Customized SCADA System to Monitor Water Distribution Network using PowerBI

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Abstract

To create a Telemetry SCADA System for water distribution network. A Central SCADA system which acts as a central Control Room shall be an integrated tool to monitor & control entire water distribution network i.e., Master Server reservoir, transmission network, Pumping Station's, Service Reservoirs and water distribution network. All the instrument's & equipment's in entire network will be connected to the Central SCADA system. Customised SCADA System Architecture Overview is designed for redundancy system, Web Client, SQL server which is for collecting all the data of sensor integrated with SCADA which is going to be used to take for different application like ArcGIS and PowerBI. This Integration of different application helps user to access the data with real time map and also helps to visible data as per requirement in customized dashboard, also helps in reporting tools and designing of report templates as per requirement. To make system record data all time we provide UPS in RTU locations to save data even at the time of power cut. An IIOT device of Battery powered Pressure Data logger in distribution network which used to measure the pressure data in network and keep network pressurized 24x7.Those data also will be collected in SQL and used in ArcGIS and PowerBI. This Proposed SCADA systems shall be technically advanced, proven and best suited for water distribution networks. Advanced features like integration of GIS maps for cross navigation, integration of third-party databases, SCADA web clients is provided.

Keywords:

SCADA – Supervisory Control and Data Acquisition, IIOT – Industrial Internet of Things, ArcGIS – Arc Geographical Information System, SQL – Structured Query Language, RTU – Remote Terminal Unit, PowerBI.

Introduction:

Objective of SCADA System in water distribution network is to establish near real time data monitoring telemetry system with all information available from RTU's in field i.e., flow, level, pressure, pH, turbidity, residual chlorine, Float switch etc. from service reservoirs and water network to control and avoid overflow of water in Reservoir and to monitor 24x7 quality and pressure of water in the network. This field instruments helps to derive daily flow, Pressure, Quality parameters for all DMA and water level of all reservoirs with graphical display and alarms as per Field instrument location. To Maintain and monitor alarm with real time map we Integrate GIS maps shape file with SCADA overview screen to make it lively for the customer. As per design GIS maps and shape file should be created separately using ArcGIS software as per the location and network requirement and it can be integrated with OSM or Satellite map in SCADA.

Figure 1: Satellite Image of Certain Location using Geographical Information System

These data from the RTU will be connected to SCADA System using DNP 3 Protocol and from SCADA System all the data will be send to the SQL server using ODBC Connection. The SQL server will contain this additional data which will be integrate with following third-party systems like PowerBI, which includes Laboratory Information database if any – Suppose if we are collecting water samples manually to test the quality of water at customer location which is collected at various DMA and recorded in database. Population - No. of connection in a DMA Systems database. Billing & Collection System database for every distribution unit. To collect volume billed per DMA, GIS system – To import updates GIS maps at regular intervals, Pressure loggers (FTP server) – To collect DMA daily critical pressure. Here below we are proving the design of SCADA architecture customised to integrate all the above listed points.

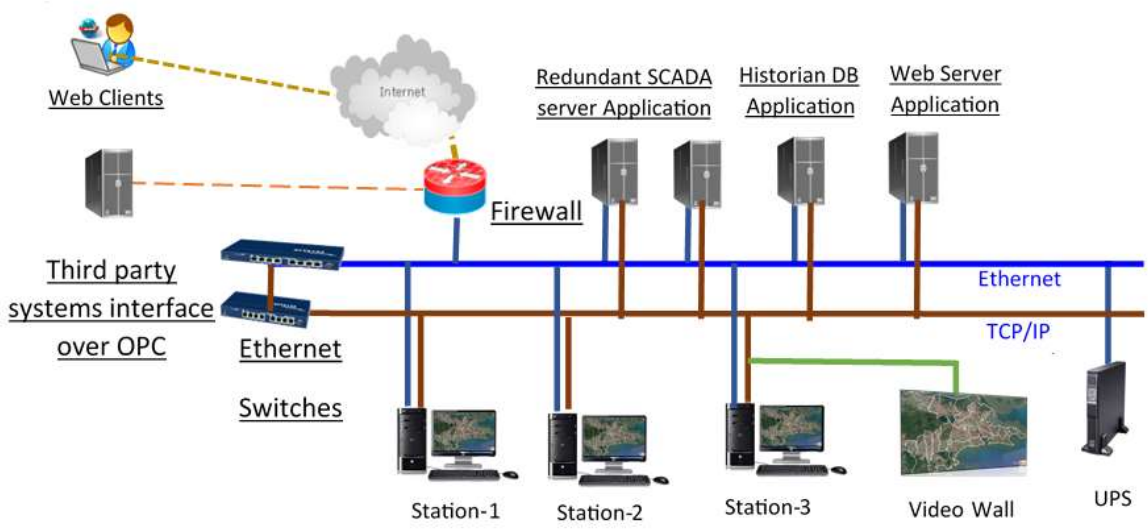

Figure 2: SCADA Monitoring System for Water Distribution Network

SCADA Architecture:

SCADA Architecture for the service reservoirs have the following layers of information's:
1)DMA flow rate – Display flow rate per DMA at any given point of time (Derived from DMA inlet and DMA outlet flow meters).
2) DMA Daily volume – Display daily volume per DMA from historical information available (Derived from DMA inlet and DMA outlet flow meters).
3) DMA Daily Min flow – Display daily minimum flow per DMA from historical information available (Derived from DMA inlet and DMA outlet flow meters).
4)DMA Pressure – derived from DMA critical pressure point.

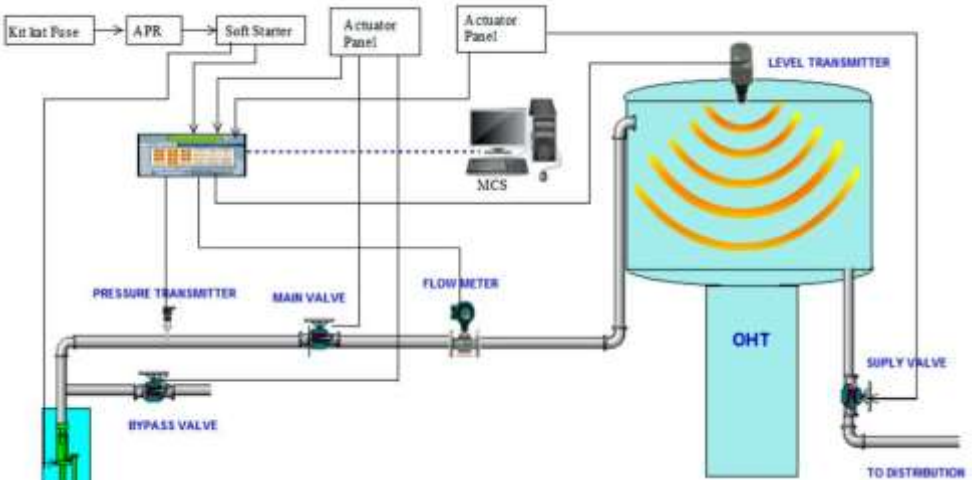

Figure 3: SCADA Service Reservoir

The overview screen shows us the feeder main network and also shows the animation of tank level, with alarm indication of level, flow and pressure of inlet of every reservoir. To navigate for real time data, click on any reservoir to go the reservoir screen. For this, communication and connection have to be linked and established.

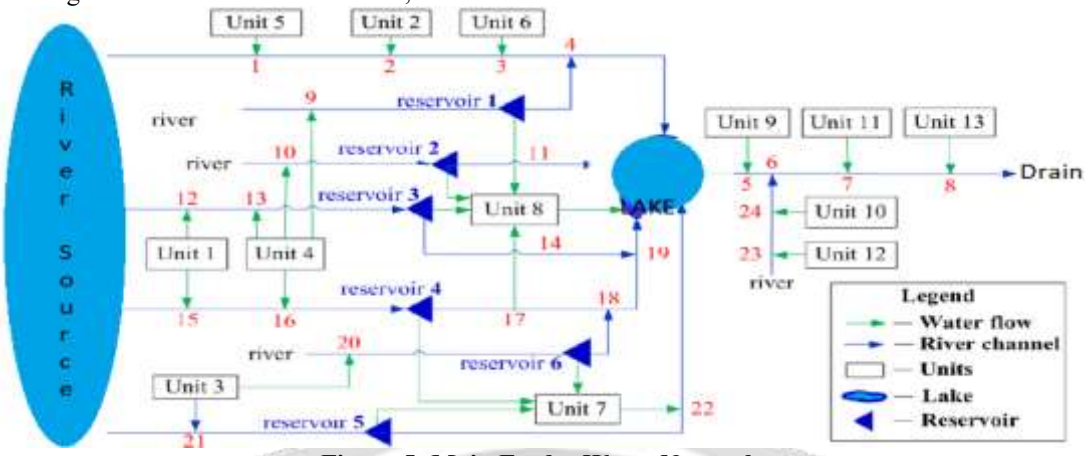

Figure 5: Main Feeder Water Network

1) DNP3 Communication Protocol:

DNP3 Communication protocol used in the main feeder water network. DNP3 Communication is established between RTU and SCADA via GPRS to transfer all the field information real time data to SCADA. SCADA & RTU has support for DNP3 Protocol, the main advantage of using DNP 3 Protocol is to attain Zero data loss during any extreme condition which may be due to GPRS network issue or Server-Side network issues. The system has capacity of storing 5000 events internally with time stamp to avoid data loss.

2)ODBC Connection:

The ODBC (Open Data Base Connection) is used to connect the database from SCADA to SQL and vice-versa. This also used to connect SCADA database to EXCEL to generate customized report where we need to set the system DSN and user DSN as per requirement correctly for smooth communication.

3) 4-20mA Communication:

As per the design all the field instrument are with 4-20mA output, which is connected to AI (analog input) of the RTU. The advantage of using 4-20mA is live-zero feature of the loop (the 4-mA low limit), which makes the loop self-diagnostic if there is a break or bad connection in the loop or a loop power supply failure. Maximum loop current (20 mA) allows the use of relatively simple safety barriers to limit loop current to an Intrinsically Safe level that prevents ignition in a hazardous location.

4)TCP/IP Communication:

TCP and IP Communication is set up between RTU and Modem for communication internally and also with SCADA. Also used interconnection of server with SCADA main server to Client server.

5)Open platform Communication:

OPC communication is used to connect IIOT Datalogger with SQL server. When to use OPC communication. Open Platform Communications (OPC) is a series of standards and specifications for the sake of domestic and industrial telecommunication. They are based on Object Linking and Embedding (OLE) for process control. In its most simple implementation, a SCADA system can still reliably distinguish between normal and abnormal operation. Even basic monitoring functions include the discrete, limit and rate alarms mentioned earlier. As in the pump station example, control actions can also be verified and alarms set to indicate failures. Alarm limits can also dynamically follow the process. For example, a ratio alarm could be set if the chlorinator feed rate were inappropriate to the water flow rate, even if it were within fixed high and low limits. If someone tampered with the chlorinator setting, this setup would catch it and report an alarm. Note that a chlorine analyzer further downstream could also back up this system. Perhaps the most advanced functions are performed when the SCADA system is used in conjunction with a modelling and simulation system. If the SCADA system is networked with the modelling and simulation system, it can provide live process information to build a model of your entire distribution system. This model can be used to establish feed forward controls and make the process to run with increased efficiency. It can also provide for back-up alarming. For Example, if there is any pumping failure in the site, the SCADA system will provide alarm indicating the signal as pumping failure in the corresponding site location. This makes the engineer to locate the pumping station which has failed in a quicker manner.

Methodology to create Dashboard:

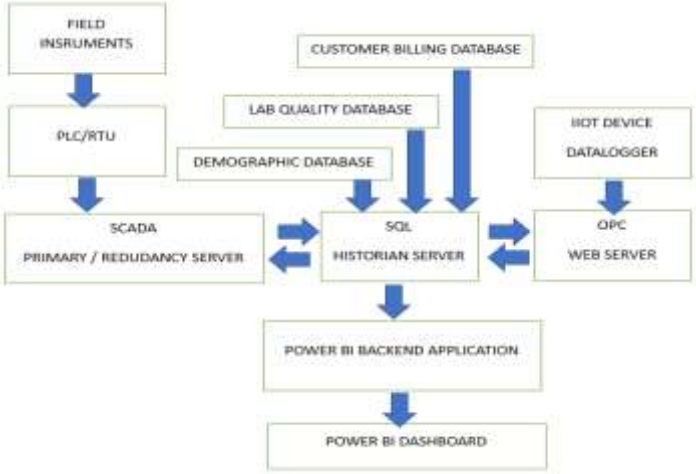

Figure: 6 Flow-Chart to Create Customized Power-Bi Dashboard

As shown in the flow chart, the field instrument from each location sends its real time data to the RTU which is connected through the 4-20mA connection, where the real time value scaled to the necessary SI units. Where the collected data by RTU/PLC will be shared to SCADA using DNP3 protocol via GPRS mode. Once the data received in SCADA primary / Secondary Server it will be displayed on the SCADA Screen and the same data will be sent to SQL and Historian Server to store the data. The stored data in Historian is used to keep as backup and where all the historic data will be stored for many years depends on the server size, The same data will be stored in SQL in a table format to access it for third party application like POWERBI for creating dashboard, In the same historian server, SQL database other database like water quality database, customer billing database, demographic database will be created in separated table.

Third-party application is used because it helps to make use of utilizing all the available data in a platform for analyzing. For example, using SCADA data we can calculate the consumption data, Quality, pressure and critical pressure in that water distribution network. In Billing database, we get data of no. of customers billed and pending bill. In water quality database, we can able to get data of individual household water quality. PowerBI helps to merge all this data and gives us a single dashboard which will be easy for our real time analysis.

Results and Discussion:

In water feeder network SCADA system is implemented for data analysis and to process the report very time for billing. In order to overcome the issue, we here used a third-party application which can help in viewing the data in customized way based on our requirements in a single dashboard. Now a days in every smart city there are control room who are asking to integrate the various project data in their control room to monitor, in that case creating a SCADA setup is very difficult as SCADA software are licensed and it has various security issues as everywhere we are using firewall. Once if we create PowerBI application we can easily share and display the dashboard using URL which is easy and does not required any licenses. Also, PowerBI application are very easy and user friendly to operate and generate report. As a result, it is used for combination of many data to analysis and report quickly which is time saving process.

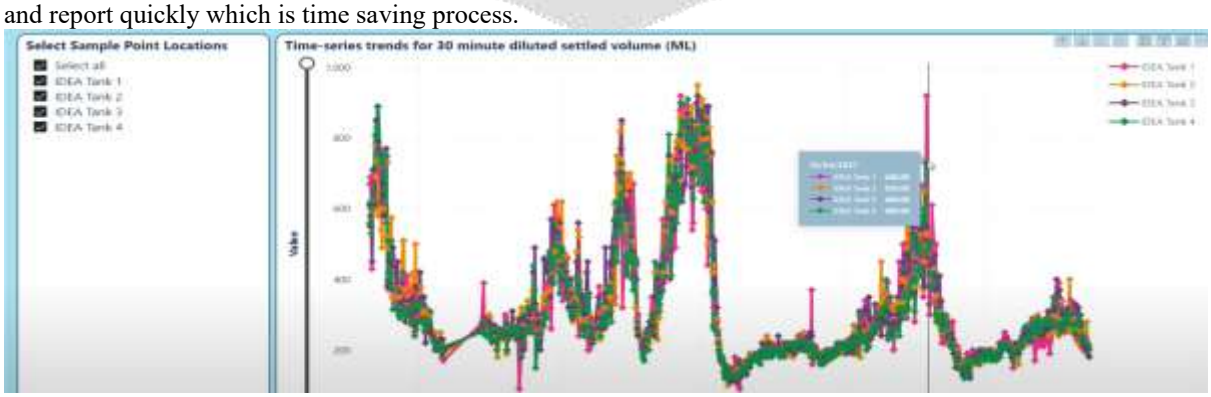

Figure: 7 PowerBI for Water Tank Capacity

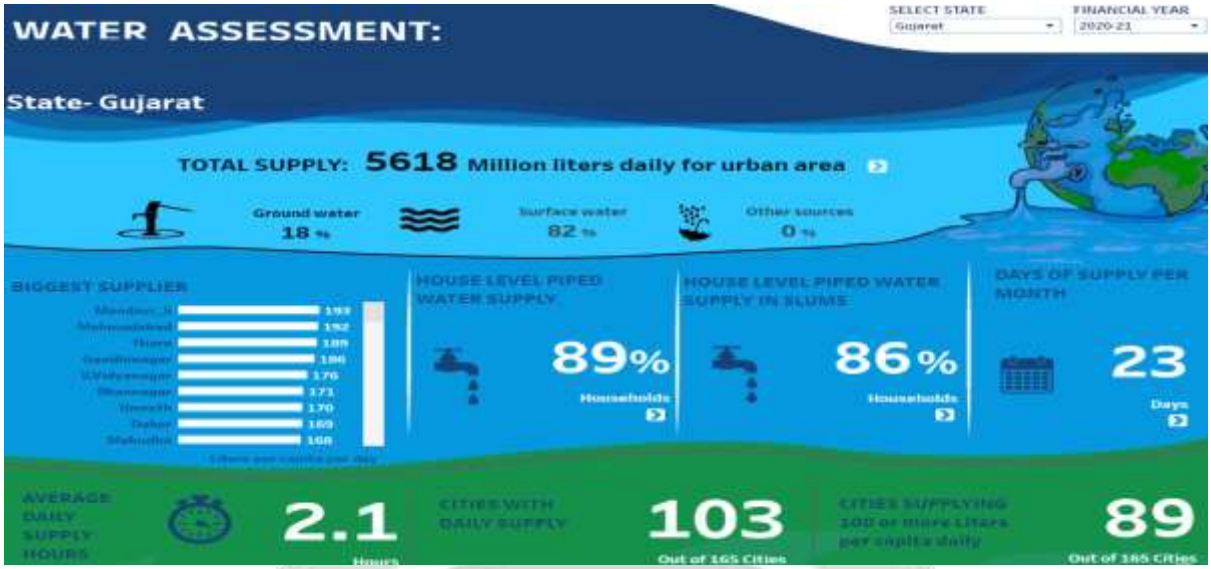

Figure 8: PowerBI Dashboard for Water Supply in a State

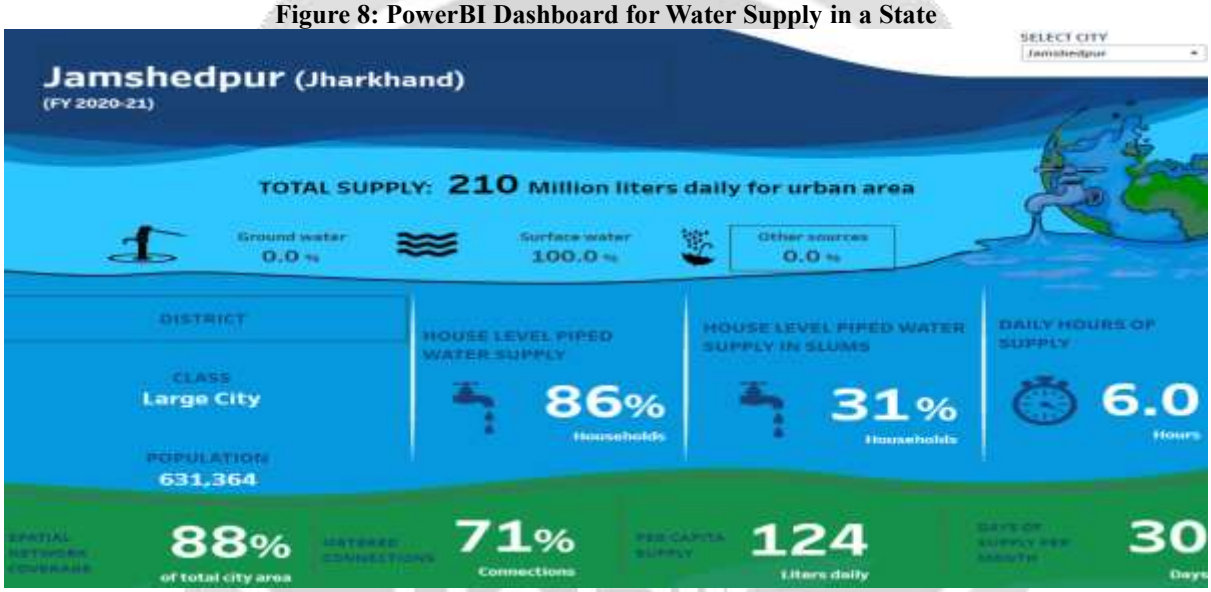

Figure 9: PowerBI Dashboard for Water Supply in large city

Figure 10: PowerBI Dashboard for Water Billing based on Consumption