**Design for Internet of Things**
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Lecture - 33
Introduction to Protocols

All right, welcome back. Let us do one more module related to protocols, okay. Do not worry about this term called protocol. Let us go back to the first week example that we had, okay.

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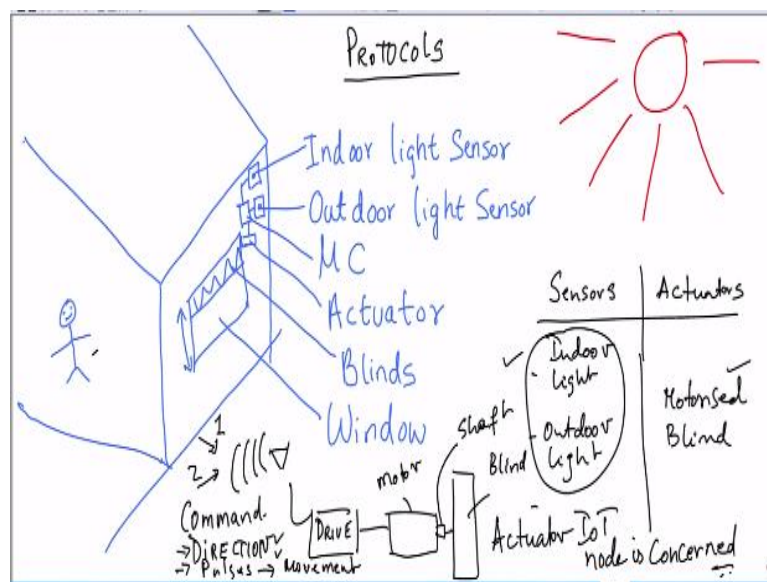
Let us go back and look at it. What was the first week example? It was a pretty straightforward one. Our objective was to adjust the blinds based on the lighting condition. If the indoor light is poor, not comfortable for the human who is sitting inside and you know that outdoor light is pretty high, because there is a sun which is shining brightly, you want to allow some amount of sunlight to enter inside.

So the best thing that you want to do is you want to open the blind and the blind opens, such that it allows sufficient amount of light to make the human happy, right? That is what you want because that is what will cheer the person. Okay, how do you realize this? How can you build such a system? You need sensors and you need actuators, correct? You need sensors to sense the light. So light sensors you need.

Actuators means you need a motorized blind. There is a motor which is, the blind is a load for the motor's shaft. And there is a motor drive. You have to give a command to the motor drive, which says it is sufficient for that. The motor will rotate, convert the rotation motion into linear motion. That is the mechanical domain circular to linear. You can use many mechanisms out there.

You have rack and pinion and so on, so many mechanisms, okay. Camshaft based mechanisms and so on, whatever be that. That is sufficient for the blind to lift, correct? And once it has lifted to the right extent, it has to stop, okay? This is the game. Remember, if there is too much light, and you have not been able to stop the command means the blind has opened more, correct?

That means you have to give a command again, to ensure that the blind comes down. If you pull it too down, the inside light may not be sufficient. So you must ensure that the command to the motor drive is just about enough that it halts exactly at that point with little oscillation in the amount of light that is coming in. It is okay, little bit here and there maybe 100 lux more or less is okay, right?

You would not even make out much difference. But beyond that, you may be able to sense the difference. So that much, blind should move up such that it comes it keeps, it does not know anything, it is a dumb thing. The motor is simply rotating. If you stop giving pulses to the motor drive, the drive will halt the motor. And if the motor halts, the blind will halt. This is what you should do.

Remember, you have to ensure that everything is done in a manner that the human is comfortable and it should be done in taking care of that to rotate it to ensure that the blinds move exactly to that distance. The sensors of interest are indoor light and outdoor light. What is your actuator? Motorized blind, okay? When I say motorized blind, what I mean is there is a motor, there is a motor shaft to which is connected the blind.

This is the blind, window blind. This is the shaft, motor and this is the motor drive. And this motor drive can perhaps accept data from some wireless link. This is nothing but the command. The command is such that, what all will it give? It will give the

direction and pulses sufficient for movement. Great, that is all you need to do folks. That is all you need to do. So who should do that?

How does this IoT node look like? All that we will build the story and we will see how it should be done. That is the first part, okay. This is as far as the actuator IoT node is concerned, okay. See, this is not going to be easy. You have to pass the command which contains information about which direction the blind has to move, up or down, plus or minus and the pulses such that it moves and halts either in the up direction or in the down direction.

This is not easy. From where will you give these commands? Who will give these commands? There is no human there. Everything has to be automated, is it not? So simplest is, do not even break your head on any of these things. Let this system only take one input, take only one input. That input is essentially the amount of light. It can take these inputs one or two depending on how you actually design.

Actually if you want to perfect the lighting condition inside your room, it needs two inputs, not one. It needs both, indoor light as well as outdoor light. So let it take the indoor light and outdoor light, convert that information into corresponding direction and pulses. So nobody is feeding any direction and pulses for movement.

It itself is intelligent enough to compute and ensure that it moves to that extent and halts there, okay. So that is the game. That is how you build your IoT node. And as I said, you will have to feed it two input, okay? And that two inputs can come from this wireless link. First input can come from indoor light. This is the first one. Second one can be outdoor light, okay? You just report the sensing condition.

Just report the sensor value, just report the sensor value and let the IoT node take these two inputs, compute and decide how much should the motor rotate and in which direction it should rotate is inferred automatically. How do you do all this? Can you get into building all these things all by yourself? No IoT has a full module.

IoT supports you in terms of exchange of messages from one system to another system in a proper engineering way, okay? There is a structured way by which you

pass these messages. And all this system is looking for is messages from indoor sensor and outdoor sensor. If it gets that it knows what to do, correct? So therefore, you need a message passing structure which is essentially the protocol, okay.

And that protocol there are many protocols. One such protocol is called MQTT, message queue telemetry transfer. The other protocol is called CoAP okay, constrained application protocol. And then there are other protocols. We will look into those details but this is the idea. You have a problem. You have to transmit that information and that is what we want to communicate. Alright, how is it done? Let us go to the next step.

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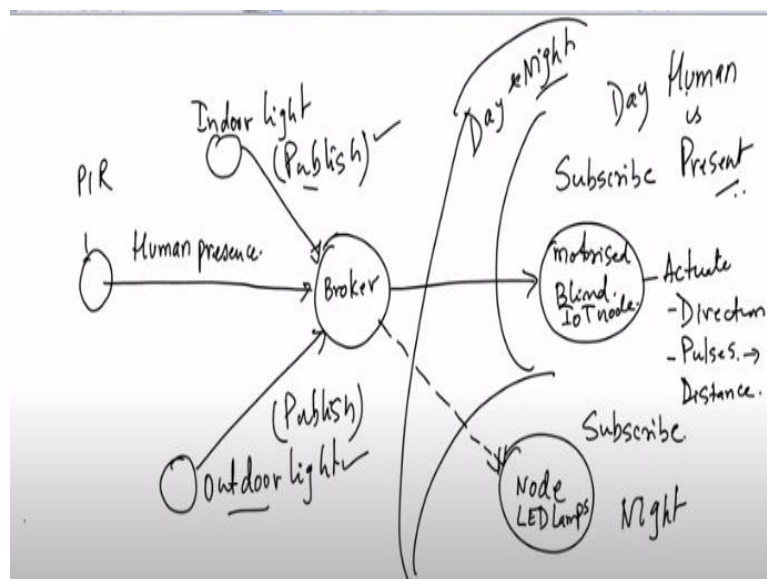
What you have to do is just this. Indoor light will have to be published. Outdoor light will have to be published okay, to some entity called a broker. You publish this information to this broker. This broker is waiting for somebody to subscribe. Now who is a good subscriber? The motorized blind subscribe, the motorized blind IoT node is a good subscriber. It gets this information and then it knows what to actuate.

As I mentioned what does it need for actuation? It needs direction open or close of the blind and the amount of distance it has to go. It is nothing but I call it number of pulses, which is nothing but the motor drive will have to be given some pulses for a certain duration so that it will move for a certain distance, direction and distance call it. Alright? See folks, this is very powerful, okay?

I will tell you why this is so powerful. This picture, you know what it has done? It knows how to open the blinds. Think about let us say you did not have sun. This guy did not exist. What will you do? Think about it, okay? Both of them indoor sensor and outdoor sensor will keep sending data to which one? To this guy called broker. They will keep sending to this one. What can the motorized blind do? Nothing. Nothing it can do.

If it tries to open in full open, still the light is insufficient inside because there is no outside light there is no sun there, it is nighttime. So you cannot do anything. You can do something very interesting with this picture that I drew in a very simple way.

And what you can do is take this publish publish data coming from outdoor and indoor and connect it to a simple node, another IoT node okay, which switches on the LED lamps inside the room, LED lamps. Look what you did. You did not create any additional infrastructure when you got these messages.

You just asked another node called LED lamps node to subscribe to the existing data, which is indoor light and outdoor light. And therefore you built an application for night. You built an application for day. Together you built an application for day and night. So folks, this is what you can do with IoT, okay. Nodes are just talking to each other. No human in the loop. Only first time to find out the level of comfort.

Only the first time threshold has to be put. And that threshold was maybe it is a small knob like a potentiometer or something. The human will go and adjust it and leave it there because that is the level at which the human is comfortable inside and rest of it is taken care. You do not need the human anymore, right?

And you want to do all of this only when the human is present, which means you need another sensor which will essentially detect that a human has come in. Only then you want to essentially get this whole infrastructure up and running day and night and all of that. What if the human is not in the house? You do not need any of that. Therefore, this thing that we wrote here is applicable only when the human is present.

Now what you can do is very simple. Very simple. You see how complicated you can build applications. Let us say I have one other sensor okay, which is giving me information about human presence, okay. Let us say this is, you can use a PIR sensor. Okay look up, you will know more about it. This guy is giving human presence. All you need to do is this guy has subscribed to indoor and outdoor.

You make this guy also subscribe to human presence; that is all. So you take indoor. So now let us draw some arrows. To keep it clean let me remove this part, okay. Let me remove this part. Let me remove this part also. Now it is clean. Now we wrote all this. Let me remove this, less cluttered, and let me remove this also.

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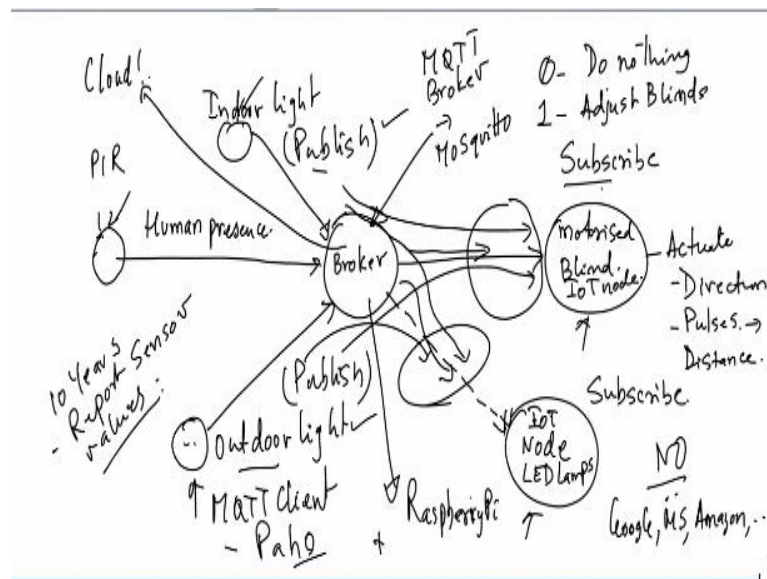
What you do? Get this guy to subscribe indoor light, outdoor light as well as human presence. Now you take the decision. If human presence is 0, do nothing, do not do anything. If human presence is 1, then start your algorithm, which will allow you to adjust the blinds. Similarly here, let this guy, node LED lamps, this is an IoT node, which is worried about the indoor lights. So what you do?

Ask this guy to get this data, get this data, as well as human presence data. You see each one of them have three arrows, these are also three arrows, okay. Therefore, with these you can start building very interesting applications. Again, you do not need humans in the loop. You are able to manage the complete IoT system with just by asking sensor nodes to just report their values, just report, just publish.

And then you build applications by taking subscriptions. You know that there are this information, you pick it and you build interesting applications. Fantastic applications can be built by this method, okay. What if the indoor light sensor failed? Yeah, you handle it here, right in your subscription you handle it. What if the outdoor light sensor failed? Okay, that means sensor has failed, but it is sunlight, okay?

Sensor has failed, but it is sunlight. Sensor has failed means what? It has no information about what is the outdoor light. So blind cannot get activated, which means indoor light is poor, blind cannot get activated, human is present, what will happen? Nothing is going to happen because it cannot move. But look at what happens to IoT node LED lamps. Outdoor light has failed, same situation happens here also.

LED lamps IoT node, outdoor light has not reached, indoor light is there, human presence has come, but no outdoor light recording is available. So what should it do? For sure, you know that your blinds are stuck, which means you have to switch on. You can easily build that here. Look at all the logic that you can build in by just getting these messages. You can apply this same thing when indoor light fails, you can do that, okay.

So essentially all of this falls into, passing of these messages will have to happen automatically. And each one of these sensor nodes that you see here, these will have to live 10 years and report sensor values. They will have to live for 10 years and report sensor values. Folks, now go back to the previous module. We did low power. You have to apply all that information that we studied here for this application such that it leaves for 10 years.

So your previous modules will automatically come in here. And this is an important thing. Now this, whatever I drew here this picture can be easily realized, can be easily realized with two packages, only two packages, okay. One package for broker and one package running on each of these nodes, okay. This package that runs on the broker is called MQTT broker. You can look up Mosquitto.

Okay, you can look up Mosquitto. That is the name of the broker. Now this package is called MQTT Client. And look up Paho. Paho is a client, Paho. So if you download very light, take a Raspberry Pi. And on this, you can run Linux, or Raspbian, any one of them and then install the Mosquitto. And this one, these are indoor and outdoor nodes. And you essentially run on all the simple controllers that we spoke of nRF52840 and 52832 and so on.

And run them on those systems and install MQTT client on those systems and just keep publishing them. This system is over. Now some of you may wonder, do I need internet at all to do this? The answer is no. You do not need an internet. You can do it inside your home. Set up the broker in one place. And put all the sensor nodes as you require and build your application. You do not need to have internet connection.

But folks, typically that is not the way to go, okay? That is not the way to go because several service providers like Google, Microsoft, Amazon, cloud service providers, many of them provide this broker on the cloud, okay? If the broker is available on the cloud, then each of these sensors have to upload the data to the cloud. How will they do that? Typically, the same paradigm is achieved, the same paradigm is achieved using, so let me draw it again, okay.

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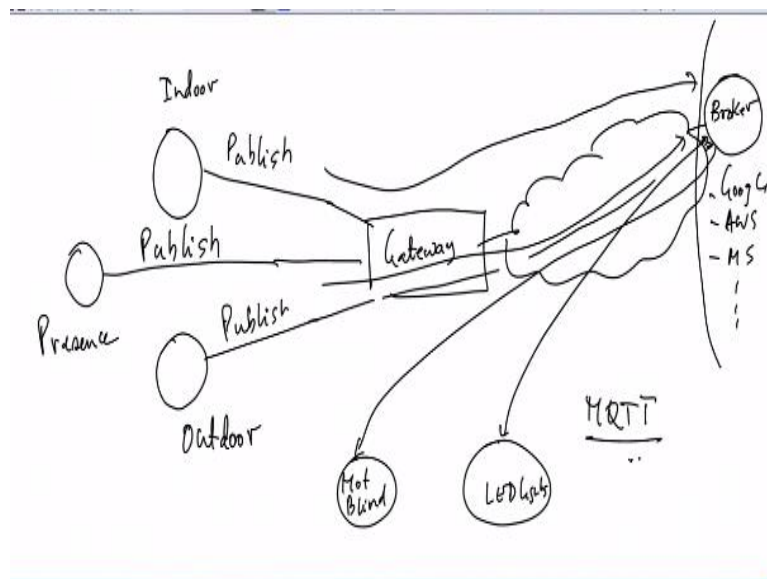
We took indoor, outdoor and presence. All of them will publish, publish, publish, publish via a gateway which in turn connects to the cloud and somewhere in this cloud the broker is sitting, okay. So this data will go like this, this data will go like

this, and this data will go like this okay, to the broker. And the broker will ensure that IoT node which corresponds to LED lights and the node corresponding to motorized system, both of them will have to subscribe, right?

So from here, so it has to come via the internet back like this. And via the internet back like this. This also I cannot bypass, so let me throw it like this inside. So folks, this how it is. This can be on the internet. That means this can be Google Cloud. It can be AWS and so on, Microsoft Azure, and so on. So many systems are available, you can do it this way.

So these are the motorized blind, Mot blind and this is LED lights just to complete the story, okay. Both are possible. Only thing is if you put gateway, it has to go to the internet and the broker is sitting on the cloud. Otherwise, you can also put the broker right here and route the data accordingly. It depends on what you want to do, folks, okay.

Why should I put a broker because if I have a home internet connection, office internet connection, internet can now actually carry the data to the broker, I do not have to set up the broker no? I do not have to buy a Raspberry Pi and put it. It can be used directly from there. You have to pay a price, you have to pay a small rental. But at least hardware is not with you. You do not have to break your head on the hardware.

So broker in the cloud may be useful. Anyway, I am just telling you that all of this is possible, okay. And this is pushed directly by MQTT. And now we will go into the details of MQTT keeping this particular example in our, in the back of our mind. Thank you very much.