PATTERN MATCHING OF LIVE DATA TO IMPLEMENT PROACTIVE NETWORK MANAGEMENT

Eur Ing Steve Mustard, Product Manager, LogicaCMG

Dr Mark Thornton, Solutions Director, Helveta

Abstract

Supervisory Control And Data Acquisition (SCADA) has been used for the past 40 years to monitor and control utility networks and manufacturing processes and provide real time information on networks to allow timely reactive responses to be made to incidents.

Experienced operations staff can identify complex situations based on information provided by SCADA systems and systems are in place elsewhere to ensure prompt reaction to these situations. Predicting the occurrence of complex situations would allow a more proactive approach to network management. There are now methods to predict such situations based on the automatic recognition of patterns in data supplied from SCADA and other data systems.

This paper considers methods for using pattern recognition on live data to create a proactive network management methodology.

Introduction

UK water utilities are constantly challenged to meet or exceed ever increasing regulatory requirements with fewer and fewer staff.

Technology and technical solutions have improved greatly over the past few years and these already help the UK water utilities in their challenges.

Pattern matching is widely used in image and signal processing as a means of automatically identifying actual or potential events or features.

The combination of such techniques with other utility systems could help to provide a comprehensive solution for proactive management of water networks.

Improvements in SCADA

The utility industry uses Supervisory Control And Data Acquisition (SCADA, also known as telemetry) as a fundamental component of their operations. Network management systems provide the water utility with critical information on the status of the network components and allow the network operators to effectively manage the treatment and distribution of clean and waste water.

A typical wide-area SCADA system will cover a very large part of a water company's operational network.

Originally based on meeting safety requirements (such as alerting a control room when a level is too high or low) SCADA systems are now also used to collect performance information on their network assets, such as the number of hours a pump or motor has been running for.

Water utilities are becoming more proactive in the use of this performance data. For instance, with information on how many hours a pump or motor has run for, a maintenance manager can optimise maintenance based on how heavily equipment is used which has an additional benefit that unscheduled outages are reduced.

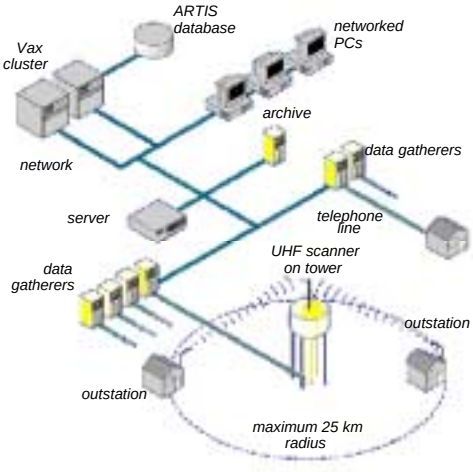

Figure 1. A typical wide area SCADA system monitoring a water utility network.

The increasing challenges for water companies

UK water utilities have made huge steps since privatisation to improve drinking water quality, reduce losses through leakage and reduce incidents such as sewage spills. However, the regulatory bodies continue to press the UK water companies for improvements and the demands for the present regulatory period, PR04 from 2005 to 2010, presents some significant challenges. These challenges all incorporate a number of themes:

- To identify potential issues before they become real problems
- To schedule remedial work in a timely manner in order to rectify underlying causes
- To learn from potential and real situations so as to improve the ability to identify potential issues.

For example, OFWAT requires UK Water and Sewerage Companies (WASCs) to minimise the number of incidents of sewer flooding and overall to reduce the number of properties at risk of sewer flooding (Regulation DG5). In order to achieve this a WASC must be able to

- Collect real time sewer network information such as level and flow.
- Relate this real time information to a network model or other heuristic information in order to determine points in the network that require urgent remedial work
- Co-ordinate field teams to rectify the work in the required timescale and identify that the work is complete and the issue is resolved
- Have a high level view of their achievement of regulatory compliance.

The collection of real time network data in a cost effective manner requires the use of battery powered devices with wireless (usually GSM) communications as otherwise it is either too expensive or impractical (for instance, to install mains power and communications links) or inadequate (for instance, logging data locally and collecting it manually will not provide true real time status).

Figure 2. Collecting network information effectively in real time requires devices that can operate at low power and with wireless communications.

Most WASCs will have a hydraulic model of their clean and waste water networks. Real time information can be applied to this model in order to identify areas where there are potential issues. Traditionally this is an off-line process taking place periodically, with intervals anywhere between 4 hours and one month. In order to meet the challenges laid down by the UK water regulators methods are required that can provide reliable information in real time or near real time.

Once potential problems are identified, the WASC has another issue, to ensure that field teams are issued with appropriate work instructions and tasked with completing work in a timescale necessary to avoid an incident. Since privatisation workforces have been downsized significantly and WASCs face a real challenge to ensure all maintenance and remedial work is planned and completed effectively. Work Management Systems, together with automatic Field Force Scheduling and Optimisation Systems are widely available and commonly used by WASCs to manage their field operations.

Figure 3. In order to meet the challenges with a reduced work force, utilities need to ensure the field force can receive work orders and view key information remotely using wireless communications technology.

Finally, the task of monitoring regulatory compliance is a significant one, consuming large amounts of time and effort for a typical WASC. The provision of information in a “management dashboard” style is becoming increasingly common. The aim is to provide the Key Performance Indicators (KPIs) that managers need to monitor in an easy to understand form so that the current situation is clearly understood and important decisions can be made quickly.

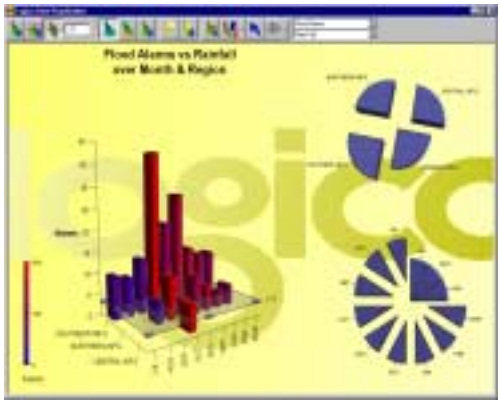

Figure 3. A typical dashboard-style report showing key performance indicators in a simple form for rapid decision making.

Pattern matching to identify situations

The use of pattern matching is not new and has been successfully applied using signal and image processing to a very wide range of scenarios such as to speech recognition (recognising words based on patterns in speech signals), automated manufacturing (detecting faults in manufactured product by comparing an image of a good unit with those being made and highlighting differences) and submarine detection (detecting types of submarine from the specific type of noise given off by their different engines).

There are many methods and algorithms for pattern matching but in principle they all follow the same approach: to identify particular situations (or syndromes) by analysis of data from one or more sources. Most pattern matching methods apply the process of self-learning so that for increasing data analysis the accuracy of the analysis increases.

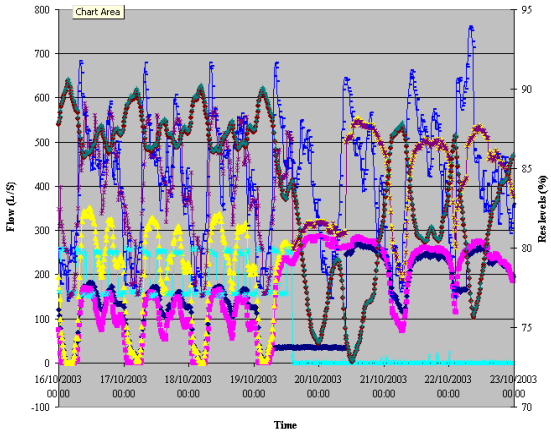

Figure 4. Looking for predefined patterns in data can help to automatically identify upcoming events.

The benefit of analysing data is that it can be done automatically using computer processing. This greatly reduces the time taken to complete the analysis and also increases the accuracy of the results.

The potential disadvantage of an automated approach is that it is entirely dependent on the accuracy of the rules provided in the first place. However, if a self-learning solution is used then with sufficient data input then the analysis results will continually improve.

Figure 5. A typical report showing potential incidents and their status.

A real world example

The following example has been modified to retain the anonymity of the client involved.

In this example a process takes a number of inputs of raw materials and produces a number of discrete outputs of product. An incident occurred whereby one of the outputs of the process was damaged and a significant loss of product resulted. This was identified after it occurred and rectified.

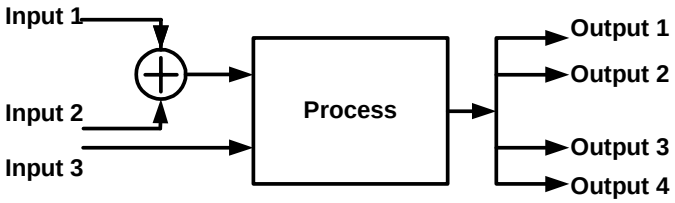

Figure 6. Simplified overview of the process.

After the event the data from the SCADA system was analysed.

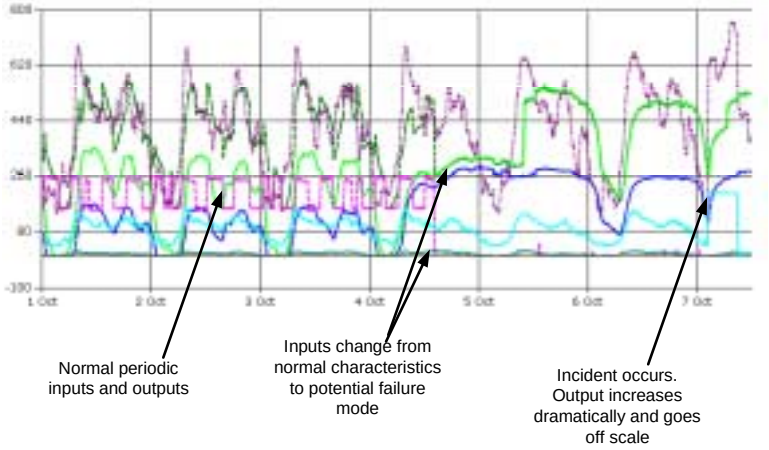

Figure 7. Analysis of the SCADA data for the process shows a distinct change in characteristics two days prior to the event. Had some form of automated pattern matching been in operation a warning would have been issued at this time and there is a high possibility that the resulting event would have been averted.

Furthermore, by using the real data and identifying the resulting event it would be possible to identify future circumstances that match the pattern and thus indicate another potential occurrence of the same event.

Proactive network management

To achieve the level of proactive network management necessary to comply with the increasing regulations from the UK regulatory bodies it is essential that WASCs integrate their key systems together to provide an integrated view as shown in Figure 5.

In this approach, real time network status is provided to the WASC control room as normal. In addition, this data is combined with metrological data as inputs to a pattern matching engine which will compare the current data to identified syndromes and raise alarms to the SCADA system if syndromes indicating problems or potential problems are detected.

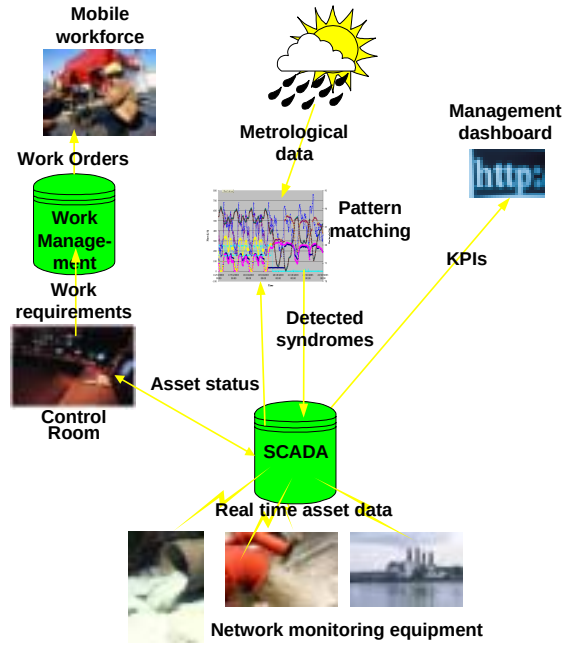

Figure 5. An integrated approach for proactive network management.

Based on information from the SCADA system, the Control Room will raise work orders automatically or manually and these work orders will be scheduled and optimised accordingly before being issued to the field force.

Information relating to KPIs will be made available to management users and this will show an up to date view of the status of regulatory compliance.

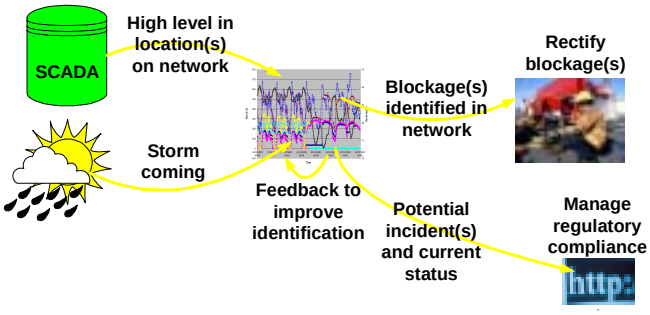

Figure 6. Proactively handling an incident.

Summary

An approach to the proactive management of networks has been considered. This approach integrates the existing utility systems such as SCADA and Work Management with information from other sources such as metrological data and uses pattern matching techniques to look for syndromes or potential events occurring in the network that require remedial work and automatically schedule field engineers to perform the work required before an incident occurs. With sufficient self-learning the integrated system should improve its ability to identify potential problems and UK water utilities will be able to schedule remedial work in a timely manner, thus greatly reducing the number of unplanned incidents.

Further information

The authors can be contacted on Steven.Mustard@LogicaCMG.com or Mark.Thornton@Helveta.com