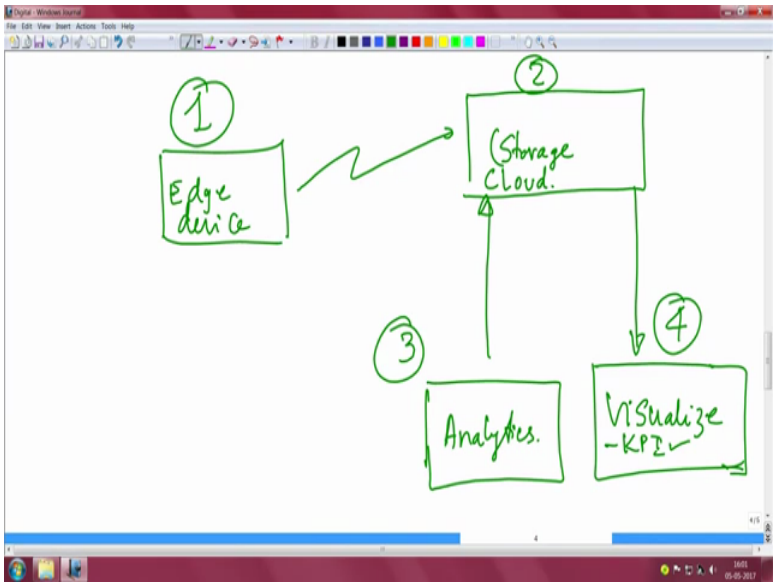
Design for Internet of Things
Prof. T V Prabhakar
Department of Electronic Systems Engineering
Indian Institute of Science, Bangalore

Lecture – 02
Introduction to IOTs – Part II

So, before we actually get into anything with respect to the design for the internet of things, let us just focus on this nice slide that we mentioned where there are four elements the edge device, the cloud storage, analytics and the visualisation part.

(Refer Slide Time: 00:25)

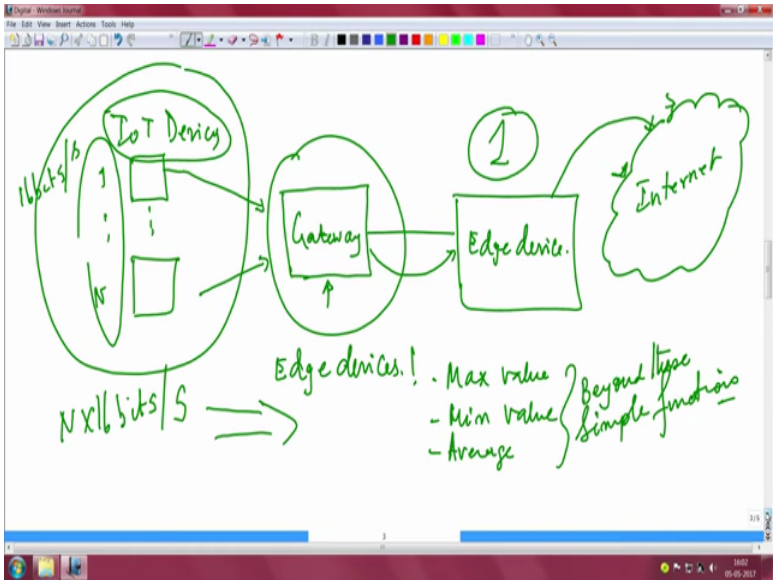


Let us elaborate a little bit on this visualisation, it appears as though that is just like a GUI which you have to worry about, but really that is not the case. This is a lot more than just apart from just being a GUI it is a lot more. For instance, one of the important things actually this refers, this visualisation tool is supposed to do is to talk about key performance indicators. What is a performance indicator? Essentially it is the measure of success which is quantifiable for someone and this quantification can be looked, viewed in different ways.

Essentially why do you want to do this quantification because, you want to sort of look

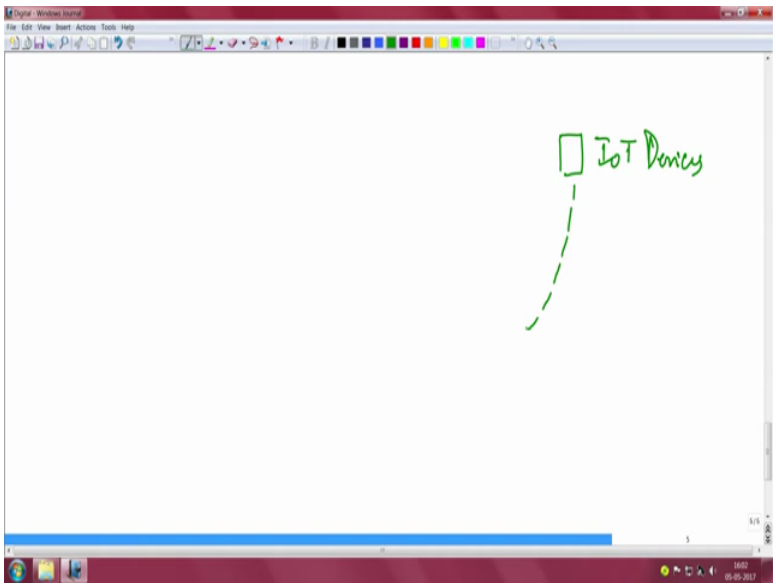
at, you want to look at let us say you want to reduce the risk of something or you want mitigate certain risks which are associated or you want to identify errors in the system, how good your system is performing, you want to let us say essentially if you are a company you are just worried about how to improve sales right - you want to reduce cost, you want to improve sales and you want to view things in real time that is the key here. So, there is a lot more things that this visualisation tool is supposed to do just apart from just you know displaying things for you. Many things have to happen in, actually happen, should happen in real time, which brings us to a very important part.

(Refer Slide Time: 02:06)



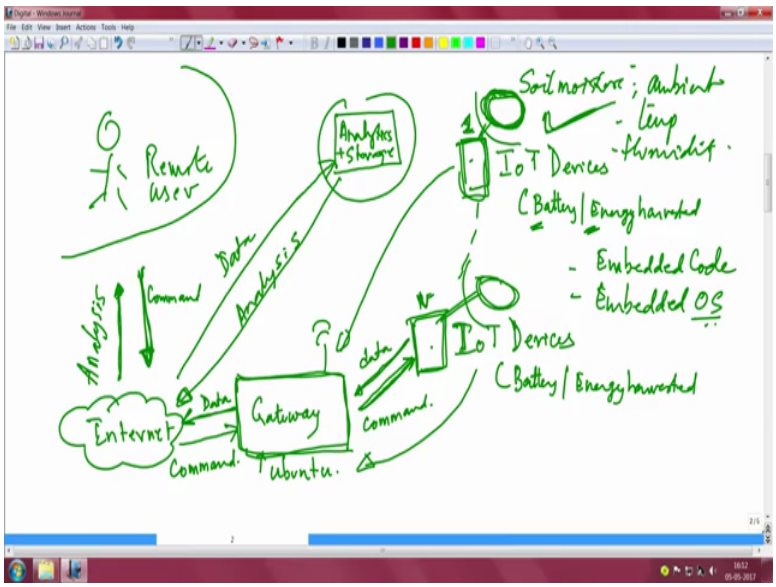
That apart from this slide that we spoke about IoT devices, gateway edge devices and internet we must essentially draw a very very interesting picture which actually summarises the whole of the design for internet of things and in fact, what an IoT system actually comprises of.

(Refer Slide Time: 02:35)



So, let us put all of what we did with respect to those four blocks into something very very interesting. Let us put down the IoT devices themselves right, so first block are the IoT devices themselves we mentioned about many of them let me just check if I already have them somewhere stored no, but this is just only one part.

(Refer Slide Time: 02:48)



I think I can take this as well. So, this I can build the story from here. So, we have 1 to n of these IoT devices, you have a gateway essentially it is an embedded system which is running either embedded OS or some embedded code and of course, it could essentially be at protocol translation which we mentioned in the last class or it could also mean that there is the internet system. So, I think I should denote it appropriately with respect to the internet essentially I will draw a cloud to represents the internet and of course, the user is somewhere here right and he obviously, he is not present he is the remote user and he is really not in the purview of these slides that we have here right, the slides these not slides the IoT devices which are here.

There are 1 to n of these devices and he is not really here he or she is not really here the user is actually sitting remotely. So, what is actually happening? We will draw a set of arrows to indicate a few things; we have already put down one arrow here which is data in one direction command coming from other direction. Obviously, there is a command coming from, this command should perhaps come from the user, so the command flows from the user back to these devices and if the user actually has to pass that command he will have to have access to some data which is coming from the analytics. So, which means the internet somehow there is a link from the internet to the block which is the analytics block right. So, this is key, analytics and maybe some storage.

Essentially we mentioned last time that it could be cloud storage or it could be local storage as well, but in any case analytics engine has to be there which means data has to go in and essentially analysis data, analysis data will have to flow back which means this analysis data via the internet has to go back to the user analysis. So, let me write it clean we will call it analysis data.

Now you see the picture, it is sort of completes the story, what does it say? It says that there are a set of devices here which are sensing the environment, these are devices 1 to n each one of them generating data periodically, these devices are either battery powered or energy harvested and they are giving data over a wired or wireless link typically a wireless link and these are ultra low power devices please note that these are really ultra low power devices, battery driven, may be running embedded code, may be running a small embedded OS, so let us put them down.

It could be embedded code or it could even be embedded OS, embedded OS right, we will touch up on embedded OS the details and that different types of embedded OS available today for IoT devices at a later stage, but let us put that down that there is some amount of intelligence in these devices not just because of some dumb code running, but indeed because there is a small amount of intelligence in terms of looking at some thresholds or looking at something with respect to the data itself before actually forwarding data to this gateway. It could be that or it could be just there also simple dumb devices just you know constantly sensing data and giving it to this supplying this data constantly to this gateway.

So, coming back, these are the IoT devices all of them which essentially are supplying data and this data is now going in the route of, to the analytics storage which means I miss this link right, this is data, it has to be data and this has to be command this has to be command, right. So, command in this direction. So, now, let us see IoT devices here 1 to n of them giving data to this gateway block and the gateway block in turn sending this data in this route to the analysis, analytics block, analysis data comes goes back to the internet, the analysis data goes to the remote user, the user looks up the analysis that the analysis the visualisation that he does based on the data, based on the data that was processed in this blocked here and gives a command back to the gateway.

Let us now convert all this into a beautiful story. Let us assume that each of these IoT devices are deployed in a large farm area and let us assume that these IoT devices which is represented by this rectangular block and the circular block circular system is actually a soil moisture block. It could either be a soil moisture block or it could be other ambient temperature measurement block, ambient temperature or it could be pressure, it could be humidity or any one of the ambient parameters including moist, soil moisture.

Now, the user is sitting here and he is collecting data from a large farm land where there are these distributed sensors which is supplying data constantly to this gateway and the remote user is looking at just water stress on the crop. So, that is what this system is actually measuring. And based on the stress condition at the current stage, in the current stage the remote user now decides to give a command perhaps inform if there is a say water stress on in the field now the remote user has to take a decision that the crop has to

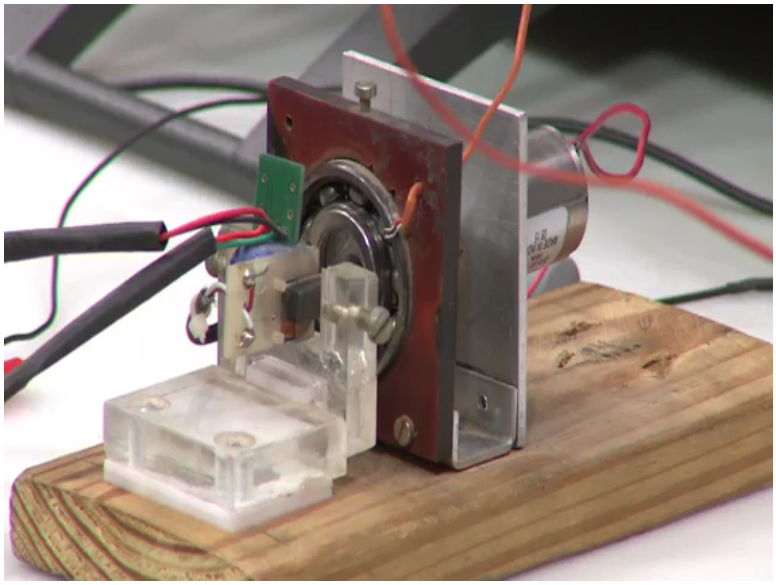
be urgently you have to supply water, right. So, you may have to call an agency which will have to supply water, so that water is you know supplied to this field and ensure that the crop is saved. So, this command essentially could be directly to a person who is on the field to request him to call up the concerned agency for supply of water or this command could directly go to the agency right and the agency intern takes this command and uses this command to come and water the surface the farm land and again ensure that these IoT devices start measuring the soil moisture, so what a beautiful story.

You have remote users you have local users here, you have a lot of IoT devices assume that this is a farm land, all these IoT devices are measuring the soil moisture and that data is going through the gateway to this remote user, before going it has to be the data is going to an analytics engine and the data is of course, stored you collect data hours, days, weeks, months, seasons and so that you are able to profile your complete area, geographical area and all the data is used to find out if there is indeed a water stress on the crop and the data you realise the remote user realises that there is indeed a stress on the crop and water supply is a must in the next 24 hours let us say for example. And that command now goes back to the agency which has to either supply water or command goes back to the personal on the field who will have to call up and get water supply to that particular field area.

This is what an IoT system for a farm land is expected to do. I just took an example of water stress, it could be any other kind of a parameter monitoring that you may want to do and you may want to complete the loop. Let us take one other example of an IoT system, but with respect to certain some other application, let us say you are interested in automotive application, alright. So, let us see what can you do with an IoT kind of a system for automotive applications.

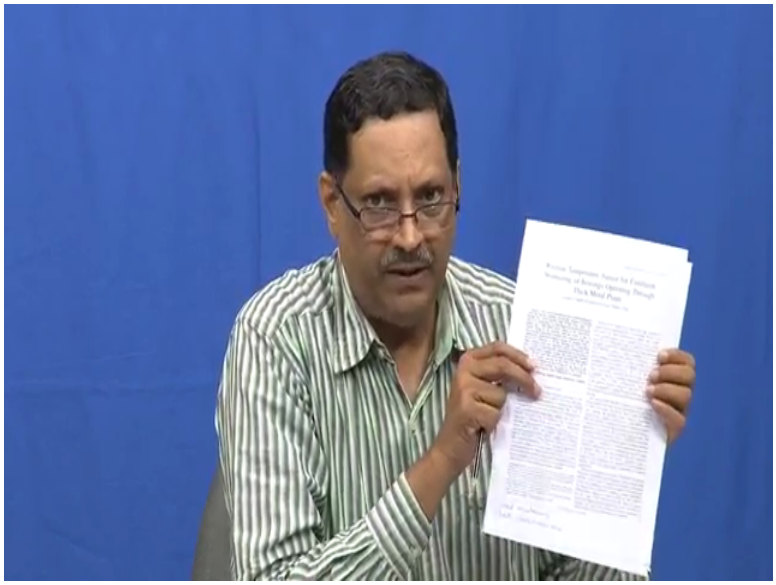
Particularly if you are looking at critical monitoring of certain parameters, for this let us shift gears and understand what it means to monitor ball bearings inside rotating machinery. This could be applicable to automotives as much to machinery which is used in large manufacturing industries wherever there are rotating parts you have ball bearings, and let me now zoom in and show you a lab setup of what we are trying to do in thought putting together an IoT system for condition monitoring of ball bearings.

(Refer Slide Time: 13:34)



In front of me here is this setup, what does it have? It has a DC motor which essentially rotates this bearing and where is the bearing? The bearing is right here this bearing essentially will allow you to, so I think there is a reversal. So, the bearing essentially will allow you, this is the bearing you can see the balls on the ball bearing here, the balls are here essentially you have an outer race and you have the inner race, the inner race rotates and so are the balls, you can see actually you can see the movement of the inner race and essentially is a system. And this system essentially is what you want to monitor the condition of this ball bearing that is the problem statement; how do we go about, how do we exactly monitor this and what is the parameter that you want to monitor that is the critical question, good.

(Refer Slide Time: 14:59)



This is essentially inspired by a paper, the paper title is here it says wireless temperature sensor for condition monitoring of bearings operating through thick metal plates. This is a paper published in the IEEE sensors journal, a volume 13, number 6, June 2013 this paper was published in the IEEE sensor general. And the inspiration for this experimental setup is indeed this paper. Now what is this paper; say what is it trying to do and what is its connection to the design of an IoT system is what we will discuss now?

Let us start by first understanding; what is the issue with respect to monitoring, condition monitoring of ball bearings? Before you get into the detail of what is condition monitoring you must first know what are the forms of monitoring, one of the simplest forms of monitoring which we are all used to is the timed maintenance - you buy a car, you buy a scooter or anything you have a schedule given to you and at that scheduled time you have to give your vehicle for service that is a time maintenance. Now there are issues with respect to time, timed maintenance and there are issues with, so this is one way, right.

Then the other way is if you have critical components like the ball bearing which we have which we were discussing here, there are other kind of issues and for instance one

of the things that you would be interested in condition based monitoring is to enable why do you want to do that and why is it different from timed maintenance. Condition monitoring will enable you safe and very cost effective operation, see what happens in timed maintenance is you may end up with a fat bill because there can be many replacements of parts if you do a timed maintenance. In fact, the manufacturer will tell you that this part has driven for, is used for let us say 6000 kilo metres and it needs to be replaced right. So, that is one way of maintaining a system.

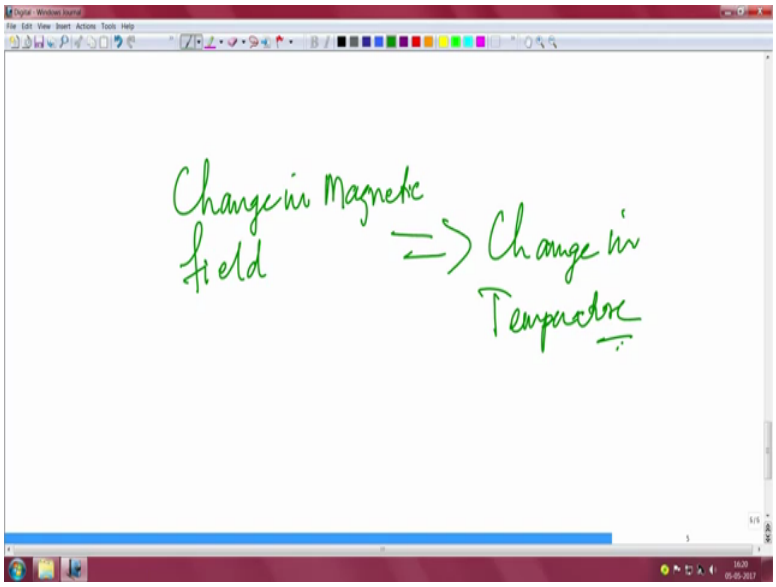
But if you are looking at critical monitoring particularly if there are rotating parts and you are looking at this condition monitoring you may have to look at safety as a very important requirement because if a bearing breaks down you can have lot of problems right, it can be a life risk. And where all do you find bearing? You will find bearings in wind generator, automobiles, aircrafts wherever there is rotating machinery you need a bearing. In fact, the paper actually list a number of reasons why you have to do condition monitoring of these bearings - one of them could be, it could be just a manufacturing defect it could be shaft misalignment right, there is this the motor and then there is this bearing and this bearing here and then there is a shaft, there is a shaft which is interconnecting the shaft of the motor is inter connecting to the bearing here and I could be, let us a fault in this shaft or it could be because the lubricant here has evaporated and all that and that in turn rising the temperature of the ball bearing.

So, any of these defects essentially what it will manifest itself will be that the bearing will manifest in terms of higher temperature, right. So, if the temperature of the bearing increases is a good indicator that this bearing is indeed faulty or it is coming to a stage where it requires maintenance or replacement right. So, that is really that the key that you must look at one parameter and that parameter indeed seems to be temperature good.

So, now, you know that you want to measure the temperature of this ball bearing. So, what we did was we put this wire here, so this wire essentially is used because this is a lab setup, you want to somehow you know want to measure it with some way, you want to measure the bearing somehow and. So, what you do you put let us say a thermometer simplest thing that you want to do is a lab or a industrial thermometer which will simply measure the temperature of this bearing here, well that is one way.

If you want to do an automatic measurement way you would do it in a slightly interesting manner and this paper actually talks about that. What it does is it measures the change in magnetic field and change in magnetic field is proportional to change in temperature. So, you are essentially looking at another important parameter here and often in IoT systems this is a very important point that you might not really measure the temperature directly, but instead you may measure change in magnetic field corresponds to change in temperature.

(Refer Slide Time: 20:20)



Now, how do you ensure that there is a change in magnetic field which means you will need magnets, right? Clearly if you go back to this nice little picture you will see that I have actually installed magnets, here this is a magnet you can see this is a magnet, but it is an arc right. We will come to the details of why it is an arc at a later stage. You see one arc, a smaller arc and another smaller arc and its back again with the longer with bigger arc sorry, not longer bigger arc, there is an arc smaller arc and another arc and you have this command bigger arc here, good.

Which means if this magnet sorry; if this magnet heats up, if this bearing heats up the magnetic field of this arc magnet would change and if you are able to read the magnetic field of this magnet change in magnetic field of this magnet then effectively read,

calibrated, measured the temperature of this bearing right. This is often the case when you talk about, this is a very important example in the sense that you may not want to measure the parameter of interest directly for several reasons for several reasons. One of the things for example, if you take this case you could have actually read this bearing temperature non invasively with an IR thermometer right, you could have let us say taken IR thermometer and show and you know take a beam, IR beam thermometer and just measure the temperature by this non invasive method, right.