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OVERCOMING HURDLES IN REAL TIME MODELING

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BACKGROUND

Water distribution system modelers have been interacting with Supervisory Control and Data Acquisition (SCADA) as long as both modeling and SCADA have existed. The marriage between modeling and SCADA has been fruitful. SCADA systems excel in indicating the current and past status of the system at a handful of locations but have no reliable way to project into the future or fill in between SCADA locations. Models provide a complete view of systems and can be used to project conditions into the future but have no way of knowing the current and past status of the system. Together, the two technologies complement one another very well and open up the potential to be able to model in real time.

Models need data from the SCADA system for calibration purposes and for setting initial and boundary conditions for model runs. Control room operators can use models for emergency planning and control, operator training and simply verifying operation of the system. As modelers and operators work together with real-time SCADA data, both groups realize a deeper understanding of what is occurring in the distribution system.

However, the marriage between modeling and SCADA has not always been easy, as each technology has a different way of viewing distribution systems and some inherent hurdles that must be overcome for the two to work together. The goal is to provide a convenient, open, accurate, understandable flow of information between modeling and SCADA, in spite of the numerous hurdles that must be overcome for the two technologies to work well together.

Some of the hurdles relate to security, the need for a deep understanding of nature of SCADA data, people issues and the diversity of SCADA systems. This paper discusses some of these hurdles and what must be done to overcome them in the following sections.

SECURITY

Most computer systems are built with the capability for data sharing as a key ingredient. SCADA systems are different, however, in that their key ingredient is security, not allowing data to be read or written without a fairly sophisticated set of permissions. This is understandable since the SCADA system to a certain extent runs the distribution system, and customers expect virtually perfect reliability. Outsiders with access to a SCADA system could cause enormous harm to water users, and as such SCADA systems are highly secure.

One the other hand, water distribution modeling is usually conducted on computers tied to the internet with all of the security risks that such a connection entails. Control engineers go to great lengths to install “air-gaps”, firewalls and other techniques to protect SCADA systems from the modelers’ computers. Some have gone so far as to remove any drives from SCADA systems that can be connected to the outside world.

It is difficult for SCADA systems to allow modelers access without compromising their security so modelers are treated as any other outsiders. Modelers usually cannot gain access to the SCADA servers to get raw SCADA data but must rely on reports that have been created for outside use and may not be what the modeler really needs, especially when modeling the current status of the system is required.

There are numerous ways to overcome these security issues. One solution to this issue is to provide modeling software on the SCADA side of the SCADA-outside firewall. This can involve having modelers work in the control room to having operators learn the basics of conducting a model run. The range of solution is as diverse as the individuals and utilities that operate water systems and there is no "one-size-fits-all" solution. A great deal also hinges on the personnel both in the control room and the modeling office as will be discussed in a later section. While working around security issues can be cumbersome, there are ways to make interoperability work.

UNDERSTANDING SCADA DATA

SCADA signals generally consist of a time stamp, a value, an indicator of the facility transmitting the signal, the property name and possibly some other information such as an indicator of the quality of the signal. The facility and property may be linked in a single value called the "tag". For example, the signal may be "17 Aug 2014, 16:13:54, 66.769375, Pump Station 3, Discharge pressure". What does this mean?

First, there is a misleading accuracy/precision issue. SCADA systems are notorious for providing many more "significant" digits than are supported by the sensor. For example, the pressure sensor in the example may only be accurate to plus or minus one psi, such that the value that can be inferred from the previous paragraph is really 67 psi regardless of what is displayed. Users of SCADA data also need to understand not only the claimed accuracy of the data, but the actual accuracy. The pressure sensor may have been accurate to +/- 1 psi when new, but may not have been calibrated for a decade, and may have drifted from its actual value such that 67 psi may really be 64 psi. For control room operations this value may be "close enough", but for modeling, it can cause significant problems in trying to calibrate a model to hit a specific value when that value is inaccurate.

Second, the value of pressure reported in the SCADA display is the value at the elevation of the pressure sensor, not necessarily the value at the elevation of the modeled node. A node may have an elevation of 654 ft but the sensor may be located in an underground vault at elevation 648 ft or in a box mounted to a utility pole or in the wall of a pump station at elevation 660 ft. Once again, these differences may be insignificant for routine operations but can cause problems for modeling where accuracy is important.

But larger issues are associated with the meaning of the "time stamp". With the exception of in-plant control systems, remote SCADA systems are not in continuous communication with the main control room servers. Instead, the remote telemetry units (RTU) at the facilities transmit their signals at a "polling interval". The interval can range from a few seconds to an hour and can make a big difference in the way that models use SCADA data, especially those that are real time models. Some systems may only "report by exception" in which case, the SCADA system only sends in signals when an alarm condition is triggered. Then, usually late at night, it will transmit a day's worth of data, too late to be of much use for real-time analysis.

When a SCADA system reports a value with a time stamp, it is important to understand whether that value is an instantaneous value at the time, the average value during that polling interval, some other type of moving average, a minimum or a maximum, or some combination. For modeling, it is usually desirable to have the average flow rate during the polling interval, but the instantaneous tank level, pressure or pump status. For example, reporting an instantaneous flow of 750 gpm at a time stamp for a pump may miss the fact that during the last half-hour polling interval, the pump was off but turned on a few seconds before the flow value was transmitted.

On the other hand, tank levels are usually converted into flow rate using the difference in tank level over the polling interval and using average values may be misleading. Small measurement errors in reading tank levels can result in large errors in tank flows when the polling intervals are small, thus requiring some type of smoothing of the data in order not to have unrealistic fluctuations in flows.

The time corresponding to pump switches may not be recorded. All a modeler may know is that Pump B was off at 16:32:18 and on at 16:48:17 but have no idea of the exact time of the pump switch. This can cause problems in demand inversing (i.e. determining demands from system flow and level data) and is a reason to use average flows from pumps rather than instantaneous values. Knowing the exact time for a pump switch is important in real-time modeling.

While SCADA systems are quite reliable, there are times when the signals do not complete their trip to the SCADA server. Signals usually start out as a 4-20 mAmp analog signal at a sensor which is converted to a digital signal. The signal then resides on an RTU where some processing occurs. The RTU transmits the information by way of radio, satellite, leased phone lines, cell phone lines, dial up lines or other method to a server in a control room where the signal is served up to a historian (i.e. a historical data base) or is displayed on the control room Human Machine Interface (HMI). Invalid values could be due to problems with the sensor, the RTU, the communication system or the control room SCADA server.

When a signal is lost, it is essential to understand how to interpret the data. In some cases, the signal can display as some type of "not a number" or "questionable" value. In others, it may display as a zero while in others it may "latch" onto the last valid signal transmitted from the RTU. In performing real-time modeling, a real-time model that relies on having every value from every facility all of the time is doomed to have issues with missing or questionable values, especially if these aren't recognized. A single bad data value can result in misleading values for demand inversing.

PEOPLE ISSUES

Making real time modeling using SCADA data invariably involves teamwork since it is highly unlikely that any single individual has all the skills to make this operational. There are usually three major groups that are needed to make real-time modeling work:

1. The modeler, who understands the model and how to make it work.
2. The control room operator, who understands the system and the values of the signals and uses the information for decision support.
3. The SCADA manager, who programs the SCADA system by integrating the signals into something that can be understood by the operator.

In addition there are utility managers and instrumentation professionals and electricians, who periodically get involved with this work. Each of these groups speaks its own language. What might be a "property" in a model might be a "display" on a screen to the operator and might be a "tag" to a SCADA manager.

In addition, each group has its own priorities, and making a model work with a SCADA system may not be the highest priority for any individual. It is important for each group to recognize the value of real-time modeling and treat it with sufficient priority, and for management to assign sufficient resources to accomplish the work. Working on real-time modeling in one's "spare time" ensures it won't get sufficient attention.

Control room operators tend to be skeptical of modeling since they see it as threatening their job security. They are concerned that with this model, management may replace them with a button. Most are not college educated engineers. They also don't have a deep understanding of modeling and are concerned that modelers will take over some of their control of the system. It is essential to get them on board by convincing them of how this work will help them to do their job better. Energy saving and responding to emergencies are two ways to encourage buy-in.

The individuals who install and maintain the SCADA system also must be involved. They are the ones who know such things as the tag names and polling intervals for signals, control permissions to access servers and understand how the signals were set up. SCADA systems generally rely on a protocol known as OPC to communicate with the SCADA server and modelers and operators usually don't understand OPC.

One key for cooperation between operators and modelers is to provide the ability for operators access model results in a format that they understand. This involves presenting the model results in the SCADA HMI with which the operators are familiar. Most operators don't have the time to learn the details of modeling but do understand their HMI. The differences between the modeler's view of the system and the operator's is illustrated in the following figures. Figure 1 shows a typical modeler's view of a system, while Figure 2 shows that same system as it may appear to the control room operator.

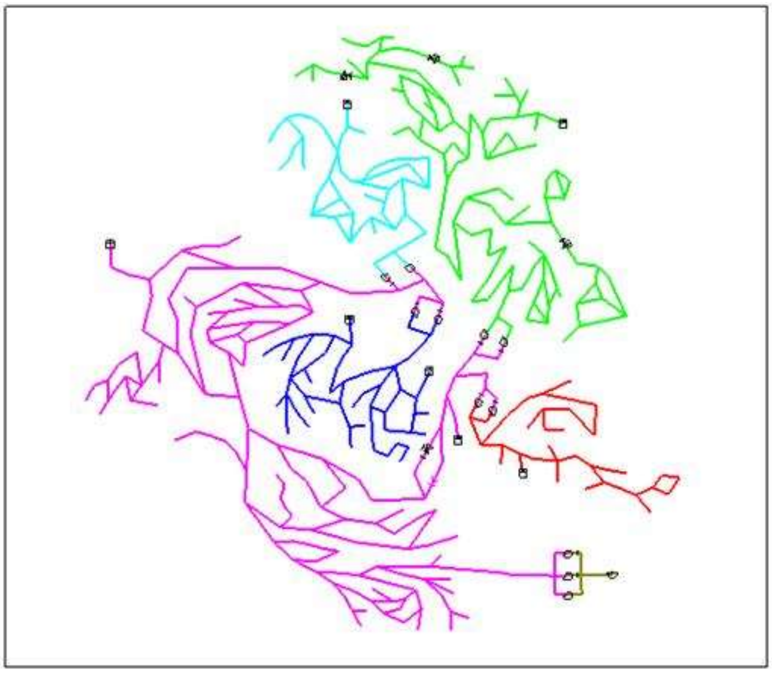

Figure 1. Example Model Display

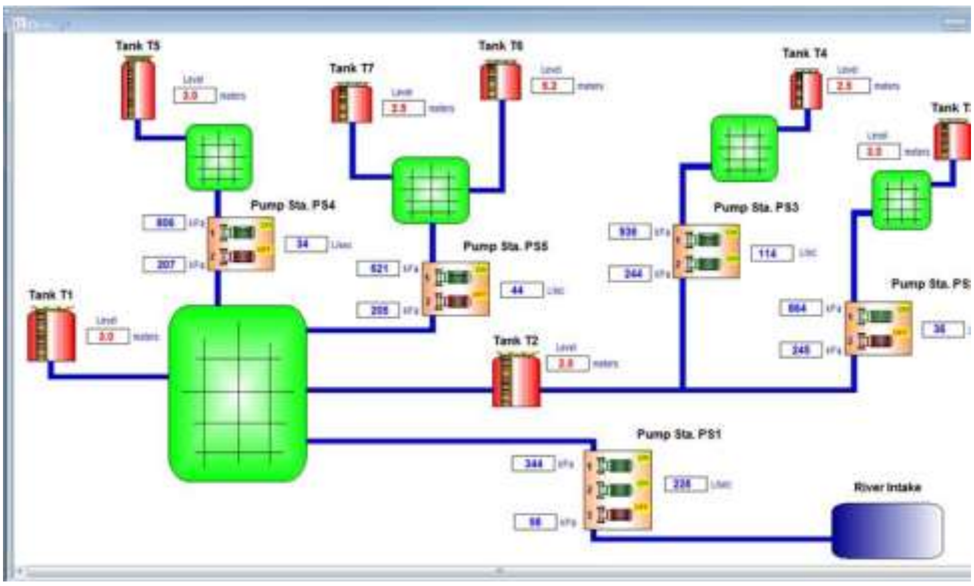

Figure 2. Example SCADA HMI Display

Creating the view in Figure 2 usually involves mapping modeling output to the SCADA OPC server and using the existing HMI screens to display modeling results in a format the operator understands. Some configuration is required but this should be a one-time effort. Having the ability to populate HMI displays with model results can overcome much of an operator's concerns and shorten any learning curve. Building elements in modeling software to simulate SCADA signals can make the configuration of the model-SCADA link easier.

DIVERSITY OF SCADA SYSTEMS

While there are several widely used hydraulic modeling packages, the diversity of SCADA systems is much greater. There are numerous vendors who supply various components and these may be mixed and matched in an almost infinite number of ways. Different OPC server software may be matched with different HMI display software. Even though each vendor claims to be compliant with OPC protocols, there are many ways to comply.

The diversity in SCADA tools means that a single "plug and play" solution is nearly impossible and some configuration will be required to make real-time modeling work. Those implementing real-time modeling will need to speak the languages of modeling and SCADA, or serve on teams that have the necessary skills. Creating real-time models for one system does not guarantee that the same approach will work for a neighboring system.

SUMMARY

While there are numerous hurdles to overcome to integrate real-time modeling into water system operations, each can be overcome with a commitment from management and cooperation between the various groups involved. By pointing out the issues involved, this paper will hopefully prepare those involved with awareness to overcome the hurdles.