Design for Internet of Things
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Lecture – 04
IOT applications – I

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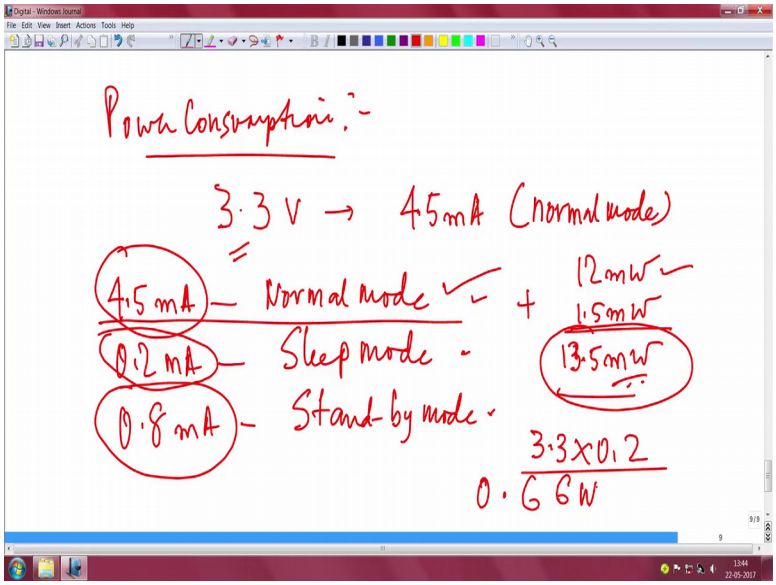

So, we did this calculation, and we find that if you go to standby mode, the power consumption is just only 0.66 watts, fantastic.

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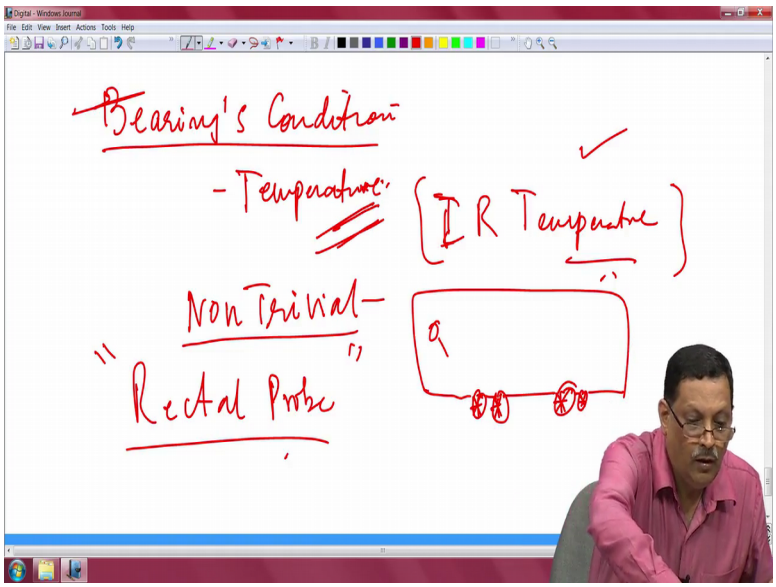

So, after this let us now look at; so, what did he start with? We started with the problem of how to measure the bearings condition and when we said we are looking at the bearings condition, we said let us measure the temperature of the bearing and we looked at temperature is a good indicator and we could not measure temperature directly, because that would be very difficult to do in a non invasive manner. So, we started to look at how to use the magnetic field and look at change in magnetic field and kind sort of you know correlate the change in magnetic field to the rise in temperature of the bearing, and we said that is the mapping that you are to establish. And then we put together a simple demo I mean graphic which actually showed the large scale system, which now would actually be do would be you know which would actually do this measurement.

Now if you just take this case of temperature; this temperature measurement is not at all trivial; nontrivial and you have to; see just one sensor as an example. So, we are just looking at in this course if you just start with temperature as an important sensor, this measurement it is never going to be never going to be trivial, and this measurement of temperature it also depends on the scenario under which you are trying to the kind of application that you are trying to build the scenario under which you are actually making this measurement.

If you take the case of new natal monetary, if you take the case of baby monitoring particularly newborn babies you want to measure them for some reason, then the measurement the way by which you actually make such a measurement is one type. If you do bearing condition monitoring it is another type, if you want to just look at detection of heat is another type. So, all these things it directly and indirectly are just looking at this one important measurement of temperature, which essentially is you are actually looking at the IR temperature; infrared temperature.

You are looking at IR temperature thermal sensors, essentially you will be able to do a lot of these things for you. So, if you look at this measurement of temperature using IR methods infrared temperature sensors using temperature sensors, you will come across a number of them for different applications. If you take an automobile and you want to measure the temperature of within an automobile, you have different types of temperature sensors for that application as compared to let us say sorry I have to connect this and to show another wheel so that it is stable right. So, we need to show another wheel and essentially we are looking at measurement of temperature inside a automobile.

So, why do you want to measure the temperature inside an automobile just because let us say everything is linked to fuel efficiency. So, you are let us say having an AC bus and you are looking at how good is this AC inside this how good is this AC working inside this bus which are the regions inside the bus or an automobile where AC not working well where is it that it is not cooling properly. So, you are looking for let us say a measurement of special measurement of temperature inside the inside the system inside the inside the closed automobile here.

So, you would put one type of temperature sensor there and you would actually not worry so much about it is accuracy, plus minus even 0.51 degrees, but if you know say that I am going to use I have to I require accurate temperature monitoring of a baby monitoring system a neonatal monitoring system, the right proper way by which you do contact based measurement of a new natal monitoring baby temperature is rectal measurement.

Everything is with respect to the measurement with the rectal measurement. So, I will

say rectal probe is actually used in most of the hospitals for exact measurement of core body temperature of the human being, but that is never going to be easy for you when you are outside a hospital, you just want to measure the temperature. So, if this is never going to be easy; there are other ways by which you can actually measure core body temperature. Now you want to let us say build an IOT system to measure this core body as close to the core body temperature as possible, but you want to use a non you want use a non invasive method known non invasive is also attractive for another reason particularly if you are looking at you know body temperatures or anything around the patient and monitoring and so on because you do not want to contact infections.

So, if there is a rise in body temperature due to some infection which is contagious, you do not want people to be a people around you to start you know having you know you do not want people to contact that particular infection. So, from a non in from a non invasive method is also useful because you do not want to you want to avoid infections. So, what do you do? If you want to measure such a temperature now for core body temperature of human of our let us say neonate or a human, you would now go in for measurement of one technique which is called you know you see this system here I will let you point you to this system here.

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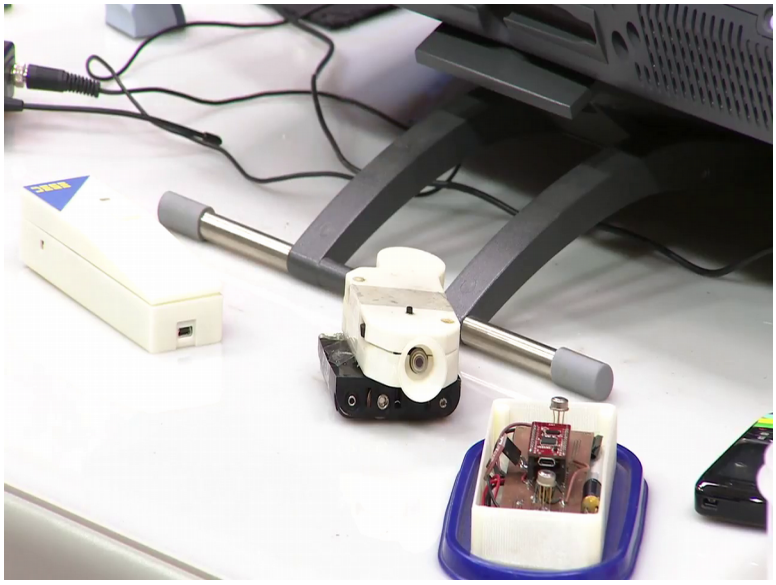

You have this nice little sensor here, that sensor that you see those are inside here this is a battery pack we did this in the lab. So, I just put a lab scale battery pack and what you see inside is essentially a medical grade it is basically a medical grade IR thermometer, medical grade thermometer.

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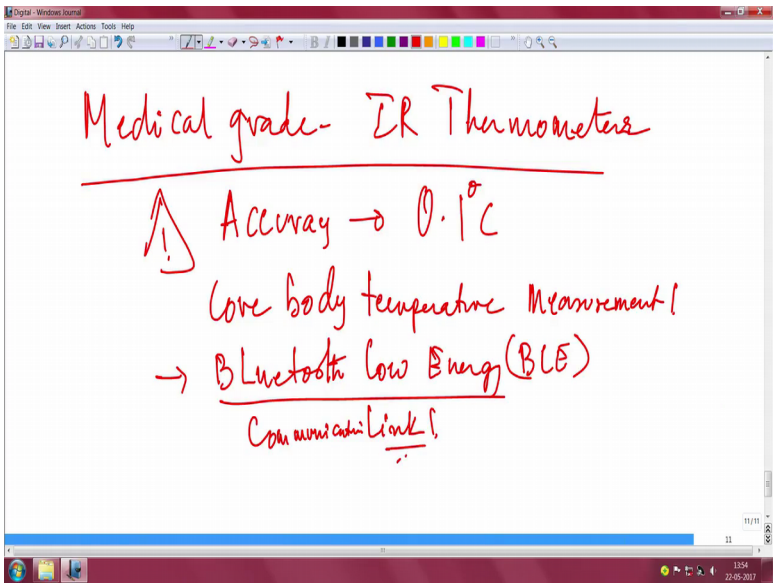

What does it mean? It simply means that if you are it simply means that the accuracy is a very important parameter and that accuracy is 0.1 degree Celsius. You have to maintain for any medical you have maintained accuracy measurement accuracy as close to as 0.1 degree Celsius. This may not so, how do we measure this how do you ensure that how do you make a core body temperature measurement right let me write it properly core body temperature measurement. As I said it is not going to be trivial how do you do that? I will show you an demonstration of how it is actually done.

One simple way one way and perhaps one way by which one technique by which you do is you hold this temperature this thermometer against your forehead side of your forehead, essentially the temple region temple you see the distance there is a cone, here I just adjust the distance of the cone you press this button here that you see you press the button here and you should be able to make a measurement and where will this value come? This value that is being read off will actually come on your phone on a simple

mobile phone, a phone like this let us say a phone like this should be able to you should be able to make a measurement and display this value on this mobile phone; what is the kind of communication that you are talking of between this device and the phone?

Well most often what people talk about is Bluetooth low energy low energy is also called BLE. BLE different standards exist we mentioned just last time BLE is the kind of communication link, communication link is essentially a Bluetooth low energy link, now how did I make this measurement.

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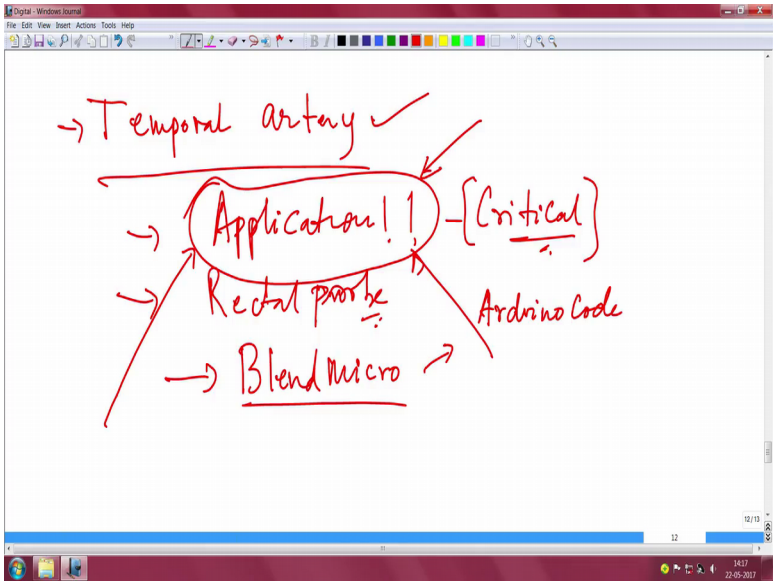

I made this measurement by reading the temperature by the heat I would say emanated by the temporal artery. Temporal artery see there is something going in parallel all the time we are spending enormous time trying to understand you want to make a measurement.

So, the idea really is when you talk about the design for internet of things, you have to keep in mind the application this is very very very important. So, I am going to say application; application is very critical most critical I would say why? If you look at what we did with respect to the bearing the temperature condition monitoring of ball bearings we measure temperature there it was not a direct measurement because we found it very

difficult to make it non invasive because bearings are very deeply embedded inside automobiles any rotating machinery or any component there. So, it is very difficult to measure there. So, we started measuring in an indirect way look at what we are doing here with this as well.

We are measuring the core body temperature which would actually be done with a invasive method by using the as I mentioned we are using the core body temperature measurement using thermistor switch, sorry, with the essentially core body temperature measurement with what we said as the rectal probe sorry. So, the rectal probe right we said about the rectal probe measurement using the rectal probe.

So, now we are saying well rectal probe is difficult because we cannot insert the rectal probe so easily particularly in homes because all that would be possible in hospitals we said we will make a measurement by putting this driving the system on using this little piece of electronic product, which essentially communicates to a mobile phone like this to a mobile phone and we could essentially use Bluetooth low energy between the phone and this device, and this is actually measuring the temporal artery. So, you see now same temperature of interest same parameter of interest, but different scenarios you need to have your IOT device, IOT system that you are going to build looked completely different the sensor is different; the way you measure is different the way you package the product is going to look different.

For instance this was with 3 D printed this is a 3D printed module, you see this cone this cone is because you have to be as close to the temporal artery as possible; obviously, if you are going to apply this to neonatal particularly one day, two day old born babies this has to be made out of very soft material, you cannot be disturbing anything look at the skin is so tender, you do not want to disturb anything there. So, really this whole packaging will be will have to be very very new natal friendly right. So, that is another thing. Now let us say you still want to measure you want use this temperature measurement for new natal, but you do not want to measure the core body temperature, but you want to measure the let us say the incubator alright. So, the incubator it is still for babies, but you are measuring the incubator temperature you could move on to something like this.

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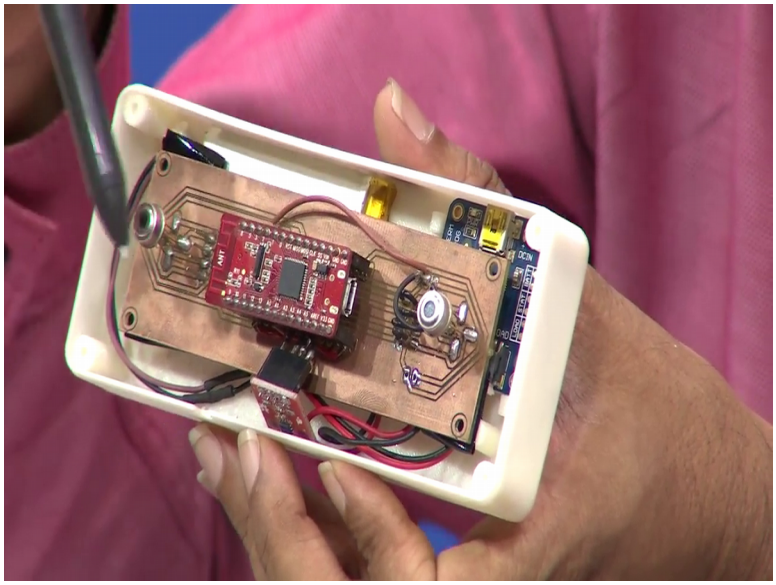

You could do something like this, what is this? Let us just go a little deeper into it you will see that it is the same sensor that you saw here in this system right, but there are two here, you can see that there are two here and it is a same communication that you want to do with a phone back to a phone, but these two there are two instead of one sensor connected to this little device electronic device, I will write down the name of this device it is a very interesting piece of electronic that you can buy quite freely, and this is called from a company called Blend micro; Blend micro essentially there they have blended. So, sorry, let me write this C R O properly micro Blend micro, essentially they have blended all of Arduino; Arduino; arduo; Arduino; it is ardu a r d u Arduino, how do you write that r duno Arduino code will directly work on this blend micro system this one that I show here; let us focus back.

This is front from blend micro what it actually has is a SOC like what we discussed last time this is from Nordic semiconductor, it has a BLE Bluetooth low energy communication link and it also since it is an arm microcontroller it is able to read from no I do not think it is arm I am sorry I do not think it is arm, I will have to look this up carefully to come back to you on that. But never mind this is a SOC which has a microcontroller and it has a radio which from which is a essentially a Bluetooth low energy radio system, it is able to read from this as well as from this system because this

is now actually placed in a incubator and the baby is placed on top of this right though this is like a bassinet which is placed below, and somehow you package everything and then you place the baby on top.

You want to measure either you can measure the baby is the incubator come baby temperature either from two locations in a manner that it is able to gather the complete temperature of the closed a new natal the new the incubator it is possible that you can measure that quite accurately. And you can see that we made this PCB to mount these two and therefore, let me draw this picture for you because everything is about how you build for the design for IOT course how do you build this kind of systems.

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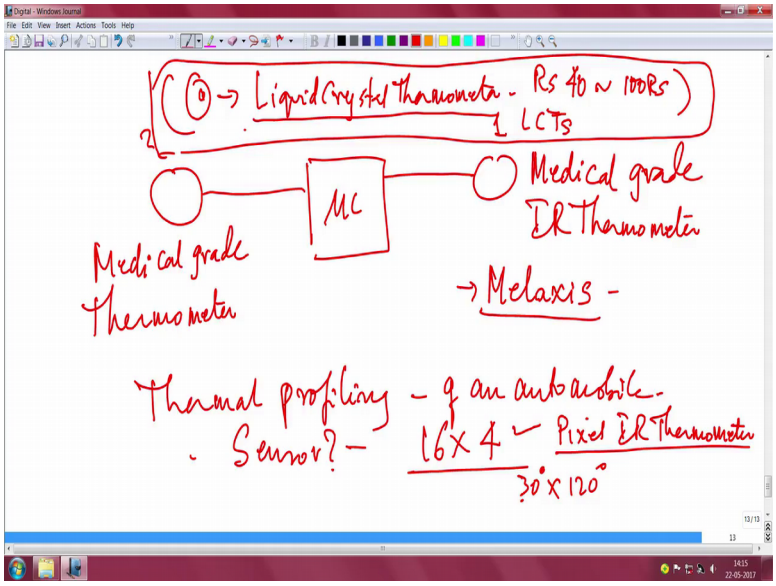

So, let me again abstract this picture for you, there is a microcontroller right there is a microcontroller and there is a I 2 there is a medical grade sorry not I 2 I have to write here medical grade IR thermometer; thermo sorry let me write this again thermometer this is one. And for simplicity I will show the second one here this is 2, this is the same one again right medical grade thermo meter. By the way if you are interested in building such a system you could look up Melaxis. Melaxis is a European company they make these IR medical grade IR thermometers for neonatal applications.

Now, let us come back if you want to make a measurement of let us say of the; you want to do a thermal profiling, thermal; thermal. So, let me rub this out thermal profiling; thermal profiling of an automobile what kind of sensor will you use sensor to use? Before we answer this question I will show you some (Refer Time: 19:18) on this issue of temperature measurement, what I am going to do is I am going to show you a nice idea which I tried in the lab many years ago, and just for fun you know you can do many nice things it is not all about technology every time, it is about your idea what kind of ideas that you can generate together and put a very simple system in place.

Actually if you want to make a measurement of human body temperature, you could do it as I said the right way is rectal otherwise temporal artery use this little IR thermometer scan across the our temporal region, and then you somehow catch the temporal regions because that will have the highest temperature, you read that value and then you said this is very close to the core body temperature. Do you have to do all of that to just get a first line indication of temperature? No you do not have to do that.

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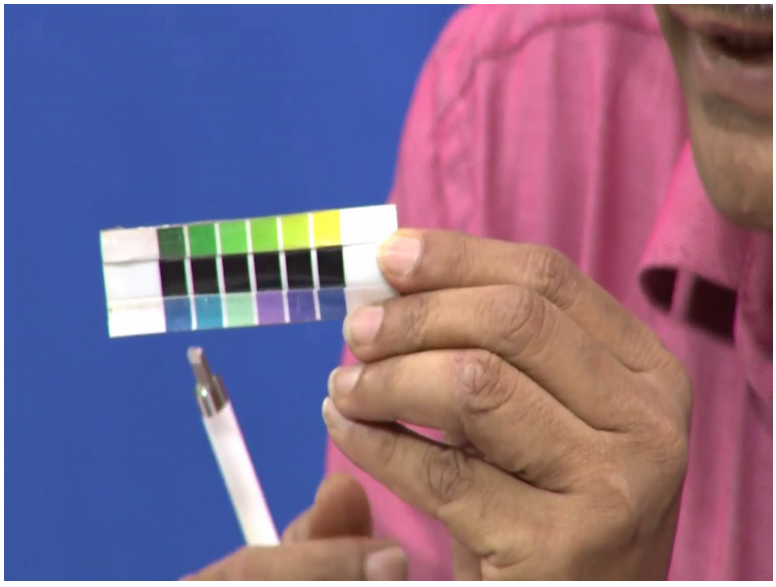

What you could do is you could get liquid crystal thermometer it is called liquid crystal thermometer in the market, in any pharmacy shop 40-50 rupees or maybe 100 rupees, you get a thermal this simple which you can simply buy it off and put it on your

forehead. Now when you put it on your forehead if depending on the body temperature it is going to indicate a colour right that particular colour is going to light up in the strip, you can see that what I have done is I have there is a particular indication of the core body temperature here in the middle one.

Let me show you in a little more detail here. So, you can see one of them here will actually yeah. So, must point it correctly one of them here will indicate will light up and then there is a corresponding mapping here to a different colour here, to different colours here, what I will do is I will map those colours to this keyboard old Nokia phone beautiful phone, map it to this write a simple application here and somebody presses a button here, will simply depending on the colour that they have identified there, a person can simply press the corresponding button here and all of that information can go out can get communicated. So, you can see that if supposing in rural areas or you have a primary health care centres or you have people who do not know are able to identify colours very well, but you know find it difficult to send out a message they are trying to monitor a baby or the trying to monitor the patient and they are just trying to use very simple system it is very low cost, you can buy this for anywhere from 40 to 100 rupees depending on the quality.

Just put it up here identify which one of them have actually got highlighted corresponding colour that you find down below, you send it out you go on to this phone in press that button the application here will simply send out a an any SMS or something to the nearest primary health care health centre. So, you can see that you can you do not have to you do not need heavy technology here, you can do many things in a I will say semi autonomous way or semi automatic way with human intervention being the most critical thing. This phone you can buy a simple phone Nokia phone you can buy Nokia is coming back with it is 3310; now which is available and you could buy a simple phone like this because you just want to send out only a SMS message with that colour indication, that colour you map it to a particular temperature right and then you can just say you know you can just make that simple mapping.

So, let us put down all what we need to do. So, let me put it here so that the critical questions which we have to answer now can go on what you can do is you map you use a

simple IR thermometer again sorry I am sorry, I used the wrong word, this is not IR thermometer this is I am sorry, I must say this is a liquid crystal thermometer I am sorry this is a liquid crystal thermometer it is called liquid crystal thermometer. This is actually called a liquid crystal thermometer which is available for anywhere from rupees 40 upwards to about 100 rupees, and use this simple liquid crystal thermometer on your forehead use this simple liquid crystal thermometer on your forehead. Read this particular mapping that you have here based on the colour that it maps to one of them in the liquid crystal thermometer will highlight in that region, corresponding colour you take use this keyboard which is now mapped to that particular temperature and colour, and press that button corresponding button so that the temperature value which is mapped to that particular colour is communicated over an SMS to the nearest a primary health care centre.

So, all of this simply indicates that you can do all this story with simple liquid crystal thermometers which are available also called LCTs or liquid crystal thermometer also called LCT LCTs. If you wish you can buy this liquid crystal thermometer from this little company which is called Thermo Spot.

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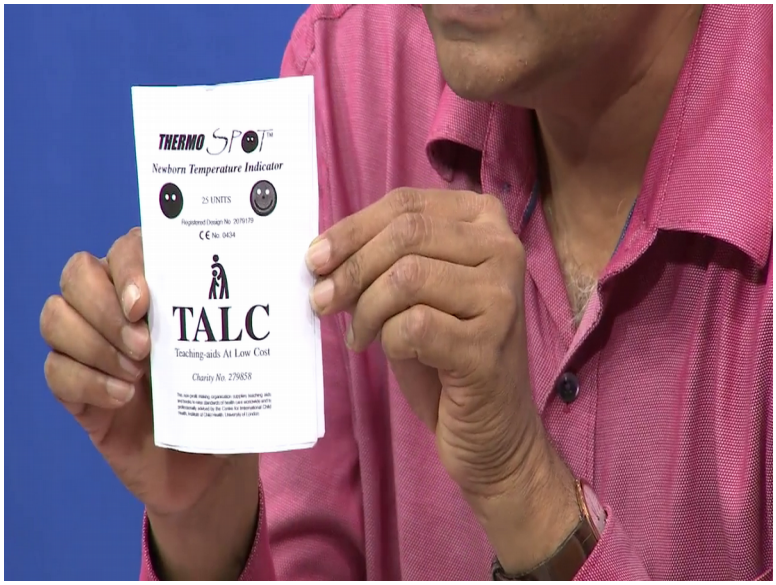

You can see this Thermo Spot this is also called teaching aids at low cost TALC, you can

see teaching aids teaching aids at low cost and I have a sample here in my hand.

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You can see that this is that little same liquid crystal thermometer that you can use.

Normally for neonatal; a newborn babies what they do is they put this little dot, and you should see a smiley at the end if there is the temperature is right at 36.5 which is the normal body temperature you would see a smiley, alright. So, that smiley is a clear indication that the temperature is maintained the thermoregulation of the baby is well maintained. You normally put it below the arm or below on the right side just below the rib both these places are to measure and that that is already. So, if your monitoring let us say a neonate and you simply have a simple phone like this, you could use a combination of this liquid crystal thermometer with that of a phone and simple SMS.

So, what is the big story of this design for IOT kind of a systems building that you are looking at? Idea is important, how to make things simple is important, you do not need sophistication of measurement techniques or the temperatures or sensors for all applications, you could do it in a hybrid way, you could use manual methods, you could use combination methods and build your systems together. So, in this example we saw that we actually used a liquid crystal thermometer for all proper mapping of

measurement of the core body temperature sorry the temperature of the neonate by simply applying it either on the below the arm or just below the rib on the right side or if you are using for adults you could simply apply it on the forehead as well right all these are possibilities to measure with simple phone. So, you can combine several technologies.

So, this is one example of how you can make a measurement. The second thing we said is about medical grade thermometers or medical grade IR thermometers, and the third example we said how do you make a profile of the atom of an automobile you are looking at AC inside an automobile, well for that what you could do is you could use.

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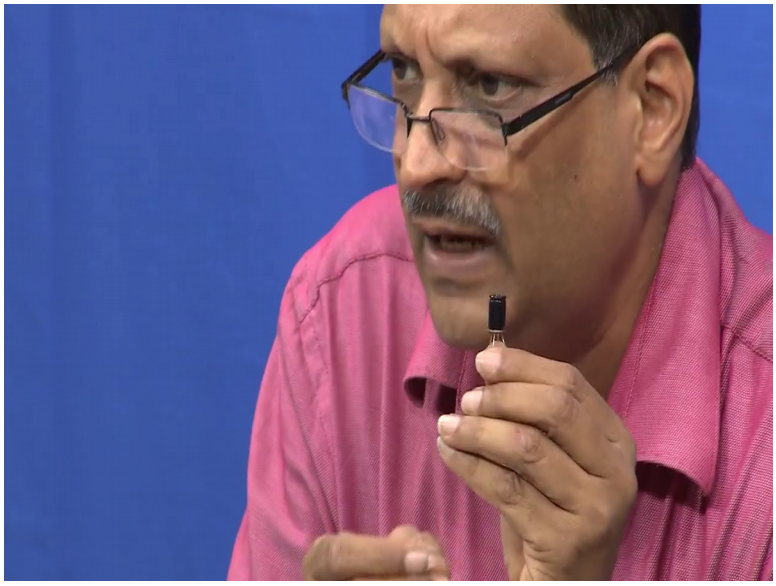

Another type of sensor this is also let me point it, it is about this long it looks like an electrolytic capacitor essentially, this is also a medical it is also a IR thermometer, but it is not medical grade right because you do not want medical grade, you do not want to invest you do not want this 0.1 degree Celsius kind of accuracy, but you want to monitor a large area and different regions.

So, what you could buy is you could buy for an automobile is 16 cross 4; 16 cross 4 pixel IR thermometer; you can call it thermometer right because it measures temperature right.

So, what does it mean and what kind why do you need so many pixels? You need 16 cross 4 pixels because you want to measure a large area like this, but you do not want too much in terms of height you only want in terms of larger wide you want it wide, but you do not want it on the y axis you do not want it very high, but on the x axis you want it to be measuring a sufficiently large areas large angle. So, you would get them in 30 degrees cross 120 degrees for measurement, this is something that you can typically use for all measurement of in automobiles.

Let us take this up as a next step, and understand this measurement of temperature in a lot more detail as we go along. So, in summary if you are measuring the ambient temperature you need one type of sensor, if you are measuring core body temperature of a neonate you need another type of sensor, if you are measuring the temperature of within an automobile you need a different kind of a sensor under different IOT system. If you are measuring the temperature inside the poultry farm let us say you are looking at measuring a particular temperature of chicken which are all in inside a poultry farm, you know they are the issues are even more quite complicated there; if it is too cold the chicken are hurting themselves together if it is too hot they are sort of sweating and they are they are unable to breathe properly they can also you know have lot of issues if temperature is high.

So, ultimately you want production to be larger, you want to have a good production of your poultry system. So, your measurement of temperature inside that poultry farm has to be accurate. So, you need a different kind of temperature measurement there. So, all this in summary says that your IOT system that you want to build depends largely on one important aspect and that is with respect to application right. This is the most important thing keep this in mind in any IOT application will move on will build systems, will understand them and let us see how these things actually can be built for several of these applications.

Thank you very much.