Moderately Priced SCADA for Mutual Irrigation Companies

by

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Abstract

In northeastern Colorado, more than 100 mutual irrigation companies have functioned very effectively in delivering raw water for agriculture since the late 1800's. As many of these canals are modernized, an appropriate technology to consider is a Supervisory Control and Data Acquisition System (SCADA), which can provide for both monitoring and control of canal operations from a centralized location. Canal flows and reservoir storage data can also be easily posted to the canal company's web site.

SCADA systems were once perceived to be too costly for most mutual irrigation companies or small irrigation districts but the hardware is decreasing in cost and becoming much more affordable for agricultural situations. The opportunity, the costs, and the benefits of SCADA for mutual irrigation companies are explored in this paper.

Background and Introduction

SCADA is an acronym for Supervisory Control and Data Acquisition. SCADA has been with us a long time but mostly with industrial process control and monitoring circumstances that could afford the technology. Irrigation, for many years, was not an industry that warranted the steep hardware cost until some irrigation manufacturers began to adapt their own proprietary hardware, and software, into a specialized type of SCADA. So, in the mid 1980's we began to see adapted SCADA systems that were specifically made for irrigation projects that could afford it -- golf irrigation, in particular. In landscape irrigation, we referred to these systems as "centralized irrigation control." These early control systems were further adapted to accommodate distributed sites such as school districts or municipal park departments. In 1986, the City of Pueblo became the first city in the country to have centralized irrigation control for distributed park sites. During this period, specialized SCADA systems found a niche in irrigation and those systems, by a myriad of different proprietary names, have been with us for almost 25 years.

Where was agricultural irrigation to be found in this picture? There were a few irrigation central control systems to be found in agriculture, but not many if the total number of irrigation districts and mutual irrigation companies is considered. Agriculture could not afford the rather steep cost of SCADA. During the early 1990's, the cost of implementing SCADA on a per site basis was generally in the range of $5,000 to $10,000 per site without gate actuation hardware. This cost was simply too high in comparison to the cost of a chart recorder

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installation on a weir or flume, or for that matter, the cost of manual actuation of valves, headgates, and checks by the canal company's ditch rider.

The current cost of SCADA implementation has come down in recent years to a point where SCADA is affordable to mutual irrigation companies. Often smaller mutual irrigation companies do not have an office or a staff per se, but a SCADA central system can be located anywhere that is practical. SCADA can provide smaller companies a lot of bang for the buck including improved canal operations and can even be a factor in protection of the company's decrees.

SCADA Concepts

Generic definitions are appropriate to help describe basic SCADA concepts. The "central system" is microcomputer based and interface software is used to communicate with remote sites. The software that provides and umbrella over everything is called a "human-machine interface" or HMI. The key hardware at remote sites is a "remote terminal unit" or RTU.

The HMI software can be proprietary and published by the manufacturer of the hardware or it can be more generic and published by software companies that purposely write HMI programs that are compatible with the hardware of all manufacturers. Software companies market programs that are known as Wonderware, Lookout, and Intellution, as examples. The SCADA industry has standardized largely on a communication protocol called "Modbus" which is quite flexible.

The RTUs are essentially a small computer that can be programmed for the specific requirements at individual sites. The RTU is also the point at which sensors are connected. So, a site with only one requirement, often monitoring the water surface elevation in a flume or weir, would have a water level sensor wired to it. The RTU then communicates back to the central or conversely the central can initiate a call to the RTU. The preferred communication is two-way communication. In other words, the central can call the RTU or the RTU can call the central. It is important to note that the RTU can be monitoring one or more sensors and perform logical operations and even create an exception report or alarm. If flows are excessive at a point in the canal system or if the water surface level is too high and freeboard too low, an alarm can be raised or action can be taken in the form of gate or check adjustments. Alarms can appear at the central computer or even be pager transmitted to an alphanumeric pager.

There are multiple levels at which SCADA can be implemented. Starting off with a "keep it simple" approach, monitoring water surface elevations only for example, is sound and likely the initial system can be expanded to other sites and capability and features can be added to sites without a price penalty.

The three differentiating levels of SCADA implementation can be described by their respective function and utility to the canal company.

- ❑ Monitoring (only)
- ❑ Remote manual operations
- ❑ Fully automated operations

Each level results in increasing capability within the SCADA system, but each level costs more. The additional cost is largely at the remote sites, not at the central workstation. The central workstation becomes a fixed cost except for HMI upgrades and the inevitable computer hardware upgrades.

Figure 1 shows a simple SCADA monitoring site installed in a rated canal section historically used by the New Cache la Poudre Irrigating Company (NCLPIC) in Lucerne, Colorado. For many years, water surface elevations have been monitored at this location using a Steven's recorder and by manually reading the gauge twice per day by the ditch rider. With SCADA, data is transmitted by radio to the central computer on a frequent basis. At the central computer, the data is reported continuously on the HMI screen. NCLPIC is currently investigating full SCADA for improving canal operations and monitoring and reporting of the company's well augmentation plan.

The HMI screen can be, and should be, unique to the user and the circumstance. Figure 2 shows an example of the HMI screen in use by district staff at the Delores Project near Cortez, Colorado. This screen is simple and intuitive in nature. Radial gate (check structure) positions are depicted graphically, each in a somewhat lower position in the HMI screen, to indicate the canal itself. The operator may raise or lower gates, and therefore water surface elevations in canal pools, by using very small incremental gate movements. Interestingly, Delores Project staff can and do make changes in their own HMI software interface without assistance from an outside consultant or system integrator.

With simple monitoring using a SCADA system, sensors are installed that meet monitoring requirements such as water level sensors. Data is collected on the central system and can then be directly viewed by a system operator or plotted depending on needs and functional requirements.

With remote manual operations, as the name implies, the operator can raise or lower gates and thereby effect the canal operation from the central computer. This is called remote manual because gate movements are implemented by the canal company staff, just as if they were at the gate or check. But gate adjustments can be made much more frequently and therefore canal operations, overall, can become more real time and precise.

Full canal automation is possible. This ultimate benefit of SCADA has been widely discussed for two decades but there are actually very few canal companies that experience full automation. One semantical note is important here. Some would refer to a canal as being automated, with SCADA, but what they often mean is that the canal is operated under a remote manual scenario using SCADA equipment. Full canal automation which logically starts with irrigation order inputs and results in automated (algorithm driven) gate adjustments for the pending day is not an easily programmed process.

Figure 4 shows a fully automated canal gate which is integrated with SCADA.

A Case Study: Central Arizona Irrigation and Drainage District

The Central Arizona Irrigation and Drainage District (CAIDD) has implemented SCADA over much of the district's 60 miles of canal. CAIDD has utilized SCADA for many years but it is noteworthy that they have just upgraded their old SCADA system at a very affordable cost. With the upgrade, using the existing gates,

actuators, and other infrastructure, the district staff installed new SCADA equipment on 108 sites for an equipment cost of approximately $150,000.

Most of the district's checks are operated in remote manual mode. See Figure 3 which shows the day operator at the central system where the upstream water surface elevation at all 108 check structures can be viewed simultaneous with three side-by-side computer monitors. Using SCADA, gate adjustments can be made in increments of $1/8^{th}$ inch which coincidentally equates to a change in flow of roughly one cubic foot per second through the check.

Additionally, a portion of the CAIDD sister district's (Maricopa Stanfield Irrigation and Drainage District) canal system is operated under full automation using a program that was developed by the Agricultural Research Service (USDA-ARS), Water Conservation Laboratory, in Phoenix, Arizona. SacMan, which stands for Software for Automated Canal Management, has been under development for approximately four years. SacMan runs in parallel with the HMI software and interface and is used to operate a key MSIDD canal in a fully automated mode.

A key approach to affordable SCADA for CAIDD was spread spectrum radios. These radios do not have a federal licensing requirement. The radios look for a clear frequency, use that frequency if it is unused, or proceed to another frequency if necessary. The line of sight range for a spread spectrum "loop antenna" is two miles and the line of sight range for a "directional antenna" is five miles. Of particular note, any one antenna can serve as a "repeater" radio to other radios. So, with a linear project like a canal system, communication can be achieved by using the radios in a daisy-chained fashion to increase the effective communication distance.

Figure 5 shows a spread spectrum radio and a directional antenna installed on a galvanized steel pipe at one of CAIDD's check structure sites.

Summary

SCADA has become more affordable in recent years and is likely quite useful now to mutual irrigation companies for monitoring, remote manual operations, or even for full canal automation. The technology has changed somewhat rapidly and can be expected to continue to change and become more flexible, more intuitive, and available at lower cost.

Figure 1. An example of a rated canal section which is remotely monitored using a SCADA system. RTU equipment is 12-volt DC powered from a solar panel that maintains a charge on a battery. Communication with the site is via radio.
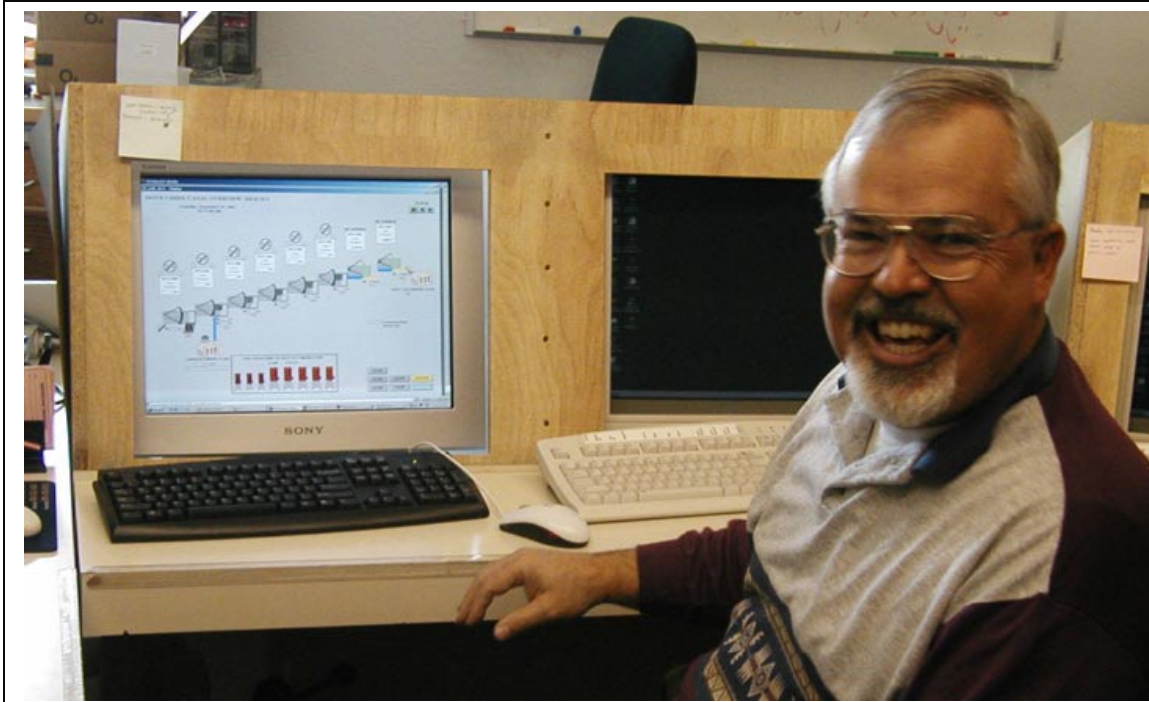
Figure 2. Chuck Lurvey, district engineer for the Delores Project in Cortez, Colorado, is sitting in front of the SCADA central computer. Radial gate icons on the HMI screen indicate the water surface level in the canal and the gate positions of the radial gates at checks along the canal.

Figure 3. An operator at the Central Arizona Irrigation and Drainage District (CAIDD) near Phoenix monitors primary flows and water surface elevations in the 60-mile canal. This SCADA system was implemented at relatively low cost using affordable RTU equipment and spread spectrum radios for communication.

Figure 4. This check structure is controlled by a Langemann gate and control is integrated with a SCADA system. Langemann gates function as a check structure and can be used for flow measurements.

Figure 5. The SCADA system at Central Arizona Irrigation and Drainage District (CAIDD) uses spread spectrum radio which is a relatively new type of radio system that does not require federal licensing. The spread spectrum radio is housed in the white enclosure and the directional antenna shown has a line-of-sight range of approximately 5 miles. The antenna is mounted on a 2-inch galvanized steel pipe.