriber alright. So, now, Madhuri and Abhirami are here Madhuri is in the role of a subscriber and Abhirami is the publi is is someone who wants to who needs the data, this is like one node and this is the other node right. Now the first step is that Madhuri we will enter the name of the topic; the name of the topic is as we said it is motion. So, she will type motion and she will subscribe she will subscribe to that topic, what is the message that you see here it is motion.

Student: Yes.

Is there anything called detector or undetected.

Student: No.

No. So, he is just waiting for any event that might happen

Student: Yes.

Through the P I R sensor which is connected to this.

Student: Yes.

Publisher right now she is about to send the topic name is motion and the message itself is called.

Student: Detected.

Detected and she is about to publish that, you can see now she publishers and it says it has published the data here and we should be able to see it here you can see detected comes right. This is a clear indicator that they are not connected physically, there is sending their message is independently to the m q t t broker, and the broker has the topic and the topic the information is held in the data is held against the topic is given out to all subscribers of that particular topic it is like a routing.

So, this machine has now receive the data. Now from here many interesting things can happen right what can happen is this is the guy who got the information that there was a detection he can issue back a message asking the system to either start recording or open the door access and so on and so forth.

We will see the remaining part of the protocol in its full architecture as we go along in the course.