Water Supply Engineering
Prof. Manoj Kumar Tiwari
School of Water Resources
Indian Institute of Technology - Kharagpur

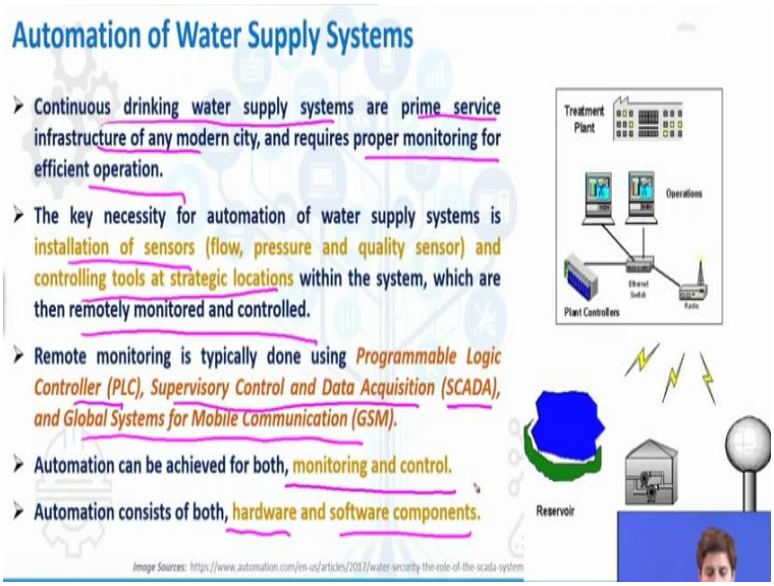
Module No # 12
Lecture No # 56
IoT and Automation in Water Supply

Hi friends and welcome back. So we have been discussing about the automation in water supply systems and smart water supply systems this week. And in earlier couple of classes we did talk about the basic features related to the automation. Now this particular class we are going to discuss about the IoT and automation in water supply system we already had talked about the metering systems ok the concept of smart water supply systems and the smart metering system we have already discussed.

(Refer Slide Time 00:50)

So what we are going to talk today is the automation in water supply system what is the scope of automation then we are going to talk about the supervisory control and data acquisition which is the SCADA systems. And we will touch upon the big data and IoT systems for automation.

(Refer Slide Time 01:08)

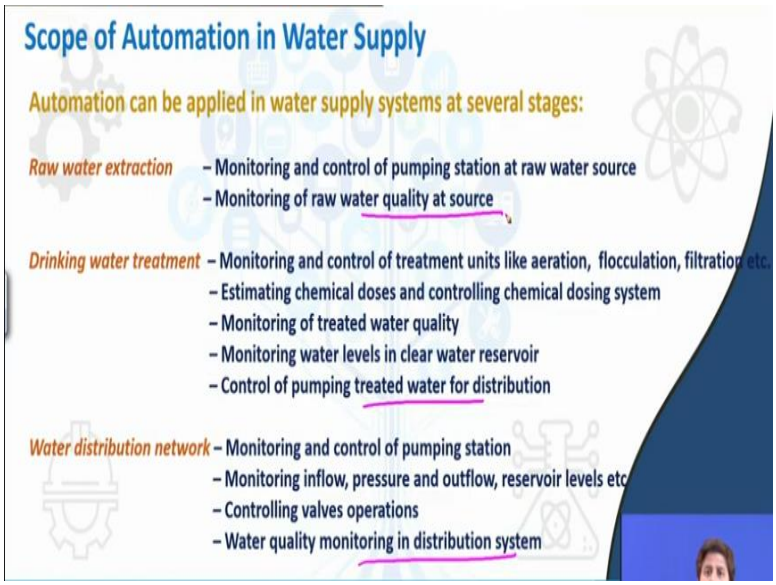


Now the essentially when we talk about the automated water supply system or smart water supply system what we intend to do is we intend to put through a system where basically with the installation of sensors and controlling tools at strategic locations. So that we can remotely monitor and control the system okay this is essential because with the scale of the system particularly drinking water supply system like they are very large system and it becomes difficult to go for physical monitoring of each and everything.

So basically the prime service infrastructure for any modern city which are these big drinking water supply systems they require proper monitoring and efficient operation. And for that purpose we go for the automation. So remote monitoring is typically done using the programmable logic controller which are PLC supervisory controller and data acquisition systems which is SCADA and global systems for mobile communication which is GSM.

These are some of the tools of course there are IoT there are ICT those tools are already there. So with the help of all these we set up an architecture system where we can kind of achieve both monitoring and control. And this system is set up using hardware and software components.

(Refer Slide Time 02:49)



Now automation can be applied at several stages in a water supply system ok like for example in raw water extraction system we can have a monitoring and control of pumping station at raw water source. We can go for monitoring of raw water quality at source okay. So again in addition we can operate the intake levels in the intake ok. So all those thing can be monitored and something like the pumping stations and these things are even controlled also you cannot control the water quality.

We can just monitor that but there are like switching on and switching off the pumps and these kind of features can be controlled also. So that is about the raw water restriction part. Then it is comes to the drinking water treatment. Drinking water treatment automation has a lot of rule ok. It can actually use it can be used for monitoring and control of various treatment units like aeration, flocculation, filtration if you are having a settling system so clariflocculator.

So all those things can be effectively monitored and majority of the processes can also be controlled in a treatment system using these automated tools. It can help in estimating the chemical dose and controlling the chemical dosing system. So like it can determine the dose of coagulant if you have a water quality sensor that will sense the turbidity and based on that turbidity or whatever calibration we have already put in the system it will decide and it will guide upon a dose which should be added and it may have a controlled dosing system as well.

So where it will pick that much amount of that much volume of the say your stock solution. And it will feed that into the rapid mix. Then there are monitoring of treated water quality. So water quality monitoring at treated water level at raw water level is both possible. It can monitor water levels in the clear water reservoir. So in a clear water reservoir what is the level of water?

So all this basically can be monitored and then through this signals it can control the pumping for treated water distribution or treated water lifting to the clear water reservoirs. So these are some of the features which can be automated in a drinking water treatment system. So in fact if you can see more or less all the plant operation can be automated in a water treatment unit. Then come the water distribution network again in a water distribution network further monitoring and control of pumping station ok.

So similar to that in the water treatment facility similar to that in the raw water extraction facility it can monitor and control the pumping station. It can monitor in flow pressure, outflow reservoir levels etc., in the distribution system wherever applicable like for reservoir it can monitor the reservoir level for pipes it can monitor the flow in the pipe. It can monitor in the inflow and out flow from the reservoir or tank it can monitor the pressure at the nodes or junctions.

So, all these operations can be achieved using the automated sensors or automated control devices which can actually be used for controlling valve operation as well. So valve operation can be controlled like switching on and switching off the valve that all such operation can be controlled using the automated systems like SCADA. And then we have water quality monitoring in the distribution systems. So that also can be achieved.

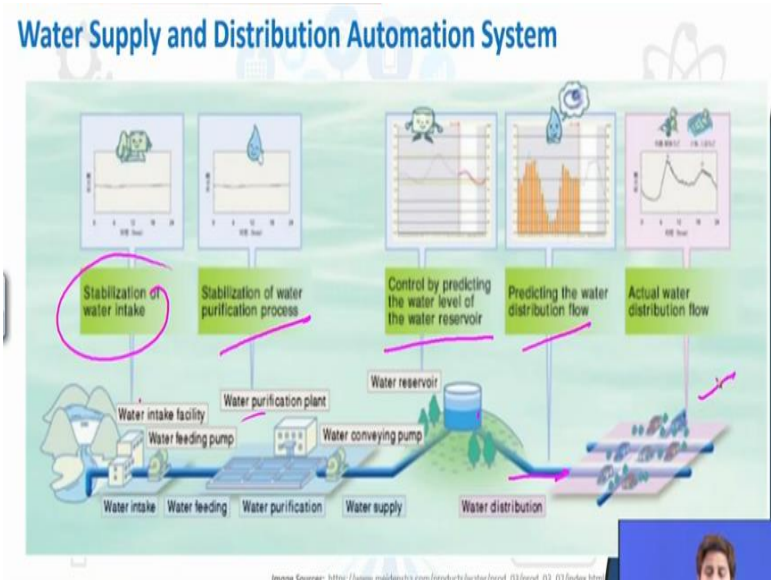
When, we are saying about the water quality monitoring here and even in the treated level or raw water level. So essentially it is not that all the parameters can be monitored ok. As we discussed, in the earlier class also when we are talking about the various types of sensors. So water quality sensors they are available for selected parameters only. It is not that all the parameters can be monitored no like there is no automated monitoring system available for say pathogen monitoring ok.

So there are many other things which cannot be monitored there are many things which can be monitored. What can be primarily monitored is the TDS temperature pH, salinity, oxidation

reduction potential, dissolved oxygen levels and then various ions ok. So all those actually can be monitored but few things like particularly the emerging contaminants organic contaminants we do not have sensors available for them.

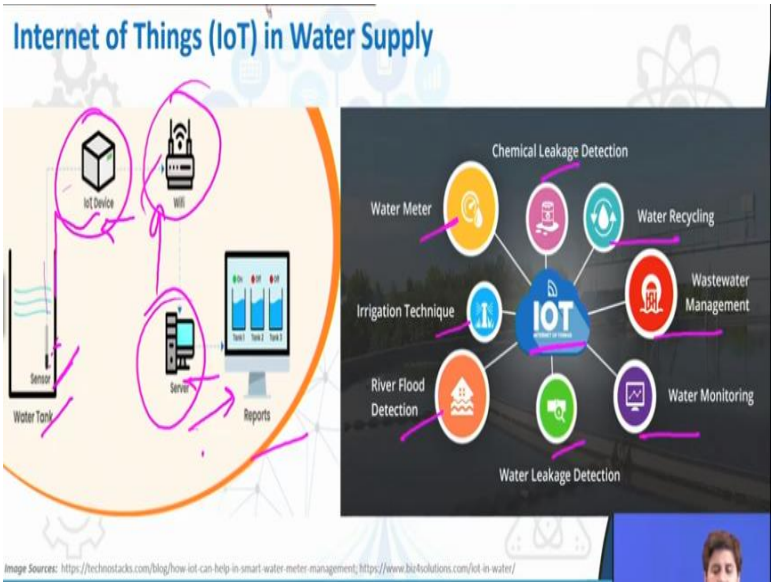
So they cannot be monitored using this; real time sensors. So whenever we say water quality monitoring there is a catch in that that we are not talking about the comprehensive water quality monitoring. We are talking about the monitoring of only those water quality parameters for which sensors are available real time sensors or detection systems are available they can be monitored.

(Refer Slide Time 08:27)



So this is an example of water supply and distribution automated system. So we can say use it for stabilization of water intake. We can work for stabilization of water purification process. We can control by predicting the water level in the reservoirs. We can predict the water distribution in the pipe ok and flow and we can basically see the actual water distribution pattern. So depending on where and how much sensors we are installing how robust system we are putting into the place we can decide on what maximum benefit can be obtained using these systems.

(Refer Slide Time 09:13)



Now the many of these monitoring and more server are not monitoring, monitoring relies on the sensor ability. But the communication through this central server relies on the advanced communication protocols ICT and IoT kind of systems. So internet of things also have a lot of role in basically automated water supply systems ok as we can fetch the data and we can give the commands through these systems.

So it helps that were like entire in a way you see that entire concept of automation in the supply system or in any system for that matter is primarily relies on the communication system okay. So there has to be a communication system which can bring the information from the sensors to the server and can send the command from the server to the sensor. So IoT kinds of systems are great tool for ensuring this kind of communication.

If we see the applications of IoT in the water sector so water meters sensing and communication of that then irrigation technologies which is not related to the municipal water supply though. Then river flood detection so the water leak detection water monitoring waste water management, water recycling the chemical leakage detection happening in the treatment plant site or anywhere.

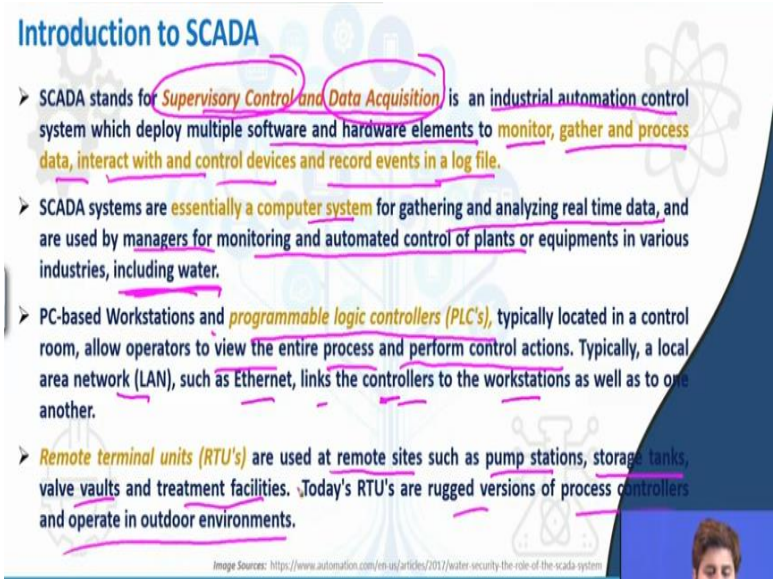
So all these operations can be facilitated with help of IoT system remember only IoT cannot do all; these thing. It is not that I have an IoT in the place and it will say monitor the flow it will say monitor the water quality parameter it will ensure water recycling no. IoT will help in developing

that protocol for using which we can record this data put that them into the cloud system and get it back from the cloud system to the server system.

Give the command from server again through cloud computing the command and messages can be sent to the sensors. So like you say you have a water tank you have a IoT device. So you have a sensor this sensor record through IoT device it goes to a Wifi this thing and then it is actually goes to through basically cloud it comes eventually to the server and from server it comes to the system and generate the report.

It can actually again lead to the 2 way communication also that you from server you send a message to the IoT device and then it actually acts upon the sensor and certain things like certain monitoring or the frequency of the monitoring and those things can be controlled that way.

(Refer Slide Time 12:21)



So these are some of the application of the IoT. The one of the most prime tools which are used in automation is the SCADA. So the SCADA stands for supervisory control and data acquisition system. Now as the name itself suggest we are actually going to have a supervisory control and data acquisition integrated together. So that means we have a set of sensing networks they will actually collect the data and then data in a supervised way it is controlled and the command can be sent through the actuators to the various valves or various tools which can perform actions in the field.

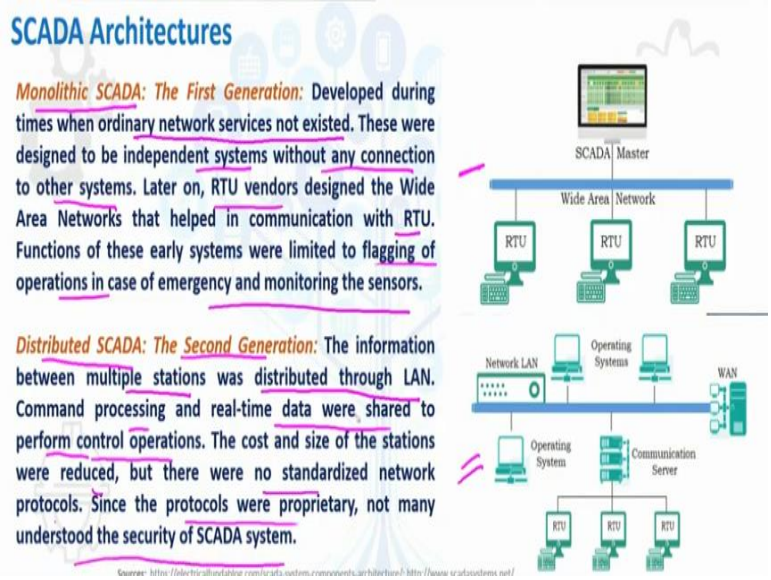
And we can actually get the things done in the field using these kind of programs. So it is essentially a industrial automation control system, which deploy multiple software and hardware elements to monitor, gather and process data interact with control devices and interact within the kind of other monitoring or controlling devices as well. And then record these events in a lock file. So this is what is typically done in a SCADA system.

This SCADA systems are essentially a computer system and then for gather analyze the real time data and then used by managers for monitoring and automated control of the plant or equipment in various industries. And water is one such industry where SCADA is used quiet frequently now. So these are like there would be PC based workstation and then programmable logic controller which is known as the PLC which is typically located in a control room.

And this allow operator to view the entire process and perform the control action. Typically, a local area network such as ethernet links and controllers at the workstation is attached. So that the communication can be established between these tools okay the wireless communication can also be achieved. So then there are remote terminal units which are used at a remote site such as where basically we want to perform the action like pump station, storage tanks, valves, vaults and treatment facilities.

So we have there the remote terminal units we give the command from here and then the remote terminal units may perform certain action there in the field. And then again the data communication also takes place through these units. So these are basically rugged diversion of process controller and operate in the outdoor environment typically.

(Refer Slide Time 15:20)



Now if we see the architectures of SCADA so SCADA when it was developed first it was basically during the time when there was a ordinary network services were not there. So when the ordinary network services were not there so these were basically designed to be independent system because there was not network that way. So they did not have any connection to the other system.

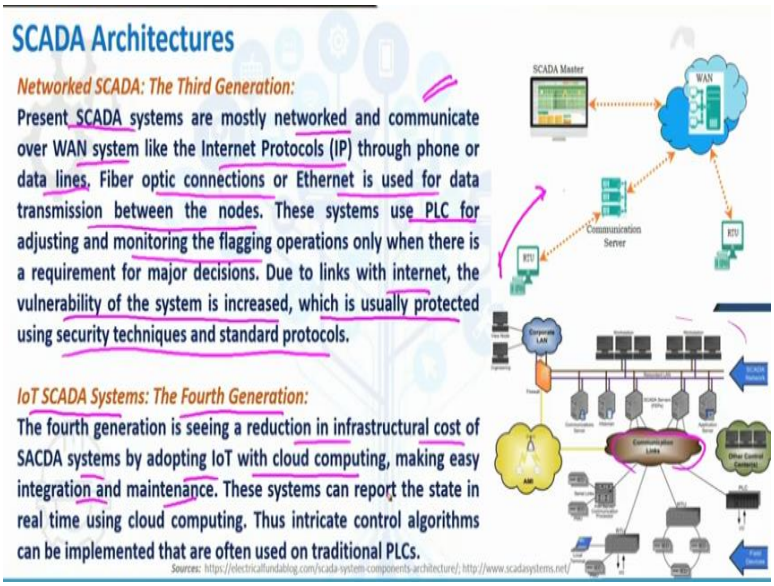
Later on these RTU vendors designed the wide area network and helped in communication with the RTU the functions of these early systems were basically limited to kind of lagging operations in case of emergency and monitoring the sensors. So they were just used to monitor the sensors and kind of give a emergency warning or emergency signal in case of any mishap or any unusual processes happening.

So these were the kind of first generation SCADA system which were known as the monolithic SCADA. Then we come to the second generation; which were the distributed SCADA. The second generation SCADA or distribution SCADA was basically was able to establish the information between the multiple stations with the distributed like information was distributed between all these multiple stations through the LAN.

So because LAN was developed so it used the features of the LAN for distributing the information across the different sensors. Now command processing and real time data where shared to kind of perform the control operations again it was through LAN primarily. The cost

and size of these stations were reduced but there was no standardized network protocol. And since protocols where proprietary not many understood the security of these SCADA systems in the second generation distributed SCADA system.

(Refer Slide Time 17:16)



Then came the third generation SCADA which is still by far like a mostly used ok so right now we are mostly using the third generations SCADA and these are the generally presents SCADA system which are mostly network and communicate over the wide area network systems like internet protocols and through phone or the data line. So it can use the phone GSM data line those things.

Fiber optic connections or ethernet is used for data transmission between these nodes. Now this system use PLC programmable logic controller for adjusting and monitoring of the operations only when there is a requirement for the major decision. Now due to link with the internet these there is a vulnerability for this system is increased many SCADA system have been hacked in the past ok even in the US.

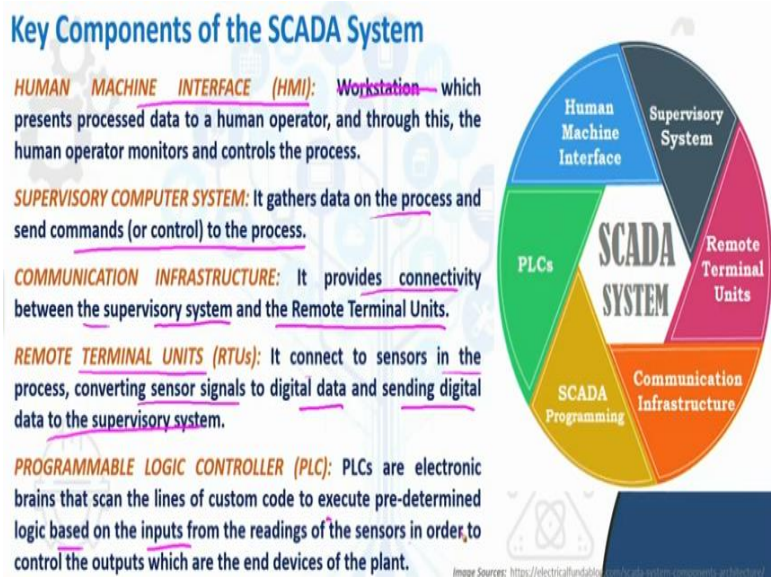
So though these are usually protected using security techniques and standard protocols. But still because they are connected to the internet so they are always prone to be hacking ok. So that is one of the demerits here. But that has eased out the operation quite a bit. So these were the third generation SCADA which were actually the network SCADA ok. And now we have the fourth

generation SCADA also though still it is being used very less we are mostly using the third generation SCADA.

But there are IoT SCADA systems which are the fourth generation SCADA. And these seeing a reduction in the infrastructural cost of the SCADA system by adopting IoT with cloud computing. And that is a way making easy integration and maintenance. This system can report to the state in real time using the cloud computing because everything is connected to the cloud all the communication is through IoT and cloud infrastructure.

So systems can actually send the real time in formation not only to the central server or not only to the SCADA server but to anywhere. It can actually send to directly to the controlling state or controlling body. So this integrate the control algorithm and it can be implemented that are often used in the traditional PLCs so that way these are the most advanced SCADA systems.

(Refer Slide Time 19:42)

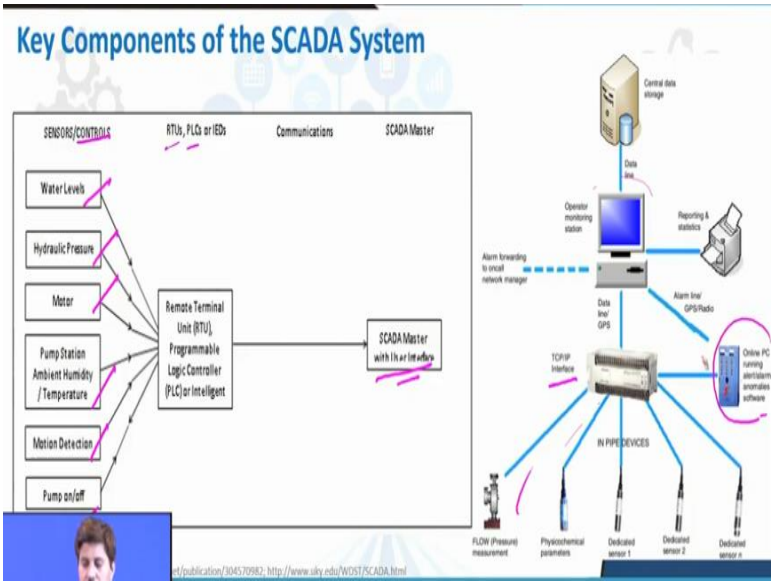


Now the key component of the SCADA system primarily the third generation SCADA system which is by far being used most are the human machine interface HMI which is basically a system interface which basically present the process data to the human operator and through this the human operator monitors and controls the process. Then there are supervisory control system it gathers the data on the process and send the commands or control to the process that is done through this supervisory control systems.

There is a communication infrastructure which provides connectivity between the supervisory system and remote technical unit mostly through telemetry. Then there are remote terminal units it connects the sensor in the process converting sensor signal to the digital data and sensing digital data to the supervisory system. And then we have a PLC which is programmable logic controller which basically are the electronic brains in the system.

So this is the major brain behind the system okay and it basically like have a custom code to execute pre determine logic based inputs from the reading of the sensors in order to control the output. So like with the help of PLC depending on certain conditions it can take the decision and inform the controller to set up certain action in the field so that the outputs are amended or modified that way.

(Refer Slide Time 21:19)

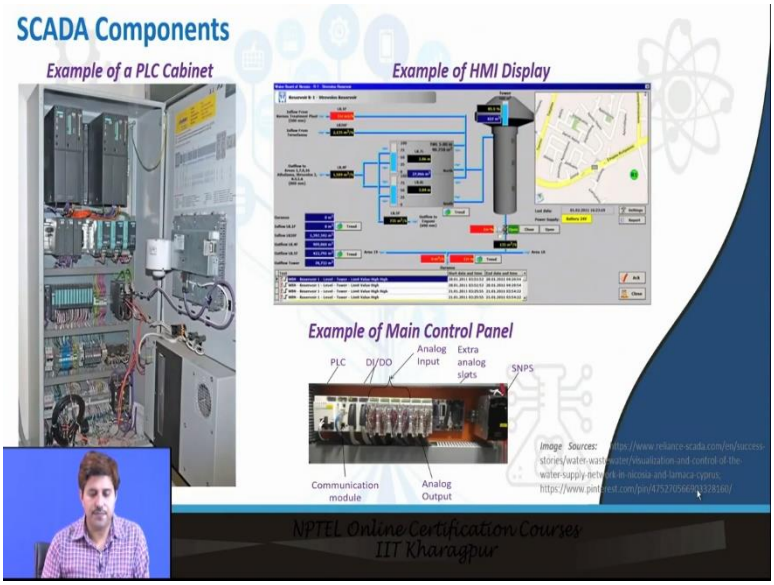


So these are the essential like from the sensor or control side we have water level sensor, hydraulic pressures, motor, pump stations all these pump on off features. So these are various things and then on the remote location units or the PLCs or the IEDs which is intelligent end devices. So there are basically they are connected to these sensors and they communicate to this SCADA master with the user interface.

So it could be like you have say this is your central server central data storage you have all the systems here then there is a TCP or IP protocols which can takes cares of input and output and

all these sensors will be basically connected in here. And we will have a online PC running the software. So this is what happens typically in a usual SCADA systems.

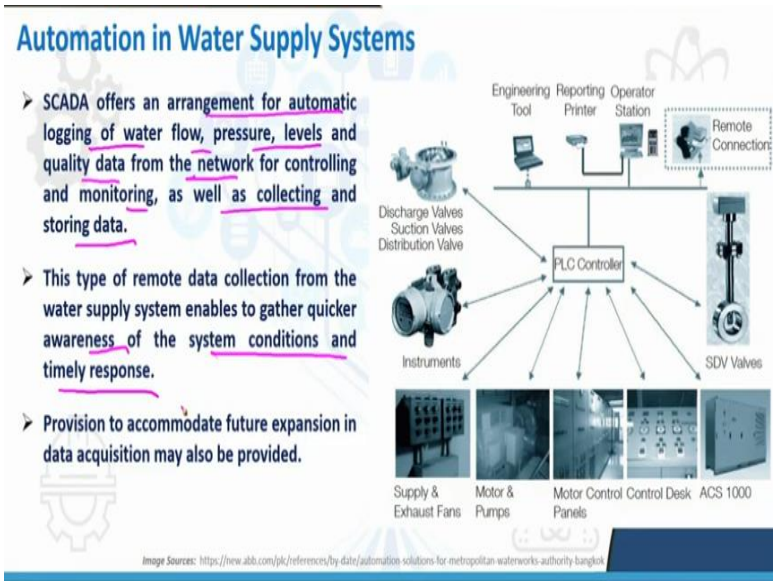
(Refer Slide Time 22:20)



These are the SCADA components so like this is an example of a PLC cabinet this is how it looks like ok. So we have all the like even the main control panel with input output systems over here and then our PLC everything is put in this cabinet. This is the example of HMI display ok. So this is like we can setup and SCADA screen and visualize the various processes links here. We can have the monitoring and some of the control features available at this HMI displaying.

This is an example of say main control panel where basically, so this is where the PLC lies ok. So we have PLC then we have digital input and digital output ports. We have analog input and analog output ports. So then we have the communication port for the LAN connection ok as you can see here. So this is for the LAN connection ok. These are the extra slots where later on can be fit in. So these are kind of example of a typical control panel ok. So these are the one that the rest of the in the server and software everything relies in the computer.

(Refer Slide Time 23:46)

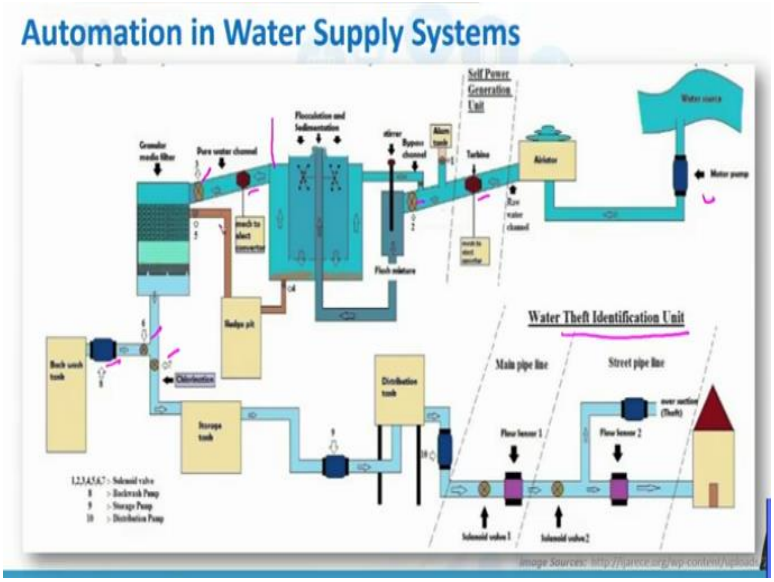


Now the automation in water supply system based on SCADA or other tools is basically again like doing the monitoring and control activity from the remote stations ok. So that is what automation offers. Now SCADA when used in a automations is offers an arrangement for automatic logging of the water flow pressure levels and quality data from the network for controlling, monitoring as well as collecting the storing data.

So it can basically control, monitor, collet as well as store the data. This type of remote data collection from the water supply systems kind of enables quicker awareness and the system conditions based on the system conditions timely response can be taken and can be communicated in order to achieve the desired outputs. Then there would like generally these systems have provision to accommodate future expansion in the data acquisition.

So there might be extra slots available in the PLC or other systems. So if you want to because many times the processes are started with like select processes are covered under SCADA but as and when the budget and time permits people may go for the enhancing those features. So there might be like always good idea to keep provision or keep extra slot for further expansion of these kind of systems.

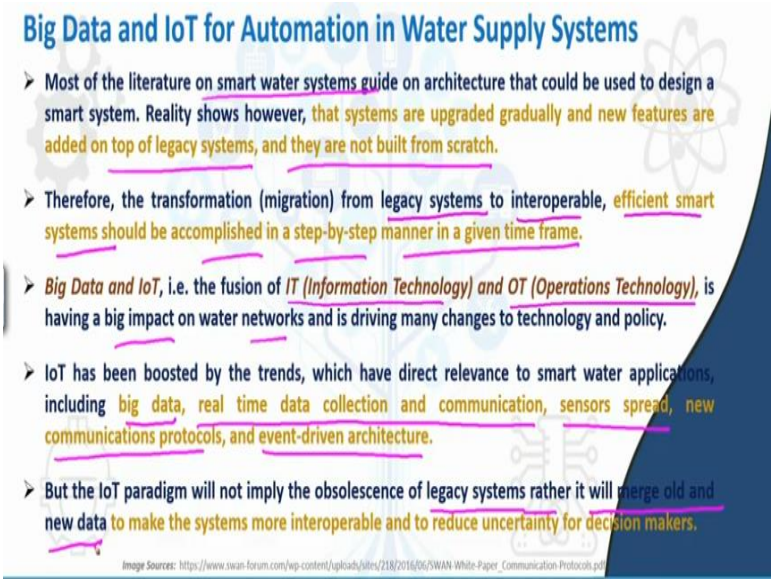
(Refer Slide Time 25:24)



This is a typical example of automation in the water supply system. We can see here that say add all these different levels we have sensors available mono like this is there are various sensors and operators available and all these must be controlled and automated from a remote station. So basically we can have the entire control of the process, the flow, the valve operation, the sensing operation.

So all these things might be in place ok we can have a water theft identification unit. Say for example we can have level sensing units, level control units, treatment process operation. So all such features can be integrated into these kind of systems.

(Refer Slide Time 26:17)



Now the along with the SCADA as just we have been discussing that IoT plays a very key role in automation. So in combination if we like put all these together the big data, IoT and supervisory control systems we can achieve a full fledge automated systems in water supply. We could do this for treatment plant we could do this for the distribution system to the extent we want. And we can do that for the raw water extraction. So any stage where ever we want we can actually apply these techniques.

Now for most of the literature there would be basically smart water like whenever we explore the literature on the smart water systems they mostly guide us on the architecture that could be used to design a smart system. So everybody tells ok follow this approach put a network layout a sensors and then kind of connect interconnect those sensors and get the data. So what architecture is needed is very well known and everybody like can guide or suggest upon the architecture which is required for putting up a smart system.

However in practice this systems are usually like it is not that we are going to build system from scratch ok. These are very rare cases when the systems are built from scratch. Rather there is a existing system and we need to upgrade that gradually with adding new features ok. So there is basically lots of legacy items lots of legacy is there in the system and on top of that legacy we have to gradually upgrade newer and newer features.

So that we can come up with the full smart system now this transformation like because we already have a legacy system and from this legacy system to be kind of going for an interoperable, efficient smart system. This cannot be done in a one day ok. It is not like we completely dismantle the system remove it and then put a new system. There is a huge cost burden and more so ever like whosoever is existing are the population that is living in that area what will happen to them? How they are going to get that water?

So we have to upgrade a system considering minimum disturbance to the existing population. So this should be accomplished in a step by step manner in a given time frame it is not a one day job ok there is no like magic stick that you go and take your system has updated. It will take time and it has to be done in a step by step manner. Then with the big data IoT fusion we have

basically the like information technology and operational technology we can combinedly put a big impact on the water network.

And that way like it can derive many changes in the technological level as well as policy level. Now particular the IoT has been boosted by the various further newer in interventions, newer approaches, newer design, newer systems which are available and it has a those many of these new discoveries has a direct relevance to the smart water applications like the coming up the big data, real time data collection and communication systems then the spread of sensors wide spread of the sensors new communication protocols which has come in or the event driven architecture which can be made or can be design.

So all this in combination with IoT helps system to like control and operate these water supply in a much smarter way and that way it kind of have a very direct and relevance and pretty good impact on the smart water supply systems. However as just we were saying that IoT paradigm will also not imply in the standalone because there is a legacy system that exist. So it has to be basically considered as a legacy system and then it will it has to typically merge the old and new data ok.

So as to make a more interoperable and reduce the uncertainties in the decision making because it we are just like now we are going to have the automated data if we rely just on that data and leave whatever the older data of the legacy system demand pattern all are there if we just leave that data. So we are compromising on the uncertainty we are actually like going to have higher uncertainty because we are losing a chunk of data.

So it is better to basically have the legacy data in together and then step by step developing new data and putting pulling out of the legacy data combining both old and new data we can make a more robust more interoperable system with lesser uncertainties which would be good for decision making systems. So that is how we can apply these techniques in the field. So will conclude this particular class here and in the next class we are going to see some examples how these techniques automation techniques like SCADA or such techniques are deployed or used in the field. So we will take certain examples in the next class. So see you in the next class thank you for joining.