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INDUSTRIAL PLANT CONTROLLER: A DESIGN OF A WEB BASED DATA ACQUISITION SYSTEM

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Abstract

With the exploited use of embedded devices the need for web based data acquisition systems is increasing day by day. In this paper we have discussed all the design components needed to build a state of the art web based data acquisition system except the design of the low level data acquisition hardware which is pretty much standardized at present. Client Side, Server Side and the Technical Process side are the three major subsystems which are inter-linked to each other over the internet in any web based data acquisition system. We have presented a standardized design architecture which will be suitable for nearly all the industries/domains requiring such a system. The design for the client side include design of a simple client view station needed to see just the critical alarms and alerts, design of a detailed remote monitoring station for getting an insight of all the key metrics and generating all kind of required reports, and design of a remote control station for getting the adequate control of the technical process for supervisory operations. The server side for the web based data acquisition system can either be designed as a simple data warehouse for logging all the raw data from the technical process or a sophisticated monitoring station fulfilling all the industrial needs for process monitoring and reporting. The design of server side for the supervisory control requires all the components of monitoring station as well as additional subsystems devising its fully featured command and control part. The industrial plant/site can be controlled/monitored through a local on site server which is then connected to the main server and its data can also be collected in the similar fashion or different devices/nodes can be directly connected to the main server over the Internet.

Keywords: Data Acquisition; Supervisory Control; Client Server Architecture; Data Warehousing; Process Monitoring; M2M; Web based Reporting

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1. Introduction

The dramatic expansions of the World Wide Web in all the areas of human interests have made it a necessity for today's world [1]. The required information can be retrieved through its hyperlinked structure [2] using the technology popularized by web called "internet" [3]. Internet based applications have a strong impact in strengthening the man-machine relationship. Internet is a short name of "internetwork" because it is global network of many types of other networks which are interconnected [4].

The increased efficiency of computer aided systems has changed the working methods of human beings. Human perceives their environments through many senses such as sight, sound, smell, taste and touch [5]. Many animals have also such perceptual capabilities and some other different channels as well [6]. Computer aided systems can also understand the outer world through sensors [7]. There has been always a strong need for collecting the field sensory data in any kind of processing industry [8]. The data is mainly used for various purposes like monitoring, analyzing, debugging, validating etc. At start data was physically collected from the field but with the advent of various technologies it is now collected either through wired or wireless links [9]. Specifically for collecting and monitoring the data for remote locations has its necessity for all the industries [10].

Remote operations are performed by supervising the devices/plants from a remote location specifically for the tough and harmful environments. Today's networking techniques have made this task very easy and cost effective [11, 12]. The extensibility of the networking methodologies connects the users and devices throughout the world with each others while handling the transparency of underlying communication media or network type [13]. This remote controlling part is far more difficult than just monitoring or data logging. The controlling algorithms have to be developed with some timing constraints based on the response of the system as well as the network. Special conditions exist where manual operations have to override the remote operations based on the operator's call who is actually observing the behavior at the local control panel in the field. With advancements in the computer networks and all the benefits coming from it, there is also a strong concern about security of the control/monitoring data which is being communicated over the cloud. This s the top most concern for the recent developments in the field of remote operations and monitoring systems. Specifically when there are many users each having their own profile and access rights for different kind of data and control operations, the system has to be secure enough to allow the authorized person to access the data and to perform the control operations based on its access rights.

The web based data acquisition systems are evolving day by day based on the specific requirements of the particular industry. There are many design techniques and components which are common among many of the monitoring and controlling applications under the umbrella of web based data acquisition. The architecture of such system involves the underlying data acquisition hardware, some method for transporting the data on the internet, the data collection at the server side, data analysis and providing the useful information/reports to the user through a web based customer user interface. The design components for a web based data acquisition systems are discussed in this paper. The remainder of this paper is organized as follows: In section 2, we discussed the

related work. In section 3, we put the design for a web based data acquisition system. In section 4, there are concluding remarks. At last in section 5 there are details of the references for all the referenced sections.

2. Related Work

There are many designs that have been employed by many industries for web based data acquisition systems, some of them are discussed here. Design and implementation of a web-based data acquisition system for multi-users was devised by Engineering University of Mauritius which collects data from remote station sites through a Public Switched Telephone Network at predefined intervals [14]. The architecture of the system is shown in Figure 1:

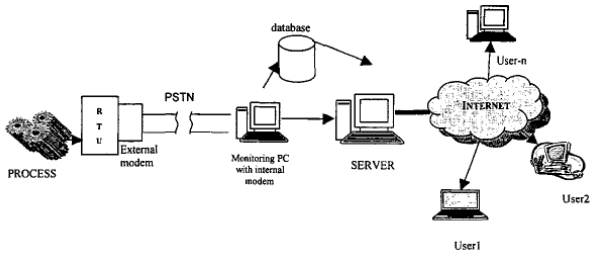

Figure 1: Architecture for the STNP based Data Acquisition

Similarly, instead of using a PSTN, an embedded web server is used to directly connect to the internet for any kind of data acquisition or remote operations [15].

A web based Supervisory Control and Data-Acquisition (SCADA) system was developed by Duo Li, Yoshizumi Serizawa, Senior Member, IEEE, and Mai Kiuchi which consists of many intelligent remote terminal units connected to distribute master station using HTTP protocol. The master station has a client-sever architecture providing the SCADA functions a multiple sets of Web site components [16]. Its flexible and scalable architecture is shown in Figure 2:

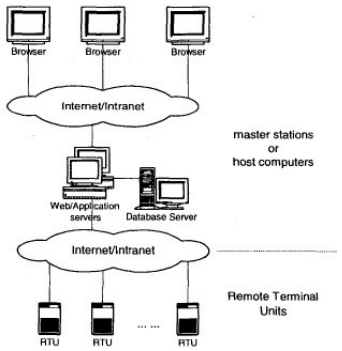

Figure 2: WEb Based SCADA System

Similarly a web based SCADA system was developed for pharmaceutical plants which consists of many wired/wireless nodes, PLCs, web server, database and customer user interface for a PDA. The main task is to see different alarms and monitor various operations [17].

A Web-based Remote Monitoring of Live EEG was developed to avoid any dangerous outcome by providing the brain EEG data to the medical specialists without any delay even when they are not present on site [18]. It has a simple architecture as shown in Figure 3:

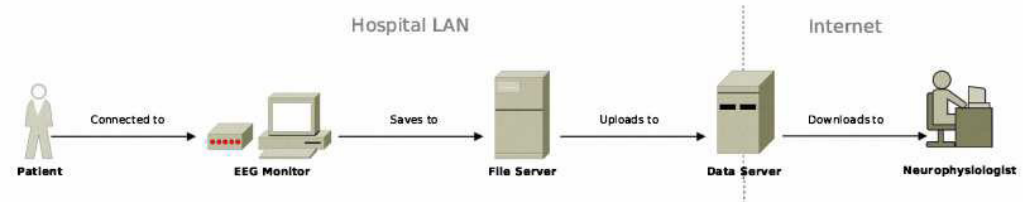

Figure 3: Web-based Remote Monitoring of Live EEG

Similarly, we based remote operations are performed on inverters in power industry [19] and security measures are taken using web based acquisition systems which usually involves monitoring and controlling [20].

This paper describes the standardized method to be used among various web based data acquisition systems which can be scaled up and down based of the actual need. By standardizing such systems we can easily move forward towards Machine to Machine control.

3. Design Components

There are three major components of a web based data acquisition system called client side, server side and the technical process. These three are interconnected over the internet cloud. The basic architecture of the web based data acquisition system is shown in Figure 4:

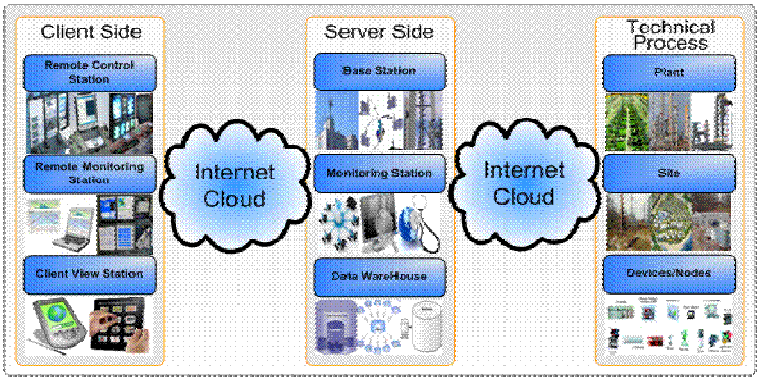

Figure 4: Standardized Architecture for a Web Based Data Acquisition System

3.1 Client Side

The Client side can either be just a client view station, a detailed remote monitoring station or the remote control station from where all the supervisory control operations can be performed. It can also be a mix of any three of them. Everything on the client side is under proper access control.

3.2 Client View Station

The client view station is a web application or usually a gadget on a hand held mobile device like PDA, iPhone, Anroid Phone, tablet etc. just for displaying critical Alarms and Alerts. These kinds of apps are usually intended for higher management so that they can keep track of the high level tasks not the detailed ones. It also contains a system health status which depicts only the current state of the system if it is stopped, running correctly or malfunctioned. Everything on the client view station is short and crisp.

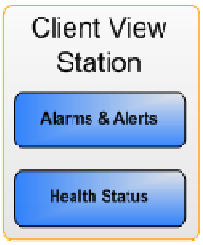

Figure 5: Client View Station

There are many other small items that can be part of client view station based on the application's need like it can has a task allocation form using which the manager can respond to an alert and assign the task to a particular resource so that in case of any emergency, it is taken care of properly.

3.3 Remote Monitoring Station

The remote monitoring station is a web application displaying key metrics of the technical process and the critical states of the system like in client view station but in more detailed manner. These kinds of applications are intended for the day by day users or usually the engineers so that they can have a tight control on the day to day work. Everything on the remote monitoring station application should be in text as well as in visual format. There are many basic features that must be present on the remote monitoring application as depicted in Figure 6:

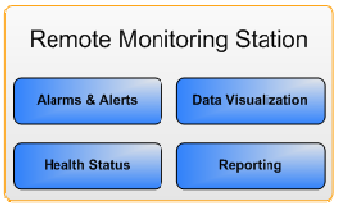

Figure 6: Remote Monitoring Station

Data visualization is the detailed depiction of all the key metrics of the technical process and its data controls must be domain specific. It must show the live data/status as well as there must be a mechanism to view the previous logs/states. It contains usually different kind of graphs, bar charts etc and the textual data in the tabular form with time stamp. It usually has the capability to configure the display by omitting/adding some data components/controls. Reporting is a very important feature in remote monitoring station. It usually contains reports in a predefined format for the specified operations like productivity reports, error reports, operator specific reports, efficiency reports etc. It also usually has the capability to generate report based on a custom filter. The reports should be downloadable and should be able to export in different formats like csv, xls, plain text etc. Alarms & Alerts and Health Status are similar to client view station but in more detailed form.

There are many other features that may be included in the remote monitoring station based on the requirement like configuration of the technical process, user management and data analysis. Using the configuration feature required components of the technical process can be configured accordingly. User management can handle access control and all the management related tasks of the users of the particular plant or site. Data analysis feature can be used for scenario recreation and figuring out the actual behavior of the system when malfunctioned or whenever needed. The software update for different modules in the technical process is also sometimes supported through remote monitoring station.

3.4 Remote Control Station

Remote control station is a web application from where operator/engineer can exercise different commands on the technical process. It contains all or some of the features of a remote monitoring station as needed plus the domain specific command & control interface test & debug interface, configuration interface and the user management/access control.

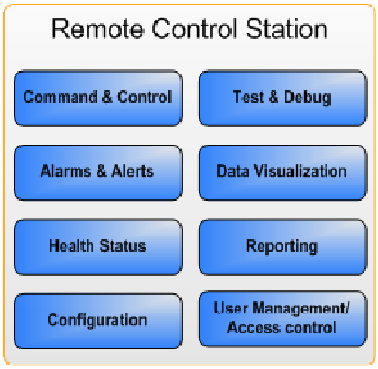

Figure 7: Remote Control Station

Command & Control is very specific to the domain for which remote control station is being developed. The main consideration here is that it should provide the controls of the

technical process in such a fashion that user feel he is operating the actual plant up front. It also some times contains the software module update interface.

3.5 Server Side

The server side can be a basic data warehouse for collecting the field date and providing as is to the user for further processing. It can act as a proper data monitoring server or the base station. It can also be a mix of any three of them. Everything on the server side is under proper access control and behind a firewall.

3.6 Data Warehouse

The Server side can act as a data warehouse for collecting required data about the technical process which is then available for further processing. It just consists of a data server for storing the acquired data and an external interface server for uploading the data from the technical process to the databases of data server along with an interface for retrieving the data from the data server.

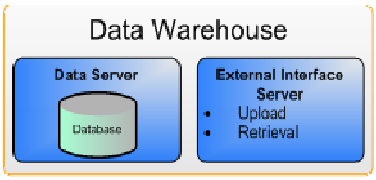

Figure 8: Data Warehouse

The database server contains database or relational databases depending on the data requirements of the technical process. The external interface server also decodes the data if required along with the data uploading and retrieval.

3.7 Monitoring Station

The server side can work as a monitoring station where it has to analyzed all the data coming from the technical process, generate specific alarms/alerts against different system states, prepare different kind of reports and act as an expert system which acts accordingly against any situation that arises thus managing all the hardware/software demands of the technical process.

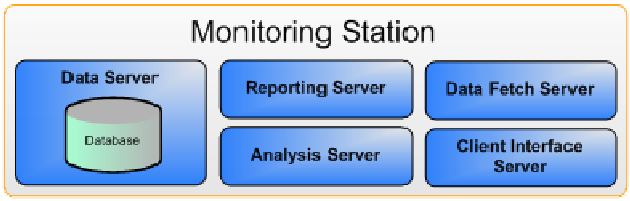

Figure 9: Monitoring Station

The data server is same as in the data warehouse. The reporting server is responsible for generating any kind of report required by the client interface server to be shown on the client user interface. Data Fetch Server is responsible for uploading the acquired data from the technical process to the data server. The brain of the monitoring station is the analysis server which acts as the expert system for data analysis and act accordingly. The actions are usually displayed on the customer user interface. Client interface is the business logic displayed on the client side and it also coordinates with all other components based on the user operations on the customer user interface.

3.8 Base Station

The server side can act as full fledged base station for providing the command & control interface to the remote user on the technical process as well as behaving as a controller for avoiding non-permitted commands/states. Every command from the user is analyzed and then exercised on the technical plant.

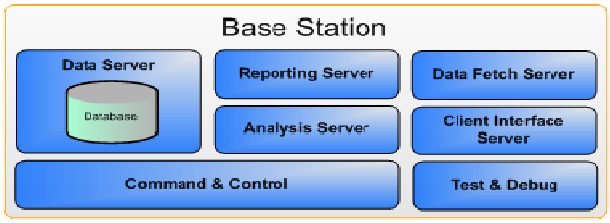

Figure 10: Base Station

All the components in the monitoring station are usually also the pert of base station with some increased functionality specifically client interface server is very much different. The monitoring data acts as feedback for the command and control module. Test & Debug is used for different diagnostic and validation purposes.

3.9 Technical Process

The technical process can be a specific industrial plant which needs to be controlled/monitored from a remote location. It usually involves the control of different PLCs, sensors, actuators and the hardware/software components used to automate the plant. All the subsystems in the plant are usually connected to each other through some wired/wireless medium on a filed bus which is then connected to a local server. Specialized data acquisition hardware is also connected to the field bus. This hardware can be directly connected to the internet if plant's data is only to be monitored. The local server is then connected to the data acquisition server via internet. The local server is usually behind a firewall and it needs to be configured to get accessed by the data acquisition server.

The technical process can also be a site where different kind of devices performing different tasks need to be monitored. The data from these devices is collected on a local server physically or through any wired/wireless medium. The local server is then

connected to the data acquisition server via internet. The local server is usually behind a firewall and it needs to be configured to get accessed by the data acquisition server. Specialized data acquisition hardware can also be used to collect all the data and upload it directly to the main server or to the local server. Some of the devices in the site may also be connected to the main server directly using their own embedded web server.

The Technical process can be simply a mesh of internet aware devices/nodes which needs to be controlled/monitored and are connected directly to the data acquisition server. The data is collected whenever available or it can be collected on a specific time depending on the application needs.

4. Conclusion

We have suggested a standardized method for web based data acquisition systems. The architecture provided is very flexible and adaptable to any industry. It can solve the web based data acquisition problem for any industry which requires a simplest data warehousing, a complex multi-user monitoring station or a fully loaded supervisory control of a technical process. We also have focused on building a platform which can assist further in the research and development of web based supervisory control systems and data acquisition systems.

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