International Journal of Scientific Engineering and Research (IJSER)
www.ijser.in
ISSN (Online): 2347-3878
Volume 2 Issue 3, March 2014

The Potential Future Innovative Application of Municipal Water Supply Database

Thewodros G. Mamo[1], Ilan Juran[2]

Department of Civil & Urban Engineering Polytechnic Institute of New York University[1, 2]
6 Metro Tech Center, Brooklyn, NY 11202

Abstract: ***The use of multi parameter sensors for the day to day operational and management activities become an essential component of leading water utility companies in the effort to modernize their water distribution pipeline networks systems. The integration of supervisory control and data acquisition (SCADA), geographic information system (GIS) technology and smart automatic meter reading (AMR) by water utility companies to their systems, with the widespread deployment of multi-parameter sensors to monitor water distribution pipeline networks operational activities, allows vast amount of data to be collected, analyzed, and acted upon in the shortest periods of time. These multi-parameter sensors not only respond to the change of operational pattern to produce data, they also embed with computing and communication capabilities. These systems are able to store, process locally and transfer data they produce to the water utility companies' main database. Therefore the main aim of this paper is to explore the potential future uses of this operational water distribution pipeline networks database considering the current limited use by highlighting the immediate opportunities these data will creates for the purpose of an innovative application to monitor and identify anomalies and optimize water utility operational and management practices.***

Keywords: Water Distribution Operation; GIS; Water Supply Data Bases, SCADA, AMR, AMI, Multi-Parameter Sensors; Smart pattern Recognizer Algorithms; Advanced Statistical Analysis

1. Introduction

The water utility company's operational data has always been the benchmark for effective operational and planning decisions process. The use of supervisory control and data acquisition (SCADA), AMR, and AMI by water utility companies, have transformed these activities by offering a tremendous amount of improvement in the operational efficiencies which includes monitoring and control capabilities, such as remotely control pumps, strategic valves, support billing, customer services, and managing utility assets. So far the water supply database applications are generally limited to offline analyses; therefore there is a growing demand for online near real-time approaches which leads from reactive to more proactive operational management strategy [2][4][5][6][8]. One of the future tools that can be used to help accomplish this growing demand for online near real-time is the online hydraulic network simulation model with historical and near real-time data driven smart pattern recognizer algorithms & advanced statistical analysis, which has forecasting capabilities and can be integrated with Multi-parameter Water supply network sensors database to provide accurate network performance and operational information from real-time data [3] [7] [9] [14]. This proactive approach will enable the water distribution pipeline network operators to quickly and reliably assess the detected problems and respond to anomalies, failures, and other non-routine situations in a timely manner[15][22].

2. Future Innovative Application of Water Supply Database

Today's the way day to day operational activities conducted by water utility companies changing rapidly. Many utility companies are integrating new technology solutions to modernize their water distribution pipeline networks, and infrastructures. Some of the Potential future innovative application of water supply database can be the online hydraulic pipeline networks simulation model with historical and real-time data driven analytics intelligence capability with automated identification of patterns, relationships, and trends in water distribution operational data. This advance intelligent system will design to inform decision making with descriptive and predictive modeling of future states and conditions of the network. Moreover, to optimize service delivery, the future innovative applications should be holistic, and capable of real-time monitoring anomalies of the entire networks environment, as well as granular insight into its every component [10][11][12][14]. The future system could insight not only into the network service's present state, but also into its past and future states to model the impacts of usage, scaling, and changes. Below is the schematic future proposed historical and real-time data driven system Architecture of virtual DMA leak detection and monitoring system which can be used advance pattern recognizer multi-class support vector machine for water distribution pipe line networks[20][21][22].

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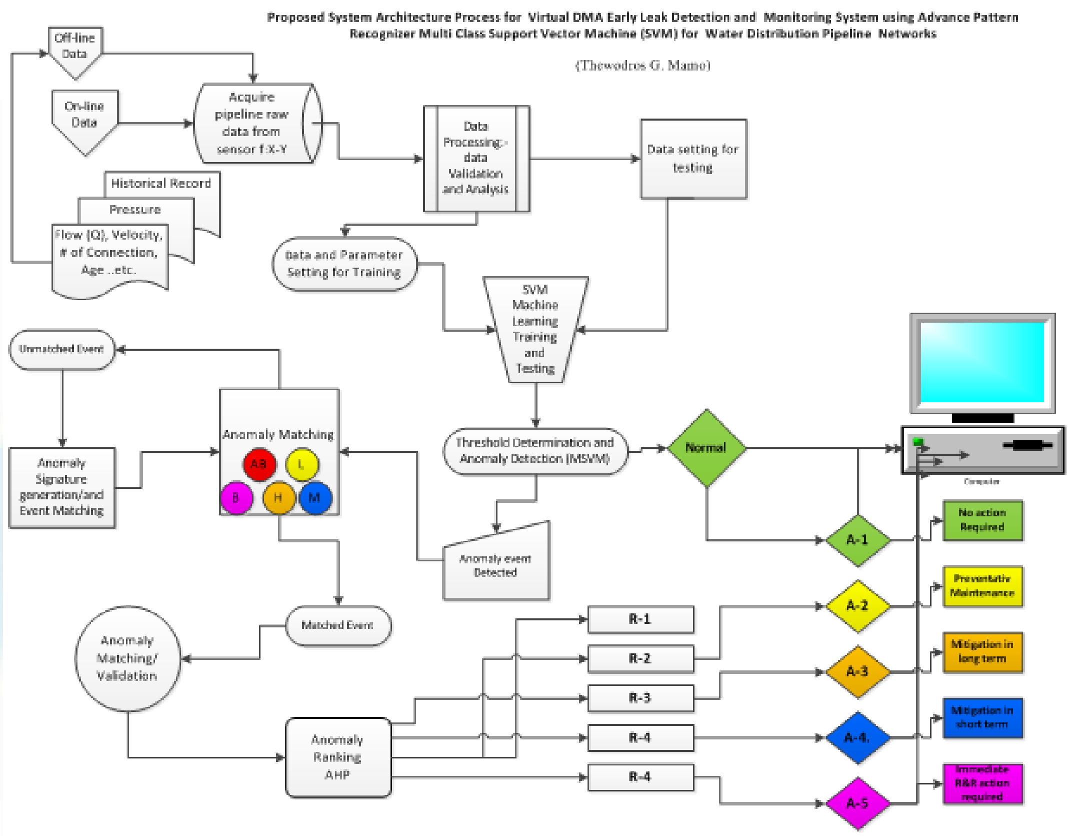

Figure 1: Proposed system Architecture of Virtual DMA leak detection and monitoring system using multi class SVM which can rank (R-1, R-2...), and classifies different events (E-1, E-2…) accordingly their severity

3. Pipeline Networks Performance Monitoring

One of the main task that can be accomplish using the historical and near real-time data driven intelligent system are real-time pipeline networks performance monitoring and analysis such as pressure, consumption, pump, and reservoir etc. throughout the entire water supply infrastructure system regardless of their locations. This component can be integrated with the water supply operation data and the historical and near real-time data driven intelligent system to offer insights into service levels, user behaviour, and optimize consumer interaction for water billing and transactions, and ensure the timely response in case of water supply line breaks, leaks or pressure drops occurred that engender the safety of consumer and water infrastructure structural integrity. Using such an intelligent data driven system to the network will provide the water utility companies operator to gain proactive control of service performance to react to events quickly, and empowers water utility companies to proactively address issues before they manifest as service disruptions or severe structural damage. More over by using the offline and online data from each services components the behaviour learning analytics track performance metrics can learn and automatically adjust baselines normal service behaviour [9][11][19][22]. This main components of advanced statistical and trending algorithms system can also help to forecast when service is likely to fail to meet its service levels and alert water utility operator and management centre and shift the process from reactive management to proactive control of critical water infrastructure.

4. Isolate the Actual Problem

Most of the time water users have a tendency to follow repeatable patterns [6] [7]. Experienced operators easily understand what is required for normal operation but, when event such as a leakage, break or burst of water main occurs without apparent forethought, they often have to respond in a reactive manner, usually with inadequate information provided by customers already impacted by the event [13][16]. One component of real-time data driven smart pattern recognizer Algorithms & advanced statistical analysis is anomaly detection and core problem analysis. Once service impact analysis determines state of failure in an essential service, the system will identify the problem's cause and alerts the operator the severity of the problem by ranking the events as R-1, E-1...etc. and color code. Using this system based on the real-time and historic position data the patterns of behaviour of each DMA or pipeline networks are compared with predetermined patterns of behaviour of interest to identify and isolate any anomalies whose signal was detected at or near a particular location on a particular data at a particular time [11][13][14][17][22]. For example, an application might showing a sudden pressure drop or increase, but the actual problem could be multi parameter sensor malfunctioning with a database, a server, or even a network connection. Performance analytics can assess all the devices and components, evaluate recent abnormalities, alerts, and events along with configuration changes (planned or unplanned), and allow the water utility staff to act on the core problem. Therefore, core problem analyses ensure prompt remedial action. These will decrease the amount of time used by water utility experienced operators manually to identify, prioritize, and diagnose water distribution-crippling problems. Moreover the mean-time-to-repair (MTTR) will greatly accelerate [14].

5. Prioritize Rehabilitation and Replacement (R&R) Maintenance Strategies

Each water distribution pipeline networks have their own distinct characteristics such as different operating pressure, service location, pipe sizes, material, and deterioration factors. Today, one of the broader challenges water utility companies are facing associated with their infrastructure includes lack of when and how to evaluate, rank, plan and execute maintenance projects that restores or replaces towards to its originally planned capacity or condition in a cost-effective manner those deteriorating water pipeline networks which have multiple leakage, and can cause in the future poorly hydraulic performance, service interruptions, damage of property, and poor water quality [1][4][6][18]. Some of the decision challenges water utility companies are facing involve selecting the optimum possible solution among a number of competing alternatives. However, to select the best solution available in a systematic and innovative way, decision support methodologies with the desired objective in mind that facilitates comparative professional judgments and eventual optimized alternative decision options are needed To demonstrate how risk based fuzzy analytic hierarchy process (FAHP) decision support approach can be used to rank existing or recently detected municipal water mainline leakages for selecting of which water main pipeline from the networks require urgent action, and to prioritize the optimal alternative rehabilitation and replacement (R&R) Maintenance Strategies with value professional judgments and stakeholder preferences.

Water utility companies must enable prioritize events and abnormalities in the system that threaten vital services and infrastructure integrity. Therefore the water utility system must design to identify issues with a true service impact. This Service impact analysis component of the system utilizes real-time service models with information from configuration operational management databases and real-time monitoring to define the entities that comprise anomalies, and their relationships to each other, then identifies which service(s) are being impacted by a faulty component so the water utility staff can prioritize work based on impending business consequences [13] [17] [22].

6. Conclusion

Water distribution operational data has always been the benchmark for effective decisions making process. The development and implementation of geographic information system (GIS) technology, supervisory control and data acquisition (SCADA), and smart AMR by water utility industries, with widespread deployment of multi-parameter sensors to monitor operational activities allows tremendous amount of data to be collected, analysed, and acted upon in the shortest periods of time allows water utility companies to save water, time, money and energy.

Therefore with an increasing number of leading water utility companies are taking advantages of using these tremendous amount of operational data coupling with information technology solutions in their operational and management practices, there is no doubt that real-time and historic data driven IT solution with smart pattern recognizer algorithms & advanced statistical analysis will be the next stage in the evolution of leak detection and location technologies and the overall municipal water supply and distribution system operational and management practices.

The most basic implication of this study is to transfer knowledge among water utility professionals, by highlighting the potential future innovative applications of municipal water supply database for decision support or other data related information technology (IT) innovations that improve important outcomes across diverse practice settings of water supply system asset management or any other operational or planning activities.

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