SCADA INFORMATION UMBRELLAS FOR IRRIGATION DISTRICTS

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ABSTRACT

SCADA systems in irrigation districts have focused on remote monitoring and remote control. In many districts, the remote control is manual, but in others the automation of structures is enabled through the usage of distributed control for the automation of individual structures. This paper presents the concept of an expanded, "umbrella" SCADA system that will perform the standard functions of remote control and remote monitoring, and will also incorporate information flow in the field for operators. The umbrella SCADA system will mesh the equipment-equipment information into an equipment-program-personnel network.

TYPICAL IRRIGATION DISTRICT SCADA SYSTEMS

Today's SCADA systems can store and display tremendous amounts of current and historical information. The total number of monitored sites in a large district may range from 10 to 50, and the number of control sites is typically less. The SCADA systems are generally linked to a limited number of key structures in the field, such as:

- Gates at the heads of canals
- Reservoirs
- Pumps
- Spill points
- Automated check structures

SCADA systems in western US irrigation districts are quite varied, but in general they fall somewhere within four broad categories:

1. Web-based remote monitoring information. This is typical public domain information that is made available through various government organizations such as USBR, USEPA, or USGS. The information can be accessed through the web, without any special equipment or technical knowledge. Having this information has been extremely helpful for some organizations – but they are

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primarily organizations that operate on a basin-wide water management basis. Examples include:

a. Weather information from weather stations
b. Stream flows
c. Dam releases

2. Local remote monitoring and simple remote manual control. Many irrigation districts have this SCADA configuration. Often these systems have been rather haphazardly assembled, with a menagerie of dataloggers, radios, sensors, etc. from different brands. Often these systems are hybrids that are attempting to use modified dataloggers as PLCs – with very limited capabilities. Office and field software is often locally designed, with considerable pride in ownership. Newer systems are well planned out with modern control, communication, and display hardware and software. The speed of data communication on the old systems is often slow – such as once per 15 minutes. These systems give districts the ability to remotely monitor water levels and flow rates in key locations throughout the district. The ability to remotely monitor and change flows (sometimes using a remotely activated timer in the middle of the night) is a major improvement over 20 years ago.

3. Local remote monitoring combined with distributed control. Automation of key structures is accomplished with local control, but target values can be changed from the office. There is often an excellent system of alarms and data archiving and screen displays. Polling (querying) of all sites in the district takes only about a minute or less. These systems have almost always been installed using the services of professional engineers and integrators. This is by far the most common "modern" SCADA system that irrigation districts are implementing in 2007, and encompasses most of ITRC's SCADA work.

4. Options (2) or (3) including some type of mobile field operator access to the office information. This may be through cell phones, BlackBerries, or radio. The access is almost always only "read-only" or "monitoring". In general, the amount of information and the speed of information transmission to the mobile field operators have been limited. Some examples will be given later in this paper.

Other Tasks

Irrigation districts use communication systems (phones, radios, even the web) and databases to organize other types of minute-to-minute information. The information from some of these databases is sometimes used to make decisions on how to use the SCADA system with many aspects of daily operations. For example, irrigation districts have developed a variety of techniques for:

- Receiving water orders from farmers.
- Verifying when water can actually be delivered to a turnout.
- Verifying that water is actually being delivered to a turnout.
- Allowing water to be turned off at a turnout.

There are many variations to this, even in districts with some type of SCADA. A range of options includes:

1. In many districts, farmers communicate directly with local ditchriders. The ditchriders have complete power to decide when and how much water can be delivered. The main office will have no idea what happened until a week or so later. The main office only knows if a change is needed by noting excess spill (for example) or if a ditchrider calls up and asks for more or less water.
2. In other districts, farmers call the district office. Water orders are accumulated on a board, on a hand-written form, or in a database. This may be done automatically via web-based access by farmers, or through some touch-tone entry by farmers. The orders are subsequently organized by ditchrider zone. Then at a daily meeting between the ditchrider and the watermaster (the ditchrider boss), everyone decides what can be done and when. At that time, the farmers may be notified that their water order has been approved.
3. In a very few districts (Delano-Earlimart ID in the San Joaquin Valley is an example), farmers call in with a request and the order-taker in the office accesses a program that checks to see if there will be capacity in the delivery system during the request time. The order is immediately confirmed or shifted in time depending upon available capacity. ITRC developed this database for the "relatively" simple pipeline system of DEID, with about 600 turnouts.
4. One interesting variation is used by Yuma County Water Users Association. The water ordering/scheduling database is maintained at the office. It identifies future orders as well as present deliveries, by turnout. That simple database is linked to the web, and ditchriders have hardened laptops in their pickups that are always linked to the web (via cell phone, which is somewhat slow). The most interesting aspect is that either the ditchriders or the office personnel can make changes to the database at any time, and everyone sees the changes.

There are other functions that involve databases and spatial information. These include:

- Hand-held data recorders, often scanning bar codes on turnouts, are commonly used in many districts to document flows and volumes. In general, the recorders are placed in docking stations at night to download information and receive database updates.

- A few districts use Global Positioning Systems (GPS) to keep track of where employees are at all times (locations and durations of stops) during the working day. A little imagination can be used to envision how this has helped management identify work habits of ditchriders and maintenance crews.

The interesting point, however, is that all of these functions are typically separate. Different databases, hardware, people, etc. are used for the different functions – although the functions are often inter-dependent. This has similarities to districts still in the first level of SCADA, which is characterized by having hardware and software that is "cobbled together". Those districts often use several different programs to display and archive different types of SCADA information, and sometimes use several radio systems that are incompatible with each other. The newer SCADA systems have streamlined the people-to-hardware information flow, but they have yet to integrate these other co-dependent functions/databases, and the field operators lack ample access to the office information.

THE FUTURE – ICIMS

In essence, most modern SCADA systems are tremendous tools to help operate main canal networks by providing information and control at a few points. However, when people consider expanding existing SCADA systems, the thinking is generally to expand the number of sites throughout the distribution system.

With recent advances in PLCs, laptop PCs, SCADA software, the Internet, and Internet service providers, SCADA system expansion should include new means of communications and daily operations. We suggest that in the future, we will not talk about SCADA systems as much as what we term an "Irrigation Control and Information Management System" (ICIMS). Figure 1 below illustrates a fledgling "Stage 1" ICIMS.

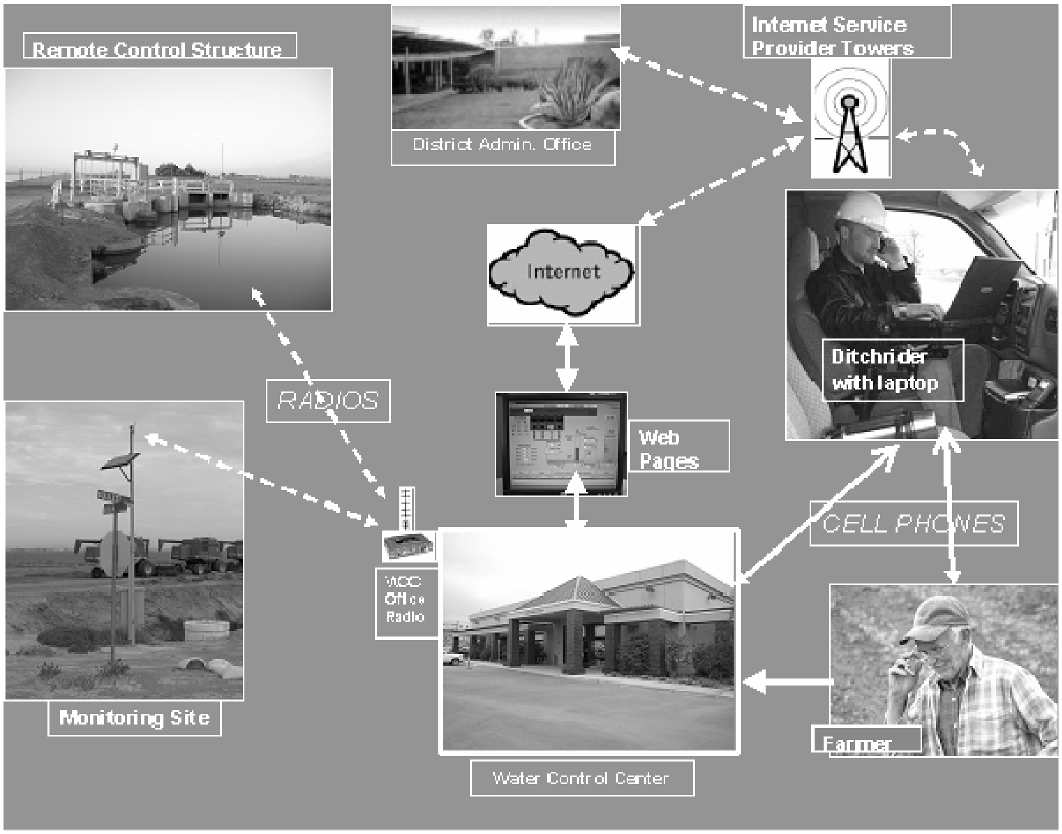

Figure 1. Envisioned organization of a Stage 1 ICIMS

Figure 1 illustrates powerful abilities to improve service. A ditchrider, for example, can know the complete status of gates, water levels, etc. within his zone of operation. Assuming the system has remote control capability, or remote changing of automation targets, there should be nothing to hinder the ditchrider from remotely making required changes throughout his zone. Obviously, there would need to be standard operating procedures for who can make changes to flows into laterals from the main canal – because that will impact more than just the ditchrider's zone. But it will be just as easy for a ditchrider to make a change as it is for an office watermaster to make a change.

A key ingredient of the ICIMS will be expanded usage of web-based information (with all of the necessary security measures). The type of SCADA that will be used in ICIMS already has several names – "Internet SCADA", "Web-based SCADA", and "IP-based SCADA". A few developments make widely expanded IP-based SCADA a real possibility for many irrigation districts today:

1. Some of the latest commercial HMI software programs, such as ClearSCADA, seamlessly translate their display screens into web pages.
2. Some rural areas now have private companies that provide local high-speed wireless Internet access. This is the same system that is used instead of cable

or satellite to provide TV access. We expect this service to expand rapidly into new areas. There are two major advantages that these Internet Service Providers (ISPs) give:

a. Communication speeds are much faster than cell phone Internet access, which means that having access to large databases (read: "typical SCADA screens") that continually update is now possible.
b. Charges are monthly, which makes them much less expensive than satellite options.
c. Strong signal strength can be achieved without needing directional antennas on mobile pickup trucks – as is generally required for satellite and radio communications. Directional antennas must be oriented properly to maximize signal strength.
d. Hardened laptops are available at reasonable prices. The hard drives function well even while being bounced around in pickups on dirt roads.

Because of the new software and the high-speed connections, the ditchrider can have real-time access to the complete set of office databases/screens, rather than just having access to very limited information on a monitoring basis. This saves both programming and training time – everyone looks at the same information (to whatever level of office data their security clearance will allow).

Once a district makes the leap to go to web-based field and office information management, many other doors immediately open up. For example:

1. Hand held data recorders can be equipped with various wireless connections to the pickup laptop – meaning instant updating of the complete database with current information on turnout flows, etc. There are other options, of course, on how to physically get the information into the common ICIMS system. AT&T, for example, unveiled a new service in the spring of 2007 that allows a BlackBerry to become a real-time wireless dispatch system that reads bar codes and also keeps track of workers in the field through its global positioning system.
2. The water ordering program/database can be integrated into the same ICIMS system – as mentioned earlier, they are now typically in a completely separate system.
3. Once the water ordering program/database is integrated into the ICIMS system, it is only a matter of time before flow scheduling/routing programs will be developed that incorporate water ordering software with canal reach capacities, lag times, etc. This will enable a quick check to be made of capacity limitations, and will also provide guidance to ditchriders as to when flows might be released or stopped at key bifurcation points – so that they arrive at turnouts at the proper time.

Implications of an ICIMS System

Suddenly, the concept of "real-time management" takes on a whole new meaning. Information is instantaneously available to everyone, and can be appropriately acted upon because the information is accompanied by control capabilities. This also requires new arrangements of power sharing, and allocation of responsibilities, among staff in the irrigation district.

Quick and appropriate responses – done manually through improved information management and remote control and distributed automation – have important consequences on a variety of engineering aspects. For example, if a ditchrider can quickly change a flow into a lateral, it can reduce spill from the end of a lateral. That in turn can reduce the size of recirculation facilities. It can also reduce the need for increasing the canal capacity at the tail ends of laterals (needed to accommodate more flexibility in shutting off turnout flow).

Embedded in this discussion is the concept that in irrigation district canal systems – which have lag time, unsteady flow, trash problems, inexact flow measurements, and sometimes unpredictable customers – we will probably generally always need some type of "open-loop" control in many areas – especially in the laterals. The fact is that ditchriders often know who will accept water early or late, if there is a temporary flow rate capacity issue in some area, if there is a high probability of strange behavior by a particular irrigator, etc. Therefore, if they have easy access to high-quality, strategic information – plus the ability to remotely control key points – they can act rapidly and efficiently.

These actions can be both anticipatory and reactionary, depending upon the circumstance. Right now, most ditchriders spend most of their time driving the canal banks with fairly unproductive time – just looking at things, driving to make a gate change, etc. The ICIMS can increase productivity while making the job a bit more relaxed and less hectic.

HERE AND NOW

Meanwhile, until the broadband private Internet service providers become commonplace, various irrigation districts are gradually working on temporary options. These will continue to vary rapidly as technology evolves, but we aren't quite there yet in most areas.

The variations that irrigation districts use to access the web, provide security, etc. are so diverse that we will not attempt to outline them in this paper. Some will be included in the conference presentation. It is our prediction, though, that this will become simpler as time goes on – not more complicated. Some of us remember how in the early days we needed to solder the wires between printers and early

PCs, and we needed to know all the pin numbers. Now it's just "plug and play" and much more powerful.

It is fairly complicated at first glance, with terminology that many have heard but don't completely understand. We thought that the vocabulary and technology primers below might be useful to the reader.

Terminology

1. General Packet Radio System (GPRS). This is a relatively newer type of mobile data service, available to users with GSM-equipped cell phones. Charges are usually accrued based on the amount of data transferred, rather than connection time (as is the case with traditional cell phones).
2. Global Positioning System (GPS). This global navigation satellite system transmits signals to GPS receivers, and identifies the receiver's location.
3. Human-Machine Interface (HMI). This is what most people think of as the "office SCADA system". A number of commercial HMI software packages are available to display information on computer screens, ask remote sites for information, store data, manage databases, send alarms, etc.
4. Internet Protocol (IP) technology. In order for your office computer to get hooked up to the web, it needs an "IP address" so the worldwide web knows where it is. The same goes for web sites – they each have an "IP address". So when you develop web pages that you want to make accessible to the web, there needs to an "IP address" associated with that information. What is relatively new is that we can now purchase devices such as PLCs, radios, cameras, dataloggers, and even sensors with their own IP addresses. As long as there is a communication link (satellite links, fiber-optic cables, radios, cell phones, or other methods), these devices can be directly accessed.
5. Internet Service Provider (ISP). This is an organization (such as Verizon, AT&T, Comcast, or many others) that offers access to the Internet and related services. Usually a monthly service fee is involved.
6. Programmable Logic Controller (PLC). This is the static "computer" out in the field that is hooked up to various sensors, outputs, a radio, etc. It is sometimes programmed to perform automation tasks.

Remote Connections to the SCADA Computer

There are a variety of ways to connect a remote PC to an office SCADA computer. Some have been used for many years. The major options used by various irrigation districts are described below.

1. PCAnywhere. This is a commercial software program that retails for about $199, but which can be purchased online for about $40. It requires that the software be installed on both the laptop and the office SCADA computer. PCAnywhere can communicate via the Internet or a phone line, and enables a

remote user to have complete access and control of the office SCADA computer – although this does not prevent the office personnel from also using the SCADA computer.

2. GoToMyPC.com. This company sells three editions of software and access, with an annual fee per PC of about $180. It allows remote access to a PC from an Internet-connected computer or wireless devices/systems such as Windows Mobile, Pocket PC, or Windows CE. You go to www.gotomypc.com, register your office computer or server, and then log in from the same site to access the office computer. It is firewall friendly, meaning it automatically determines the best method to connect. It does slow down the remote access somewhat, because the gotomypc server is an intermediate step between your remote PC and the office computer. This service provides end-to-end encryption of the communications and some other security measures.

3. Virtual Networking Computing (VNC). VNC is a graphical desktop sharing system that uses a special protocol to remotely control another computer. It was originally developed by AT&T. It works between almost any two types of operating systems (including Macs to Windows). It is similar to gotomypc.com, but it is open-source software and is free. The disadvantage is that it isn't extremely simple to set up – a user needs to understand about firewalls, networking, etc. It works by installing the software on the office computer, and then remotely accessing the office computer using the VNC Java Client software. That Client software runs in a browser (such as Internet Explorer or Netscape) over the web, and can be downloaded to the remote PC from www.realvnc.com. This is only for web access, not for phone access.

4. Windows Terminal Services (WTS). This is very fast and can be used over phone lines or the web. It utilizes software that is included with various Windows Server packages. With the WTS server software on the office server, and WTS client software on the remote PC, it allows multiple remote users to access the office server simultaneously, running any office application they have access to. It is quite fast.

Our impression is that users usually believe the first two access methods described above are fairly secure. The last two connections are less secure, but can be made quite secure by also incorporating a Virtual Private Network (VPN).

On a remote PC, it is common to have some type of special security software, called VPN, that matches similar software or hardware on the agency/company's web server. These have to be synchronized. Some people refer to this as a type of firewall, which is used to separate a private network from a public network for security (see Figure 2). In other cases, the VPN is more a security type of software designed for access through a private local network (Intranet) rather than for remote access; it is used to establish a tunnel through a department's firewall.

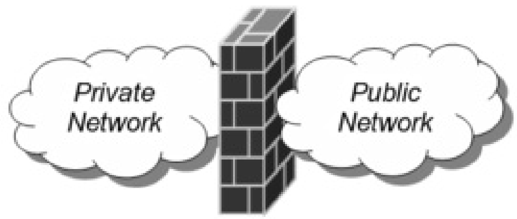

Figure 2. Illustration of a firewall
(From http://en.wikipedia.org/wiki/Firewall_%28networking%29)

The VPN, then, is some type of software or hardware set up for security purposes. It runs on two ends – at the server, and at the user's PC (the user-end could have many PCs at a time). It is typical that the server end of the VPN is set up as a VPN "box" on the inlet/outlet of a private network; the user end (or client end) runs on mobile laptops or home computers. The VPN is constructed by using public wires such as the Internet as the medium to virtually connect many computers as a private network for transporting data. It uses encryption and other security mechanisms to ensure that only authorized users can access the network and that the data cannot be intercepted.

VPN is also described as a port-forwarding, tunneling, or encapsulation technology in TCP/IP (Transmission Control Protocol/Internet Protocol), which is the basic communication language or protocol of the Internet. There are many commercial VPN products available, including a VPN from Check Point (www.checkpoint.com) and SonicWALL VPN (http://www.sonicwall.com).