

A GEOSPATIAL PLATFORM FOR ACCESSING DATA AND COMMUNICATING WITH SECURITY AND WATER QUALITY MONITORING SYSTEMS

Dan Kroll, Chief Scientist Hach Homeland Security Technologies
5600 Lindbergh drive, Loveland Colorado 80539
DKROLL@hach.com

ABSTRACT

On-line monitoring systems typically consist of a means of measuring basic on-line water quality parameters - often coupled with interpretive algorithms for event detection and classification. These systems facilitate an unprecedented view of the basic water quality anywhere in the network. One deficiency in these systems derives from their widespread geographic deployment. Monitoring site access for instrument verification, data acquisition and other housekeeping and emergency response tasks can become daunting when it is understood that a system may be comprised of tens or even hundred of monitoring nodes. This, combined with the expediency of being able to view the network as a whole makes the need for a hierarchical centralized system of command and control a must. The solution described here consists of communication and data handling software that will give utilities a bi-directional monitoring and control system that integrates the data flow from water quality monitoring points strategically located throughout a water supply network. This gives utility personnel the ability to simultaneously view and minimize response time to critical water quality data anomalies from any Internet browser at any location.

INTRODUCTION:

On-line monitoring systems used to survey our water supply networks are becoming more ubiquitous. After 2001, the additional inducement of water security was added to water quality as a motivating factor for monitoring. This has led to a rapid deployment of monitoring schemes for all aspects of the water supply network from the source water supply through the treatment plant and on into the distribution system. These systems consist of a means of measuring basic on-line water quality parameters often coupled with interpretive algorithms for event detection and classification. These

systems facilitate an unprecedented view of the basic water quality anywhere in the network.

However; there are some drawbacks to these monitoring platforms. One deficiency in these systems derives from their widespread geographical deployment. Monitoring site access for instrument verification, data acquisition and a wide variety of other housekeeping and emergency response tasks can become daunting when it is understood that a system may be comprised of tens or even hundred of monitoring nodes. This, combined with the expediency of being able to view the network as a whole so as to be able to correlate and relate patterns of response, makes the need for a hierarchical centralized system of command and control a must.

The solution described here consists of communication and data handling software that will give utilities a bi-directional monitoring and control system that integrates the data flow from water quality monitoring points strategically located throughout a community's water supply network. This gives utility personnel the ability to simultaneously view and minimize response time to critical water quality data anomalies from any Internet browser at any location. The capabilities of the system provide utilities with a virtual command center for water distribution monitoring and control from a location or locations of their choice. This allows for effective response and coordination of multiple sites and functions within the organization.

In the past, utilities could either physically download data from an individual instrument monitor or use a remote service such as VNC (Virtual Network Computing) to view one distribution-monitoring site at a time. Every action took a significant amount of time. Only a single computer could access the data. With the new system, multiple utility personnel can simultaneously view all the data together, giving the utility a comprehensive, immediate and real-time picture. On a single screen, utility personnel can view the current status of all monitoring points in the network; download data and clear alarms remotely. Users can easily "drill down" into data from an individual monitoring point in the same manner as if they were physically standing at the site. The underlying algorithms at the monitoring sites ability to calculate a fingerprint of a water quality event and its ability to learn, combined with utility personnel's ability to access real-time and historic data, can provide utilities with a deeper understanding of their

network's performance. This in turn can allow them to streamline operations, reduce costs and labor, and boost efficiency - all while further strengthening public health protection.

MULTI-PARAMETER MONITORING SYSTEMS

Multi-parameter monitoring is the method of monitoring common water quality parameters and then looking for anomalies that may be indicative of a water contamination event. Immediately after 9/11, the concept of deploying common sensors to act in just such a manner was investigated for water security monitoring. A number of government, (Hall 2007; ETV 2005) academic (Byer and Carlson 2005) and private industry studies (Kroll 2002) evaluated a variety of sensors to see if they would respond to the contaminants most likely to be used by a terrorist in an attack. These studies verified this approach as valid.

A variety of instrument manufacturers have developed multiple parameter water quality monitors based upon this premise for source water, treatment plant and distribution system water. These systems encompass a diverse selection of different sensors and can be tailored to meet monitoring needs. See fig. 1. The current state of bulk parameter on-line monitoring with existing instrumentation is that significant actual events are detectable.



Fig.1 Instrument packages have been designed for different applications including source water and distribution systems.

The problem then becomes what to do with all of the data generated by such instrumentation. Enormous amounts of streaming data need to be processed, correlated and acted upon. Another problem is the minute-to-minute variability that is present in a system. How are we to determine if alterations in water quality parameters are significant against a background of dynamic changes? Unless a full time team of statisticians is to be employed to make sense of this information, there is a need for intelligent algorithms to streamline the process. A number of such algorithms have been designed as an integral part of a water contamination early warning system (EWS)

These intelligent algorithms are capable of detecting the subtle changes in bulk parameter readings that are indicative of an incursion into the system. Some are also capable of discriminating the unique pattern of responses that are elicited by different classes of agent. These differences may be enough to identify the class of an event and possibly fingerprint the most likely members of that class. An assortment of sophisticated algorithms for interpreting on-line data and recognizing threats are being developed by a number of private and public entities including Sandia National Labs and the EPA in their Threat Ensemble Vulnerability Assessment TEVA program. One such commercially available system designed by Hach Homeland Security Technologies makes use of 5 common bulk parameters that are monitored simultaneously in real time. The parameters that are monitored are pH, Conductivity, Total Organic Carbon, Turbidity and Residual Chlorine. When measured in real time, these parameters can show a lot of variability in a given system. That is why a baseline estimator that is sensitive to small perturbations and yet is resilient enough to not be constantly alarming due to normal fluctuations is required when developing such a system. Many classical methods of baseline determination result in poor sensitivity or high false alarm rates. The proprietary baseline estimator used in this system addresses these problems. See fig 2.



Fig. 2. Algorithms for early warning and event detection are housed in the event monitor trigger system.

There are a number of criteria that a successful early warning system for water should address. These include: (EPA 2005)

- 1) The system should provide a rapid response.
- 2) The system should be capable of detecting a sufficiently wide range of potential contaminants.
- 3) The system should exhibit a significant degree of automation, including automatic sample archiving.
- 4) The system should allow acquisition, maintenance and upgrades at an affordable cost.
- 5) The systems should require low skill and limited training to operate.
- 6) The system should demonstrate sufficient sensitivity to detect contaminants at the levels of interest.
- 7) The system should experience minimal false positives/false negatives.
- 8) The system should exhibit robustness and ruggedness in continually operating in a water environment.
- 9) The system should function continuously.
- 10) The systems should allow for third party testing, evaluation, and verification.
- 11) The system should allow remote operation and adjustment.

- 12) The systems should identify the source of the contaminant and allow accurate prediction of the location and concentration downstream of the detection point.

The algorithm sensor packages currently available do an excellent job of addressing the first 10 criteria, but they fall short on numbers 11 and 12. Software managed to get us into this predicament and it will require software to get us out.

REMOTE OPERATION AND ADJUSTMENT

The widespread geographical dispersion of sensor packages in an EWS network often becomes a enormous problem for those responsible for the operation and maintenance of a system, Travel to remote and widespread areas for routine functions and trouble shooting can be an enormous drain on money and personnel. If the system is not easy to maintain and operate it is likely to be neglected and fall into disrepair and inoperability.

The new software communication package allows the user to visualize the instrument readouts as if the operator were on site. See fig. 3. End users can drill down and visualize individual aspects of the data and compare it to historical trends or rapidly compare it to other sites in the network. Sensor faults are accessible allowing maintenance teams to be dispatched when needed. Users are able to access the event monitor software from remote locations of their choice rather than going to the site at which the instruments are deployed. Once the event monitor has been accessed, operators can exert bidirectional control of numerous event monitors from one or several remote locations. This will enable the end user to clear alarms, name events, reconfigure event monitor settings and alarm thresholds, and trouble shoot without travel to the site. While travel to individual sites for functions such as calibration and routine maintenance will still be required, the decrease in travel for other functions now capable of remote manipulation can be substantial.

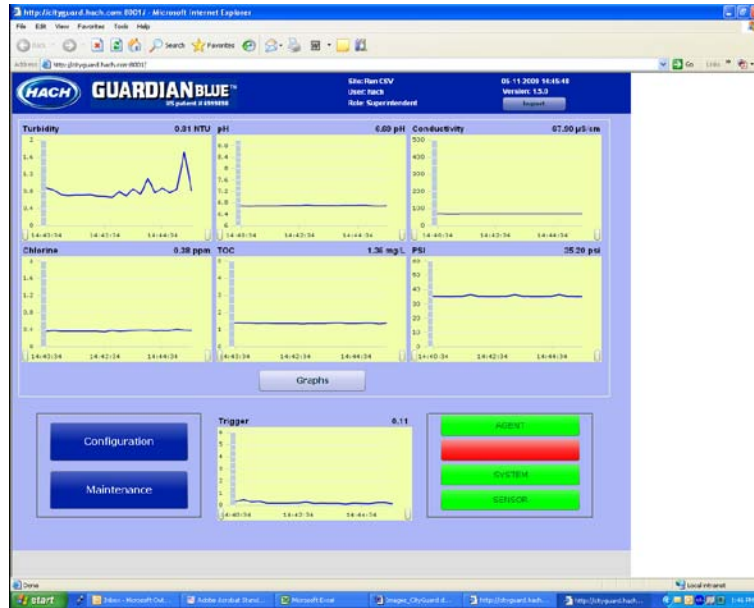


Fig. 3. Individual sensor readings can be visualized as if you were on site.

IDENTIFICATION OF CONTAMINANT SOURCES AND PREDICTION

The new system allows for the overlay of early warning system monitoring sites with street maps and aerial photographs so that a detailed spatial temporal snap shot of the early warning system network can be obtained. This allows easy visualization of monitoring platforms and their alarm status. A simple color-coded (red, yellow, green) icon scheme is used to denote alarm status. This allows for a quick visualization of which nodes in the system are alarming and which are not. See fig. 4.

This combined with flow information can allow for prediction of which nodes in the system are likely to alarm in the future if an actual event is occurring and the alarm is not due to other causes. This visualization can be very useful in accelerating public health response, determining isolation schemes to prevent spread of contamination and reducing damage to infrastructure and cost of remediation. When prompt and appropriate action is taken water service can be restored in a timelier basis.

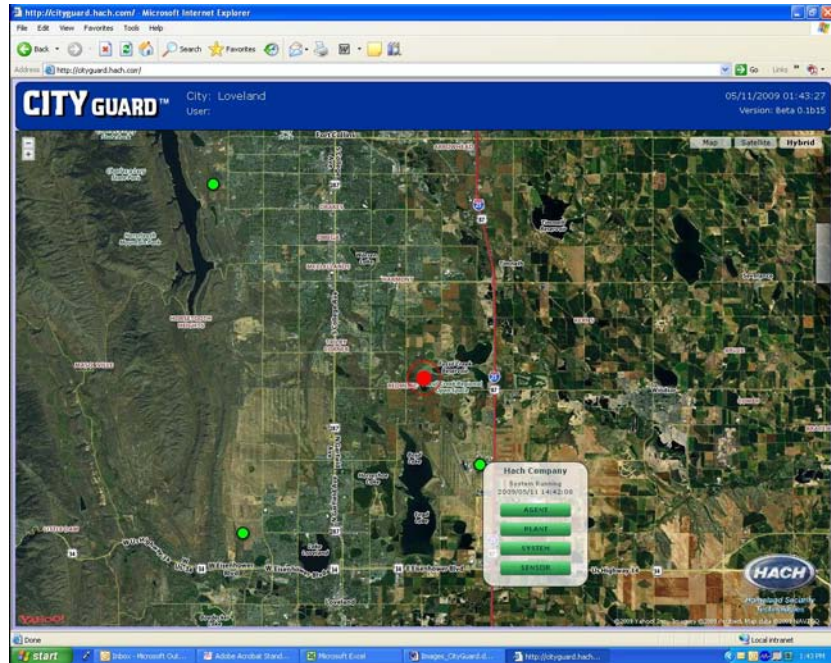


Fig. 4. A simple color-coded icon scheme allows for rapid visualization of which nodes in a system are alarming and which are not. Circles denote monitoring nodes. Green nodes are not alarming. Red nodes are alarming.

Simply clicking on a node will bring up a window with the on-line data for that site. Multiple sites can be brought up at once to compare instrument readings. See fig. 5. This allows evaluation of whether predictions about plume movement within the system are correct with out visiting the sites.

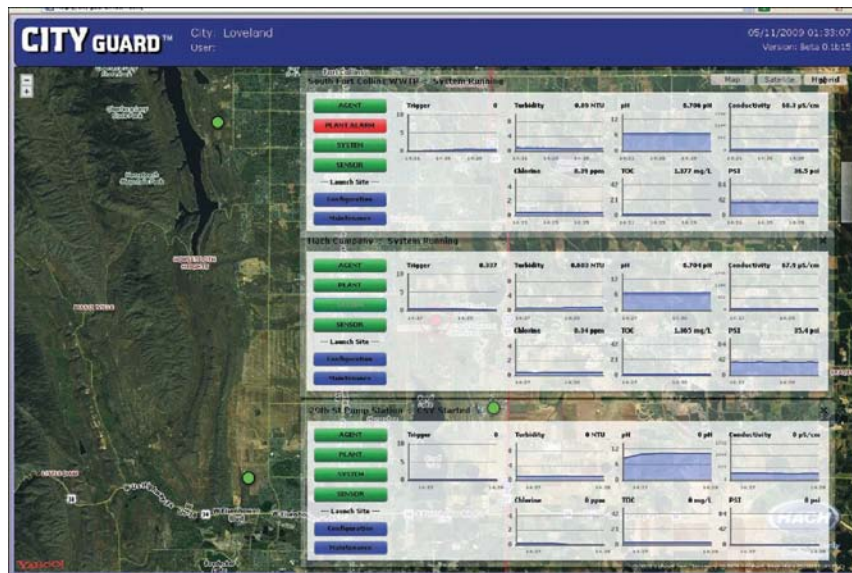


Fig. 5. Data from multiple sites can be simultaneously accessed by simply clicking on their icons.

CONCLUSION AND FUTURE WORK

The benefits of such a software package as the one described here are that it allows you to derive enhanced value from remote monitoring while making operation and maintenance less onerous. The software allows the viewing of multiple monitoring points at a glance. This combined with the mapping function allows users to better visualize and understand patterns of sensor response to events, which in turn can be used to streamline response.

The system gives the user bi-directional control of multiple monitoring stations at the same time from any location with Internet access. This allows a savings in time and costs associated with travel to remote monitoring sites. End users can also drill down, view and analyze water quality data from multiple sites without leaving the office.

In the future, this system will be coupled with a WIMS or water information management system will serve to enhance the system even further. This new functionality will allow users to correlate water quality data from many different sources including laboratory and field-testing with the on-line generated data streams. WIMS systems will enable the correlation and comparison of these diverse data streams and will have capabilities to automatically generate reports for both internal use and reporting purposes.

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