

# REAL-TIME WEB-BASED SYSTEM MONITORING

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**Abstract** - New techniques in software architecture and development have empowered users by giving them access to real-time plant data in a fluid and versatile environment. These solutions allow you to custom configure a control screen right from your web browser with analog gauges, digital gauges, charts, spider charts and more. Data is sent in real-time from your PLCs directly to a central repository on the Internet, where trends and reports can be generated with the click of a button. This paper will illustrate how such a flexible system can function through a case study in the oil and gas industry. The aim of such a system is to allow key decision makers easy access to personalized information that is necessary for them to make critical decisions.

*Index Terms* - real-time monitoring software, AJAX, MODBUS, PLC, animated gauges, web-based

## I. INTRODUCTION

Representation of real-time plant data on the web is not something that is completely foreign to most industry professionals. The web, however, has in the past presented various limitations that have led to a lack in the fluidity of transmitted data. For several industries, high data quality and fast transmission times are not adequate performance indicators to ensure that important decision-makers have a correct, unambiguous representation of information to make mission-critical decisions.

The scenario that will be presented throughout the remainder of this paper will illustrate how significant changes in software technologies have enabled the oil and gas industry to profit from data versatility, leading to increased profits and better, more informed business decisions. Furthermore, the methodologies and software architecture discussed are not industry-specific and can be directly applied to pulp and paper.

## II. ARCHITECTURAL OVERVIEW

The system in discussion consists of several service rigs that move from location to location, at times on a daily basis. These machines are equipped with sensors that relay analog and digital signals back to PLCs located in the control room. Once received, the PLC then communicates these signals over RS-232 using the industry-standard MODBUS communication protocol at speeds as low as 9600 baud while still providing near real-time results. Although MODBUS is the protocol of choice in the oil and gas industry, compatibility

can be built to make this type of system work with any proprietary communications system. On the receiving end of these signals is a software system that allows for the dynamic allocation of incoming PLC registers to data source IDs within the software. These register-mappings are application and rig-dependent, meaning that they may or may not be consistent on each of the service rigs in use.

Computers that are present on the rig lease can subscribe to updates from the machine connected to the MODBUS. A TCP/IP Ethernet or wireless connection allows encrypted data to stream to client machines. The delay from the MODBUS-connected machine to its clients is negligible. In terms of speed, a typical cycle time would range anywhere from 200ms to approximately 1 second; however, factors such as PLC register configuration, register range size, and speed of communications all play a role in determining the overall cycle speed.

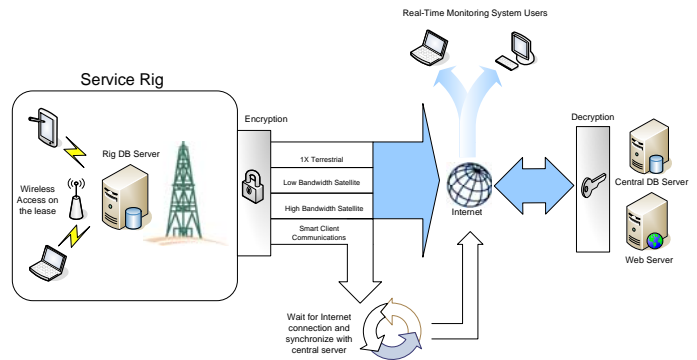


Figure 1: Communication with the Central Repository

From each of the rigs, a secure channel is initiated with a central repository of information on the Internet via a TCP/IP connection. If the connection is persistent, the data packets are sent to the repository from the rig as soon as they are available. In many situations, however, rigs are located in remote locations where Internet connectivity is limited to a satellite connection where usage is time-based (as opposed to data-based). In such situations, every second spent online translates into service costs. As such, the rigs are equipped with data segmentation mechanisms where data is sent either in specific intervals throughout the course of a drilling operation, or as one encrypted file at the end of the job.

In any case, the data is date and time stamped in a structured XML packet which is then interpreted by the central repository and stored in a relational database. In order to

identify the relevant rig and job, each rig requests a unique identifier from the central repository and uses this identifier for future communication for that specific job. In addition to data packets, there also exist XML setup packets which upload information pertaining to registry mappings so that the central repository can maintain a separate listing of data source IDs in use for each rig. In the case of a mill, one could substitute the use of a rig for a mill's department in order to better understand the architecture.

### III. SOFTWARE INTERFACE

Large organizations often have very strict internal IT policies and regulations. When designing a real-time, web-based monitoring system, it is important to ensure that the design meets the minimum requirements of these organizations while still empowering users with an integrated, intuitive system. One of the prime design considerations that need to be addressed is the installation of client-side software in order to allow the user's system to connect to the central repository of data. Not only may the installation of proprietary software conflict with IT regulations, but it is also an arduous administrative task to ensure conformance.

A more effective system would make use of nothing more than the user's web browser as a window to the repository. With the advances in web-based technologies, there is no need to rely on external applets to provide users with a completely fluid graphical experience that they are used to from traditional Windows forms applications.

The traditional nature of web form processing relied heavily on server post-backs which rendered any attempts to create the look-and-feel of a Windows application next to impossible without the aid of external applets. Information entered on a traditional web site would be sent to the server through a post-back, and the entire webpage would be refreshed to reflect the update. Users have come to expect these delays when performing tasks in a web environment. By leveraging the exchange of asynchronous data with the web server using a technique known as Asynchronous Javascript and XML (or AJAX), an environment free of delays to due post-backs can be developed. This allows the user to feel as though they are manipulating desktop-resident software. Drawbacks to this technique include a movement away from the expected behaviour of web sites, and it forces developers to clearly delineate between application states; however, when properly designed, the benefits to speed and usability are significant.

By using AJAX, versatility in data representation can be achieved. By connecting to the data repository from a web browser, the user can easily stream information from an array of data sources into a multitude of customizable controls. For instance, a dynamic page could be setup that would allow the user to stream data into radial gauges, horizontal and vertical bar indicators, alarm indicators, spider charts, horizontal charts, digital gauges, among others. Because post-backs are no longer required, each of these gauges is animated in real-time without having to refresh the web page, and without any external applets. Not only do these gauges animate without posting back to the server, they can also be moved and resized to any location on the screen in order to suit the user's specific display preferences.

Raw data streaming in over the MODBUS protocol is captured in near real-time while it is being shown, and stored

in a local database. This data repository provides the foundation for custom reporting modules and calculations. Custom statistical reports and mathematical functions can be performed on the historical data or even on the raw data that is streaming in real-time. All calculations are performed on the raw data once it arrives at the computer to utilize the computers processing power and the flexibility of the custom software solution. This allows the user to setup their own formulas for rate, volume, etc. and show them in real time.

### IV. MODULARITY

Although there is a great deal of similarity in the basic needs of rigs in the oil and gas industry, there also exist special circumstances where custom work needs to be done to develop specialized gauge controls that relate to a certain client's work process. As an example, in the oil and gas industry, a client may want to pictographically display the location of the drill bit with respect to certain depth ranges in the earth. If the code for the software isn't designed in a modular fashion, the implementation of such a task could become quite arduous.

Modular code should allow for custom gauges to be developed independently and dropped into the overall infrastructure, each gauge sharing the commonality of the association with a PLC register as a data source. The modularity of an application will also give rise to its flexible nature – allowing for multiple screen configurations to be instantly developed based on the various modular gauge components.

In the pulp and paper industry, each individual in a mill has unique problems, responsibilities and concerns. As a result, individual workspaces are equipped with a unique set of traditional gauges and digital indicators. In essence, each employee requires his/her own unique window to the mill processes.

Web data-acquisition software is designed to allow for total flexibility. In this manner, each user may configure their own screens with the combination of gauges and graphs that best suit *their* needs. In this way, a mill manager's screen may look different from a production superintendent's screen, but still bring that same pertinent information to the eyes of the appropriate individual from *anywhere*. Software packages allow the configuration to be saved, loaded, and redistributed throughout an organization.

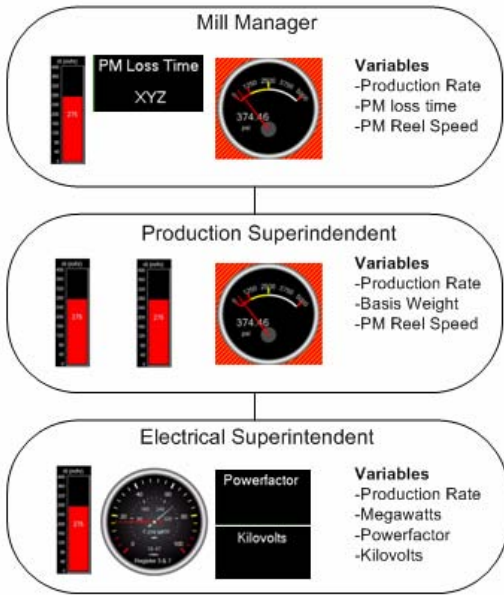


Figure 2: Flexibility in screen configurations

## V. INTERCONNECTIVITY

Robust software solutions make the look and feel of an interface identical for all users, independent of the connection method in which they acquire the data. An engineer may load his configuration file into a PC in the mill, or in an office halfway across the country, and expect that he/she will see the same screens.

Through a connection with the central server, each mill can provide this real-time data to engineers and supervisors across the globe. Secure web interfaces and encrypted data allow for safe transmission of information. In the oil industry, process speeds have been drastically improved. No longer do geological engineers need to wait for a drilling rig to complete its work, a supervisor to fax a spreadsheet, or a disaster to happen before they make critical decisions.



Figure 3: Troubleshooting through remote simulation and collaboration

Due to the extensive store of data that exists on the central repository, there also exist mechanisms within software that allow users to replay various events in history as though they were occurring in real-time. A user has the ability to navigate to a particular job, select a desired time frame, and use playback controls to affect the speed at which gauges propagate the historical data to the web.

## VI. APPLICATIONS IN PULP AND PAPER

The incredible flexibility of modern software coupled with the use of the industry standard MODBUS make the porting of these solutions to the pulp and paper industry relatively seamless. Virtually any PLC can feed information to these software packages. This information can be plotted, recorded, and displayed in any manner imaginable. Custom software solutions allow end-users to develop their own custom controls, or to select from a library of existing ones.

The applications for this type of interconnected real-time monitoring software are endless. The following presents a few sample scenarios of its use within a pulp and paper mill.

## VII. MILL USE CASE SCENARIOS

While away on business, the superintendent of operations in a mill may be concerned with the production rate, among other variables. He/she can simply login to a secure internet site and promptly be at ease as all plant operations lay right before his/her eyes. The software will allow the superintendent to see the data they want, in the manner that they want, from wherever they want. A sample screen shot from the oil and gas industry can be seen below in Figure 4.

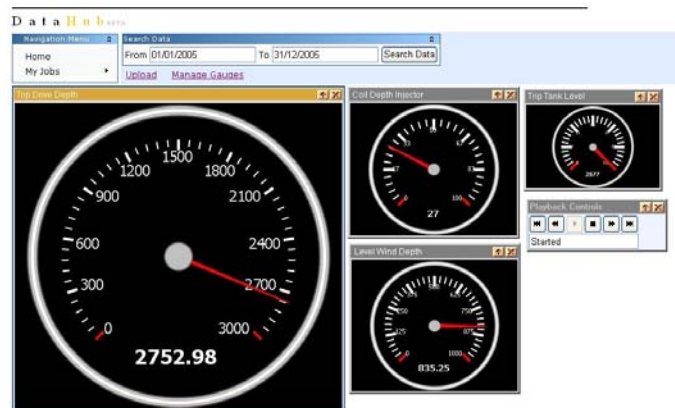


Figure 4: Department Remote Monitoring Screen Shot

Similarly, for mills that generate their own power, a steam plant superintendent will want to see information such as steam flow, kilowatts produced, and load. They can just as easily setup a configuration and begin watching or simulating past occurrences.

Furthermore, an electrical maintenance superintendent will want to measure the amount of incoming power consumed, voltage sags and swells, and load. They too can have their own window into the plant through one convenient web-accessible site.

With a solution like this in place, mill managers and VPs can get an overall picture of the mill from anywhere in the world. Superintendents who are traveling can keep a close watch on their mill from any location with an internet connection.

Also, the data is not only stored digitally *forever*, but can be used to generate reports, run simulations, and the user can perform any number of other mathematical operations on it. It is available to export to any number of formats and custom packages can be built to tailor reports to industry standards.

### VIII. BENEFITS

Usage of an interconnected real-time monitoring system presents several benefits for managers, VPs and engineers alike. Current software and hardware technologies have alleviated security and speed concerns of the past and have empowered users everywhere.

Benefits of using systems like these include:

- Increased Productivity
- Rigorous security for data protection across wired and wireless networks
- Quicker troubleshooting for engineering through a global interconnection
- Archived data that is digitally stored forever allowing for simulation of past events
- Dynamic configuration of control screens providing flexibility for system users
- Real-time monitoring means that users will experience only a few seconds delay from actual plant events to halfway around the world
- Simultaneous monitoring of multiple plants for company VPs
- Installation versatility through direct connection with industry standard MODBUS

These are only a handful of the benefits brought forth by making use of such an interconnected system. Key decision makers will ultimately have up-to-the-second information at their disposal, and will no longer have to waste time tracking numbers down. Management will always be aware of what is going on within their mill and can quickly take steps to seek remote help from others or simply monitor events while on the road.

### IX. CONCLUSIONS

The advent of this technology has given the oil industry the key to unlock endless possibilities in the realm of interconnected real-time monitoring. The biggest advantage that these new technologies offer is the ability to present real-time data in a manner that is intuitive, and gives its users the power to control the way they see their plant information. Often times, trends and anomalies in data can be missed simply because the user does not have the power to alter screen components to see incoming data in a graphical format that they recognize, and in a configuration that is more personalized and easily understood.

These issues need not occur and the cost of deployment has become seriously reduced due to these new web

techniques that do not involve proprietary client-side software to be installed on user machines. In the pulp and paper industry, this same technology is a necessary component that can easily fit into a mill's existing infrastructure giving real-time data interconnectivity, versatility, and security.

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