

Automation and control of a ground water based municipal water system.

Utility:
Water/Wastewater
City of Fresno



UNITED STATES

Introduction

The City of Fresno Water Division, located in the central valley of California, is a municipal domestic water production and distribution provider. Fresno is approximately 110 square miles in area and its current water supply comes entirely from underground. In order to supply water, the City, over several decades, has installed over 245 wells. Fresno's water system is now the second largest ground water system in the United States.

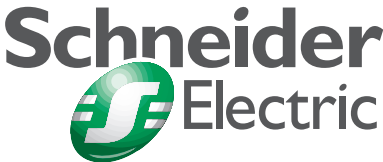


The application

There are currently 245 wells and groundwater treatment systems located throughout the city with more under development. The city is also in the final design phase of a 20 MGD surface water treatment plant. With the number of wells and large geographic area involved, a SCADA system is the logical solution for control and data acquisition. The control system for the City of Fresno is a classic SCADA master (Host)/ slave (PLC) arrangement. The Host software resides at Water Division headquarters and polls all sites through a three channel, repeater based, 900 Mhz radio frequency MAS system.

Actual pump station control is performed by a Modicon Momentum PLC at each well site. The Host software issues requests to start, stop, ramp up, ramp down, etc.

- Merlin Gerin
- Modicon
- Square D
- Telemecanique





Well with PLC panel (R).



Panel close up showing Momentum PLC, radio, batteries and power supplies.

SCADA Host

The existing SCADA (Supervisory Control and Data Acquisition) system installed in 1988, has reached a “mature” state in its life cycle. While fully operational, it is being pushed to its performance limits for the following reasons:

- The currently installed version of OpenVMS operating system will not support system hard drives of a larger capacity than one gigabyte and will not support the latest release of the vendor’s SCADA application.
- The currently installed version of SCADA software is not Year 2000 compliant.
- The history database system is proprietary and does not dynamically interact with the business LAN.

Field Controllers (RTUs):

The existing RTU (pump station control) hardware is of the same vintage as the SCADA system and has also reached a “mature” point in its life cycle. Items of concern are:

- RTU hardware is antiquated and extremely difficult to program. All control programming is accomplished using the vendor’s macro assembly language. Programming from Central (the Water Division SCADA office) is not possible.
- RTU hardware is failing at an alarming rate. In the past 12 months, 38 RTU’s have failed out of the total installation of 245 in the field.
- Currently, installed RTU’s have been obsoleted by the vendor.

Radios:

The existing RTU radios are also the same age as both the SCADA system and the RTU’s and raise concerns in the following areas:

- Installed base of radios has been obsoleted by the manufacturer.
- They require regular maintenance and tuning.
- Pump station antennas are corroding which introduces additional path losses.

The objective

The City of Fresno had the following objectives for this project.

The HOST must:

- Be RTU/PLC independent
- Support MODBUS-RTU protocol .
- Must be able to poll three radio channels simultaneously

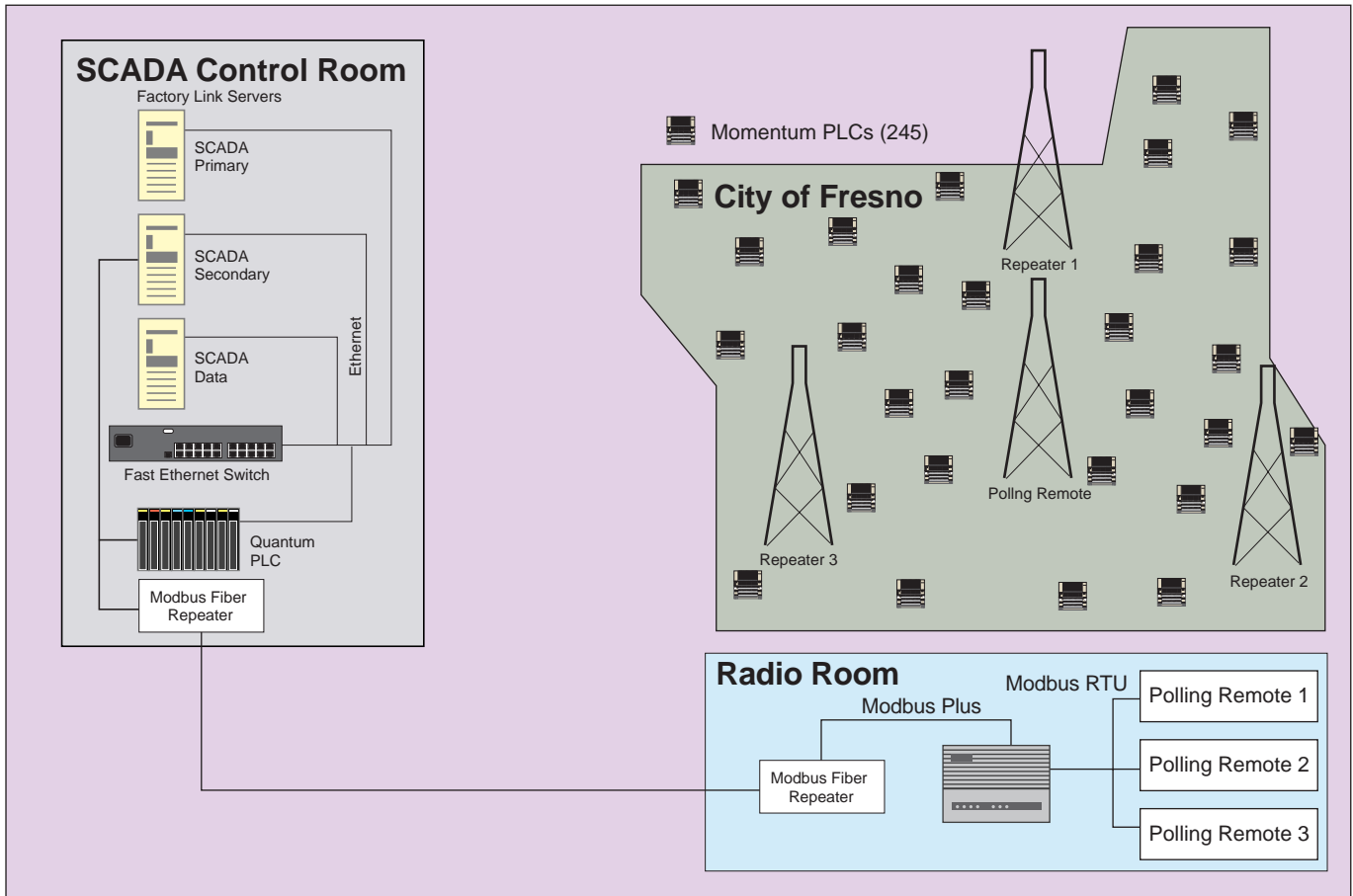
- Function smoothly with greater than 1 million database tags
- Poll indefinitely, only interrupted by set-point changes to the PLC or start requests to the PLC
- Support server redundancy
- Function with only one server talking to I/O at a time
- Execute under Windows NT
- Stream historical data to an industry standard database such as MS-SQL server.
- Have remote access capability with displays
- Have an alarm system
- Have an alphanumeric paging system
- Allow indirect referencing of displays to minimize repetition
- Dynamically change points, displays and devices
- Have a security system
- Have an event system for time or other event based actions
- Have a recipe system for changing set-points based on events
- Have a direct connection of history database into the business environment through the use of industry standard databases rather than proprietary ones.
- Allow on-call troubleshooting via remote GUI (home PC).

The RTU/PLC must:

- Be SCADA Host system independent
- Support MODBUS-RTU protocol
- Be a Programmable Logic Controller (PLC)
- Fit in existing controller enclosures
- Be downloadable to PLC from a PC into nonvolatile ram (no burning chips)
- Be ISO 9001 compliant
- Have both programming port and port for communication with polling host.
- Have available ethernet card for plug in to rack
- Use RLL (relay ladder logic) and C or structured text instead of assembly language.

The solution

A nonproprietary PLC based SCADA system was designed by the City of Fresno Water Division engineering staff around Modbus-RTU protocol over a 900Mhz MAS radio system. This new system has the same or better performance as the older system, and far superior usability, programmability and flexibility. The Modicon PLCs selected are programmable in ladder logic and structured text.



By far, the industry standard for radio-based communication of RTUs is MODBUS-RTU protocol. Nearly all SCADA software packages and RTUs available today support this communication protocol. By definition, it is, therefore, product independent.

All design, programming, panel wiring, and installation was performed by in-house staff. The City of Fresno was able to draw from a pool of multi-disciplinary expertise. Their in-house staff is experienced in system integration, control systems, nuclear instrumentation, refinery instrumentation, electronics, and radio. In house staff: Garth Gaddy, Ed Esheim, Bill Watkins, Larry Akman, Ed Ortiz, Jack Baker, Ramon Parangalan, Bob Souza, Vance Ahtye, Kano Esheim, Diem Tonnu, Robert Nickel, Robin Small, Larry Kramer.

Processes monitored are the following:

- At each site:
- Pressure
 - Flow
 - Pump motor Kw
 - Pumping water level

- Panel temperature
- Battery voltage
- Pump start/stop status
- HOA status
- Power quality alarm
- Pressure alarm
- Flow totalizer
- Run time accumulator

At some sites:

- Differential pressure across a filter bed
- Generator oil pressure, water temp, fuel level
- Water treatment air flow

All PLCs (sites) are polled and report this information. The data is then logged to a historical database for viewing via Factorylink or other tools the City of Fresno has designed such as a web based reporting tool that accesses the data and reports in tabular and graphical formats.

The system uses a master (Host), slave (PLC) communication arrangement with three radio frequencies for communication. Three 100' repeater towers are strategically located in the City. A single "Polling remote" 100' radio tower is located at the Water Division headquarters



Typical residential wellsite.



Wellsite with treatment vessels in background.

where the SCADA host is also located. The HMI is Factory Link. It polls the well sites by communicating over a Modbus Plus network to the bridgemux which is located at the polling remote radios. The bridgemux then converts the Modbus Plus signal to Modbus RTU (RS232) for the three radios.

In addition, the City of Fresno also uses a Modicon Quantum PLC on the Modbus Plus network near the host which acts as the energy and pressure optimization controller. It gathers the data polled by Factory Link, averages the pressure in a given geographical city zone (the city has 25 zones), and compares it against a high and low set-point for that zone. In addition, cost is calculated for each pump station in dollars per acre-foot pumped. If the zone average pressure falls below the zone low set-point, the most cost-effective pump which is off in the zone is turned on. If the zone average pressure rises above the zone high set-point, the least cost effective pump which is on in the zone is turned off. This complex algorithm is programmed entirely in the Quantum using structured text. This complex programming would be impractical to attempt using any other PLC which does not support a procedural programming language such as C or structured text.

The benefits

- Time spent programming well site controllers (Momentum). The old system involved assembly language and burning chips. The new is Concept 2.1. The city can also

program over the radio in some cases saving travel time.

- The use of structured text in the well site controllers allowed the city to add features previously unheard of. Algorithms which calculate the season, holiday, time of day and utility power rate eliminate running certain pumps when not economical. Running them at the wrong time leads to penalties from the local utility.
- On line trending of field data on Factory Link has aided in trouble shooting speed. The use of a nonproprietary database allows the Water Division to access the data and process it using web enabled tools. This decreases the amount of time it takes to determine the cause of a problem.
- The Water Division has in the past saved approximately \$500,000 per year in utility costs by using the energy and pressure optimization algorithm. Plans are underway to improve on this and squeeze more savings out of the utility costs.

System statistics	
Individual sites	245
I/O points	12,000
Polled points	35,000
SCADA database tags	1,000,000