

EASTERN IRRIGATION DISTRICT CANAL AUTOMATION AND SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)

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ABSTRACT

The Eastern Irrigation District (EID), located in southern Alberta, Canada, is a farmer owned entity that delivers water to 300,000 acres (121,500 ha) of irrigation and encompasses a total area of 1.5 million acres (607,000 ha).

EID implemented automated level control on major water control structures in its system. The first controllers used were industrial-rated computers. The technology now employed has evolved with the industry and Programmable Logic Controllers (PLC) have replaced the computers for control functions.

The SCADA system was developed with Wonderware's Intouch graphical user interface. This interface is used to extract data from the PLC's and display it graphically as well as provide central trending and call out alarms. Operators can connect to the system via the Internet using a password protected remote control program, or call in using a touch-tone phone and retrieve the latest flow and level data.

The EID recognized the need to provide Internet access to the local area, and therefore started operating as an affordable Internet Service Provider (ISP) to district water users. Being an ISP allowed the EID to provide a unique communications backbone for their SCADA system. Recently the EID has teamed up with a wireless Internet provider (IP Plus Wireless Corp.). Existing control structures are in the process of being upgraded to take advantage of this infrastructure to allow secure, cost effective, collection of data and structure monitoring.

INTRODUCTION

The Eastern Irrigation District is one of thirteen Irrigation Districts operating in Alberta. The EID has the largest land base and the second largest irrigated area of these Irrigation Districts.

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The Canadian Pacific Railway Company (CPR) originally developed the Irrigation system in the early twentieth century. The land base was given to the CPR as part of the payment of land by the Dominion of Canada for building a railroad across the country. The CPR believed that irrigation would encourage settlers to the area and, in the process, give the CPR income from land sales and increased use of the railroad to ship crops.

Construction of the irrigation system began in 1910, with the first irrigation water flowing in 1914. The original concept of settlement and crop transportation was basically sound, but the railway company found that the cost of operating the irrigation system was prohibitive. In 1935 a delegation of irrigation farmers negotiated a deal with the CPR to take over control of the project. Thus began the present day structure of the Eastern Irrigation District.⁴

Presently there are 1.5 million acres (2,350 square miles) within the District's boundaries, making the EID larger than the State of Rhode Island. The Red Deer River forms the northeast boundary and the Bow River the southwest boundary of the District. The area within the EID includes 300,000 acres of irrigated cropland, 600,000 acres of prairie grasslands owned by the EID, with the remainder comprised of non-irrigated cropland, privately owned grasslands and three Provincial Parks (Kinbrook Island Provincial Park, Tillebrook Provincial Park and Dinosaur Provincial Park).

HISTORY OF AUTOMATION AND SCADA AT EID

The Eastern Irrigation District identified a need to improve the management of its water resources. Prior to the 1990's water control was performed by ditch riders operating gates and manipulating stop logs by hand. The ditch rider had to balance the ever-changing needs of the irrigators with the flows in the canal by continuously moving gates and stop logs as more or less water was needed. This system of operation tended to result in water being wasted as it was in the ditch rider's best interest to ensure that farmers did not run short of water. Finer control was needed to reduce water wastage and to assist the ditch rider in better managing the water resource.

In the early 1990's, the EID made the decision to implement an automated control system on their major canals. The objectives for automation at EID were as follows:

- 1) Provide automatic upstream level control,
- 2) Estimate canal flow at all head gates, check structures, turnouts and weirs,
- 3) Provide remote access and control of the structures,

⁴ Source: EID's web page at <http://www.eid.ab.ca/about.htm>.

- 4) Accumulate trend data for analyzing canal operations,
- 5) Provide alarm callout and logging for abnormal conditions.

In the initial stages EID automated 8 check structures that were presently controlled by electrically operated overshot and radial gates. The automation consisted of automatic upstream level control, flow calculations, and alarm call out. The ditch rider could enter an upstream level set point and the gates would adjust automatically to achieve the desired level. Each structure used either PI (proportional-integral) or PID (proportional-integral-derivative) control algorithms to maintain a constant upstream water level while minimizing the number of gate moves. For most canals the simpler PI controller is used. The PID is used for canals that need more predictive controllers to prevent canal level oscillations. Since radial and overshot gates move through an arc pattern, equations were developed to calculate correct gate height from the gate position transmitter.

With the upstream water level held constant by the automated check gates, consistent flow could then be diverted through the manually operated turnout sluice gates. When the ditch rider changed the turnout flow, the check gates would react to maintain the desired upstream water level.

Each of the control structures operated independently. The ditch rider could access each structure via telephone and a PC by using "pcAnywhere" remote access software. Each structure was fitted with an auto-dialer so that emergency conditions such as high flow, low or high level, equipment failure, or loss of power would be called out to the ditch rider. Depending on the severity of the situation, the ditch rider has the option of simply acknowledging and resetting the alarm, or going to the structure to further investigate the situation.

Due to the success and operator acceptance of the initial efforts at automation, more structures were added to the system.

Some control structures are located in remote areas of the District and do not have a readily available source of AC power. Recent advances in solar panel and motor/gearbox technologies have made available PLC's and gate motors that can operate on 12 or 24 volts DC. These advances offered EID the ability to automate remote structures without the expense of constructing power lines to isolated locations.

In the initial stages of development, the controllers were Industrial PC Computers, which could easily handle complicated flow and gate position calculations. Trending was performed on each of the local computers to aid in trouble shooting. Microsoft DOS was the primary operating system and the control programs were written in C++. Modicon PLC's were used as Input/Output (I/O) devices to transfer gate positions, reservoir levels, and limit switch signals, etc to the PC.

Water level was measured using ultrasonic probes and gate position was measured using variable resistors and a transducer. The water level transmitters and gate position indicators would send the PLC a 4-20 mA signal. From these signals, gate position, canal level, and flow rate were calculated.

Initially the ditch rider had to call each structure individually to retrieve the current status at that structure. To get the status of the entire canal, a call had to be made to every structure, which proved to be a time consuming activity. Also, since each structure had its own auto-dialer, if a call-out phone number changed the auto-dialer at each structure would have to be reprogrammed to reflect the new number. The net result of this architecture was that it was very difficult to view the operation of the entire system.

To aid in viewing the entire system a scheduled automatic call-in was programmed. Data was extracted from the structures and stored on the EID local area network. A custom written Java interface was used to display data on a map with other structure data and a time stamp was used to indicate the last update. A web browser was used to run the Java application and display the SCADA information. Trending data remained on each structure's computer so the ditch rider could still call into the computer to view the local history.

PRESENT AUTOMATION AND SCADA

Over the past few years, PLC's have increased in their ability to perform more complex computations, which means that PC-based control was no longer required. Modicon's Momentum PLC has proved to be a good fit for the EID. A Human Machine Interface (HMI) is used to allow the user local control of the system.

The variable resistors and transducers used for gate position measurements tended to be problematic and error prone. They were also difficult to recalibrate mid-season. As an alternative, optical Interbus encoders were adopted to give more reliable and accurate gate position measurements. The encoders are programmable so they are easier to recalibrate than with the earlier technology. The encoders also solved the problem of signal float common to the variable resistor/transmitter system.

A Modbus serial radio network is used to connect structures to the network. The radio network allows full time connection without requiring a dedicated telephone line. Repeaters are strategically placed throughout the District to allow connection to remote structures. The radios and repeaters are addressed to allow secure communication to the structures.

A data concentrator PLC is used to poll data from each remote site and to push changes back to the sites. This PLC is used to give fine control over the

communication to and from the sites. It can poll each site for a specified interval and, after either a successful communication or a time-out, move to the next site.

A SCADA system was developed for the EID using Wonderware's Intouch interface software. Intouch communicates directly with the data concentrator PLC's. Intouch is set up with access codes such that if a user is logged off, a limited set of screens can be viewed and control changes are not allowed. Once the user is logged on to the system then access is permitted to more screens and changes to the control system are possible. Alarms can be viewed and called out from a central location. After a period of inactivity the user will be logged off the system.

The SCADA system also keeps a trend of structure data, such as gate positions and water level. This information can be viewed locally or extracted for use in a spreadsheet or another database program. Trending is very useful for troubleshooting the control system and is also used for fine-tuning the control algorithm for each structure.

The SCADA system has two auto-dialers, a software auto-dialer and a backup hardware auto-dialer. The software auto-dialer gives the users the ability to both receive calls and to call in to the auto-dialer from any touchtone phone and receive the latest level and flow information. A time stamp is used to let the user know when the last update occurred. If the primary software auto-dialer fails, a backup (hardware) auto-dialer alerts the users of the potential problem.

Authorized users can connect to the system using a password protected freeware remote control program called Virtual Network Computing (VNC). VNC operates on an Ethernet network and requires a single port to be opened in an Internet firewall to allow access. Once connected, passwords are required to make control changes. pcAnywhere is also run on the same computer for administrative updates and monitoring. Should one remote control package fail, access can be accomplished with the other package.

Ethernet as a Communications Backbone

While serial Modbus communication is reliable, the high cost of repeater towers and the limited versatility of the Modbus networks led to investigation of Ethernet as a communications backbone.

In the Brooks, Alberta area there was no Internet Service Provider (ISP). EID took the opportunity to become an ISP to provide a much-needed service as well as to provide high speed Internet access for their office. As technology has progressed over the years EID has kept up in providing both high and low speed Internet to its customers. Having this technology in place has enabled EID to take

advantage of the latest communications advances in the PLC market, which includes Ethernet.

Ethernet is a fast communications protocol that is being widely adopted. Ethernet enables users to get past the limited bandwidth of serial communications and it also enables bidirectional communication. For example, in a typical Modbus network there is one master and multiple slaves. The master has to poll each slave and request information. Typically the speed of the equipment is limited to 9,600 baud or 19,200 baud and is restricted to serial I/O communication only. Ethernet has the ability to communicate at higher speeds.

Ethernet equipment is less expensive than high-speed networks of proprietary PLC suppliers. Ethernet is also more versatile as it supports bidirectional and multiple communication paths. Manufacturers like Modicon and Allen Bradley encapsulate their protocol into Ethernet packets and transmit it to other devices on the network. With an Ethernet “backbone,” information from a variety of devices by a variety of manufacturers can be transmitted on the same infrastructure. Cameras (such as web cams) can also be connected directly to Ethernet. As newer, faster Ethernet technologies come out, the communication equipment can be upgraded without having to replace the PLC equipment. This gives the end user the ability to expand the system to take advantage of new technologies as they are developed.

The EID selected Modicon Momentum PLC's, as these units are capable of Ethernet communications. A continuous connection is made to the EID office using a full time dial-up link to the EID-owned ISP. A 3-Com 56K Lan Modem blends an Ethernet Hub, Server, Gateway, and modem all into one small, cost effective device. The device is able to call in over a landline and connect the local network to the Internet. Once connected, the PLC transmits data through an Internet socket (using Modicon's port 502) to a data concentrator located in the EID office. Security was built into the PLC program to force users to input an access code before changes are allowed. Without the access code, data can only be monitored.

Communications Security

When connecting any Ethernet device to the Internet, security becomes a concern. In a world of hackers, viruses, and worms, network systems everywhere have the potential of being a target. Various methods may be employed to secure the network, such as using PLC's “hidden” behind Network Address Translation (NAT) pushing data to a data concentrator.

NAT allows the PLC to be hidden from the outside world. The PLC uses its own internal address. Outside PLC's cannot get beyond the router to access the PLC. The data concentrator PLC needs to have a static address and a port opened in the

firewall to access the PLC. An internal password is needed to make changes that will be sent back to the remote PLC's.

Another secure method is to use a Virtual Private Network (VPN). A virtual private network can be set up between the host and remote systems. The VPN creates a secure encrypted data tunnel to each PLC. All the PLC's and other devices can then be on the same network. The central PC can access each of the PLC's directly and this information can then be displayed on a SCADA screen.

INTO THE FUTURE

Currently only one user at a time can connect to the SCADA software. Products like Microsoft's Terminal Services make it possible for multiple users to connect to the system at a given time.

At present, a PC is required for access. As technology progresses, PDA's will be able to directly access the network to give the user remote control and access.

Using high speed Ethernet gives the system the ability to install web cameras to assist in monitoring structures. Cameras can provide viewing, send alerts and save pictures during an alert condition.

SUMMARY

The Eastern Irrigation District began with automated control of single check structures on its major canal systems using PC's as controllers and PLC's as data concentrators. Initially each structure was a stand-alone facility that the ditch rider could access via telephone to retrieve structure information. Auto-dialers provided alarming in case of abnormal operations.

As technology evolved, the EID implemented a network system that employs Ethernet communications via both dedicated telephone lines and radio, and makes use of Internet connectivity to gather, store, and disseminate data. Security features ensure only authorized personnel have access to the structure and control functions.

As with any new technology it takes time for personnel to develop trust in a computer to perform functions and make changes to gates that have historically been made by the ditch riders every day. The staff at the EID were initially slow to embrace the changes that were being thrust upon them but they are now eager to have new structures added to the control system.