PEA SCADA Online Monitoring

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Abstract: A trend of the electric power enterprise construction will be the online monitoring, but the PEA SCADA system cannot monitor from outside by web browser or internet because PEA's SCADA system in some areas is also a centralized computing system that is not designed to interface or monitor with external systems. Normally, the SCADA system in such area should be renovated or upgrade to a network computing system but requires a very high investment. For this reason, we try to use the existing system and develop an online monitoring applied to the problem of the centralized computing system. This paper presents a solution for SCADA substation online monitoring, an online monitoring architecture for the SCADA system to support smart grid, and presents a concept of online monitoring and network virtualization for this system. The aim of this approach is to propose an architecture of SCADA online monitoring that ensures access, available, flexible and consistent for PEA SCADA online monitoring. This paper discussed the feasibility study of handling of monitoring of unmanned substation on internet framework retaining smart grid security in Thailand. The monitoring of the device status and analog value of substation can also be done from the network through cloud-based SCADA with the online monitoring using internet connection. The assessment results allow the network administrator to plan infrastructure expansion with confidence in the security and reliability of the network's operation.

Key words: Online monitoring, SCADA, substation.

1. Introduction

Provincial Electricity Authority (PEA) is a state enterprise responding for electricity in Thailand, which focused on providing efficient, reliable electricity services, related business for developing the quality of life, sustainability of economics and society. Supervisory control and data acquisition (SCADA) system have been implemented in PEA since 2004 to support the distribution dispatching center. (DC)

Presently, the SCADA system is implemented in all of PEA's responsible areas, totally 13 centers include 12 areas and one central center. The remote devices can be supervised, controlled, and monitored the substation, transmission, and distribution system.

Nowadays changes in power system and innovations for power supply are essential. In order to manage and operate this changes and innovations, the electric grid system is developed into the smart grid. SCADA system plays an important role in a power system. It supports control of the remote device, gathers data from substations, device, and shares all the gathered information with other systems. All data collected from power systems will be gathered into the SCADA system; all these information will be exposed with this software application.

SCADA system has been developed from the first generation, mainframe-dominated, centralized computing system to the third generation, the distributed network computing system. [1] The rapid development of information technologies brings the great opportunity to the SCADA system to deal with this challenge. The smart grid is commonly recognized as the next generation power grid with improved operational benefits of control, reliability, and safety, and advanced two-way communication provided by the adoption of modern Information and Communication Technologies (ICT) [2]. A smart grid is conceptualized as a combination of an electrical network and communication infrastructure, a smart grid is capable of delivering electricity more efficiently and reliably than the traditional power grid.

SCADA system has an efficiency limit when it comes to the vast amount of computing resources with an enormous amount of data. In order to prevent the capacity limitation, all database and monitoring application can be installed under internet base computing system or as it is often called cloud computing [3].

The Internet/Intranet technologies make the new generation of cloud-based SCADA system possible. Various SCADA applications based on web technologies have been addressed in the past [4]-[10]. The challenging issues for SCADA systems today are not the same as they were a few years ago. There is an increased importance placed on integration, functionality, communication and network technologies, reliability, security, and other purposes.

Presently, about 80 substations, supervised and controlled via DC, were distributed over this area with the 115 kV transmission line, and 22 kV distribution line. There is a lot of information of SCADA system for management and monitoring, and still, continue to increase.

The objective of this implementation is to monitor data through the online system by internet connection, which means clients can access the database and monitoring application with the web browser from anywhere at any time. The paper will lead to the development of power system management for controlling and monitoring in the larger power systems under an online monitoring system for the benefits of future smart grids.

2. Backgrounds and Motivation

This part describes the backgrounds and motivation for this implementation. Technology adoption in control systems or SCADA system lags behind that of IT, due to the differing system requirements. These include the high availability and reliability of systems coupled with significantly longer lifecycles; fifteen to twenty years is not uncommon and can be even longer. This is often characterized as engineering conservatism in industry. The benefits of online monitoring for SCADA and control systems will need to be compelling for organizations to consider the migration from established practices, notwithstanding the impediment of security concerns.

The SCADA system of PEA is the centralized computing system, and cannot monitor from outside. Although there is software that can help to monitor the SCADA system, such as remote software or virtualization software, but there are still a lot of limitations, such as must install software each point, more configurations, more resource usage, difficult to use, limitations on the duration of each use, and effect to core system, as shown in Fig. 1. For this reason, we have an idea to bring an online monitoring system to manage the SCADA system.

There are many advantages of the online monitoring system, such as not effect to control system, no need to install any software, less resource usage, and user-friendly, etc. But the major advantages of the online monitoring system are ubiquitous network access, higher flexibility, and scalability. The online monitoring is the product of the fusion of traditional computing technology and network technology like grid computing, distributed computing and parallel computing [11]. The SCADA control mechanism will suffer to manage vast distribution networks due to this growth of distributed generation and the network scales. This complex scenario requires a lot of data exchange between the nodes and the computational system. To this end, a distributed computation, monitoring, and control have to be provided. Meanwhile, cloud computing for online monitoring and remote is suggested as a computational solution to manage the overwhelming information generated in the smart grid due to widely deployed monitoring, measurement and control devices [12].

It is reliable and scalable. All resources are virtualized and in case of demand, more storage or computing without downtime or impact can be added. Using techniques like templates can deploy thousands of machines with few clicks [13]. Industrial Control Systems (ICS) and SCADA system have high reliability and availability requirements. These critical requirements can be met with the scalability of the online monitoring on cloud-based, with increased flexibility, redundancy, and availability.

The flexibility of cloud computing for online monitoring stems from its dynamic scalability; it is available as required, at short notice, and inexpensive. Such benefits are not easily achieved when purchasing increased computing resources. This would require individual user management, procurement, deployment, configuration, testing of new servers, software and networks. The increased delay may increase risk.

The online monitoring with cloud computing has an answer for computing resources, high-performance monitoring, and storage needs of the future power system.

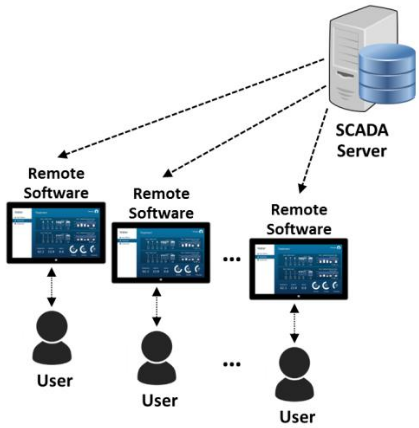

Fig. 1. Example of remote software conceptual.

3. Methodology

In this part, describe the online monitoring model, scope of work, tools, parameter setting, configuration, procedure, and implementation of this research. The main idea of this work is integrated SCADA traditional model with cloud computing for online monitoring.

SCADA online monitoring is an application layer to monitor the status of the protection system, main power feeders, voltage, current, power demand, etc. The online monitoring is used in this project as a SCADA substation online monitoring and notification to demonstrate the web-based monitoring application using cloud-based framework.

In order to manage SCADA systems and share data with a large number of SCADA Clients a MySQL database, which can be accessed over the internet. Using web pages for SCADA monitoring can display the substation state using any computer connected to the internet; no matter what browser it is used.

3.1. Overview Designed

Web server hosted or internally hosted SCADA application pushes real-time process and historical data to the web server for data analytics, storage or remote access. A web server offers the highest degree of monitor over performance, reliability, and security.

The major advantages of moving SCADA applications to a cloud are: saving on cost, support for system redundancy and scaling, and increased uptime [14], [15]. We design cloud computing architecture for the SCADA substation online monitoring which is suitable for the development of future smart grid, smart home or the internet of things (IoT), as shown in Fig. 2.

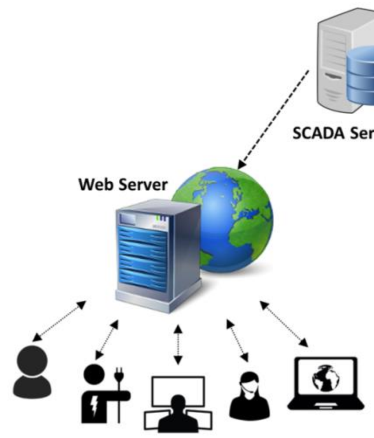

Fig. 2. Example of SCADA online monitoring conceptual.

From the Fig. 2 shows that data access is not directly connected to the SCADA server, but it will access the system through a web server instead. This method will reduce the resource usage of the SCADA system, and high security for core system function.

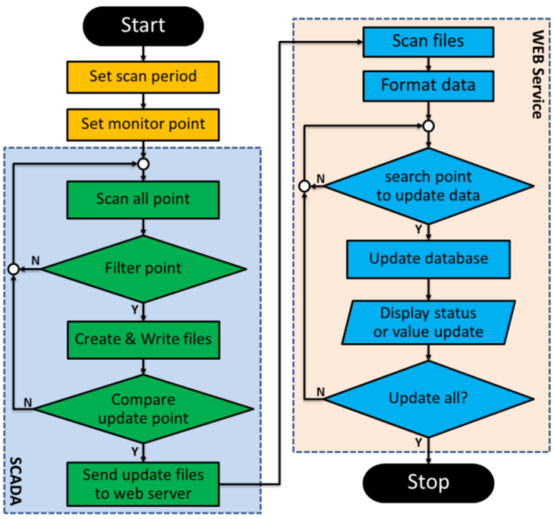

Fig. 3. The flow chart of this implementation.

The architecture of this implementation can be divided into 2 main parts, the first part is the implementation of a SCADA system, and the second part is the implementation of cloud computing. As the first step, the data that are received from a memory database of the SCADA server will be recognized and send the data to the database under a cloud environment with XAMPP. The second part, the graphic user interface (GUI) is used for creating data monitoring interface or scheme for the cloud service part or online monitoring. In order to increase the performance of data accessing, the web server is developed into the cloud with PHP programming language. This web-based application, a client can access the database, and monitor easily with a web browser.

In the Fig. 3 can describe that first step in SCADA part, the program initiates the polling time, and point of concern, next step, the program at SCADA server will scan all point of the database, point filtering, and then update file creating, both analog and digital file. When there are the update files, the program will send update files to web server. In the cloud service part, the program at web server will scan and format the update files, search point from update file to update device status and the data value in the database at web server, and last step, the program will change the color of icon status and number of data value on display screens.

3.2. Scope and Setting

The programming from visual studio application that was used for acquisition data from the SCADA server, and sends directly to web-based through internet connection then all the data will be stored in Microsoft SQL Server. The connection from SCADA server to the web server will be done through cloud service server via TCP/IP protocol.

In digital data, when receiving digital status change, the program will record new status and display, for example, when the device status changes that are closed and opened, the color of the icon will change to red and yellow. This real-time change graphic is utilized for a client or user to monitor the substation.

In analog data, every time when receiving analog data change more than 0.5 from old data, namely, active power (MW), reactive power (MVAR), voltage (kV), and the current value (Amp), the program will record data value and displayed.

The total number of implementation for this monitoring system consists of 84 substations and can be divided into 4,878 digital points, and 7,735 analog points. This system has initiated the retrieval of data every 5 seconds, both digital and analog data. There are three digital point types for device status both transmission and distribution system, as shown in Table 1, and five analog point types for the value of the power system, as shown in Table 2.

Table 1. Digital Point Type of Online Monitoring

Point Type	Status
Circuit Breaker	Closed/Opened
Discon-Switch	Closed/Opened
Lockout Relay	Lockout/Normal

Table 2. Analogue Point Type of Online Monitoring

Point Type	Status
Active Power	MW
Reactive	MVAR
Voltage	kV
Current	Amp
Tap Position	Number of position

In the web service part or monitoring part, Microsoft SQL Server was used in the implementation in order to store all the data received form the SCADA part.

3.3. Implementation

In this implementation, the webpage is developed by using PHP programming language to create a script for the web application. The web server consists 2 parts that present different data from 8 points, which are circuit breaker status, switch status, a number of tap position, lockout relay status, active power, reactive power, a voltage value, and current value.

When an event has been updated, the program at the SCADA system will check the necessary data of the memory database, such as device status, analog value, etc. If all constraints are satisfied, the program will send the updated digital data or analogue data only to the web server via TCP/IP protocol, and then the cloud service will check mapping data of the database from web server, if the data from SCADA is matched, the icon on the web interface (Scheme) will be updated the new status and value automatically and immediately. The cloud service will repeat this loop until all the data has been changed. For this reason, the user can access the SCADA system for monitoring with the web browser as shown in Fig. 4.

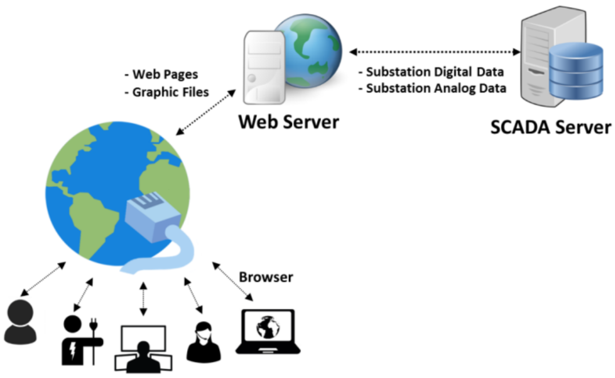

Fig. 4. The online monitoring for this implementation.

The sequence of value data updating as shown in Fig. 5, the first step, this system in SCADA part will scan and filter the point name in the SCADA database, for example, CB_ST, MW, and CT_B. In the value filtering, this system will find substation name that concern only, and get the value and time from the memory database of SCADA system, then compare the difference value that more or less than 0.5 from old data, and the last step, the system writes the point name, new value data and time to the new file then send to the web server.

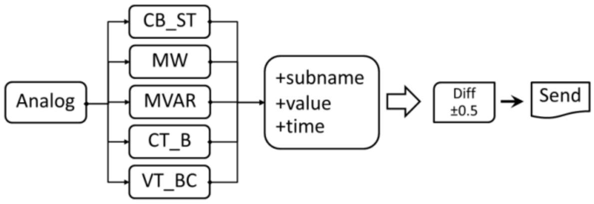

Fig. 5. The sequence of value updating.

The sequence of status updating as shown in Fig. 6, the first step, this system will scan and filter the point name of circuit breaker and disconnecting switch in the SCADA database, next step, find the changed status, then write the point name, new status, and time to the new file then send to the web server.

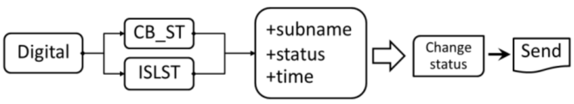

Fig. 6. The sequence of status updating.

This implementation, we try to use the existing device and the existing data from the substation in the SCADA system to develop the online monitoring with cloud computing. All icons and analog value on the scheme will link to the database for real-time monitoring. The display screen for the substation is shown in Fig. 7. The database linking to device icon and power system value bar in the substation is scanning for update device status and update data value in every one second in every measurement from SCADA server, and in this scheme, the JavaScript Object Notation (JSON) was used to create the communication interface of the web server.

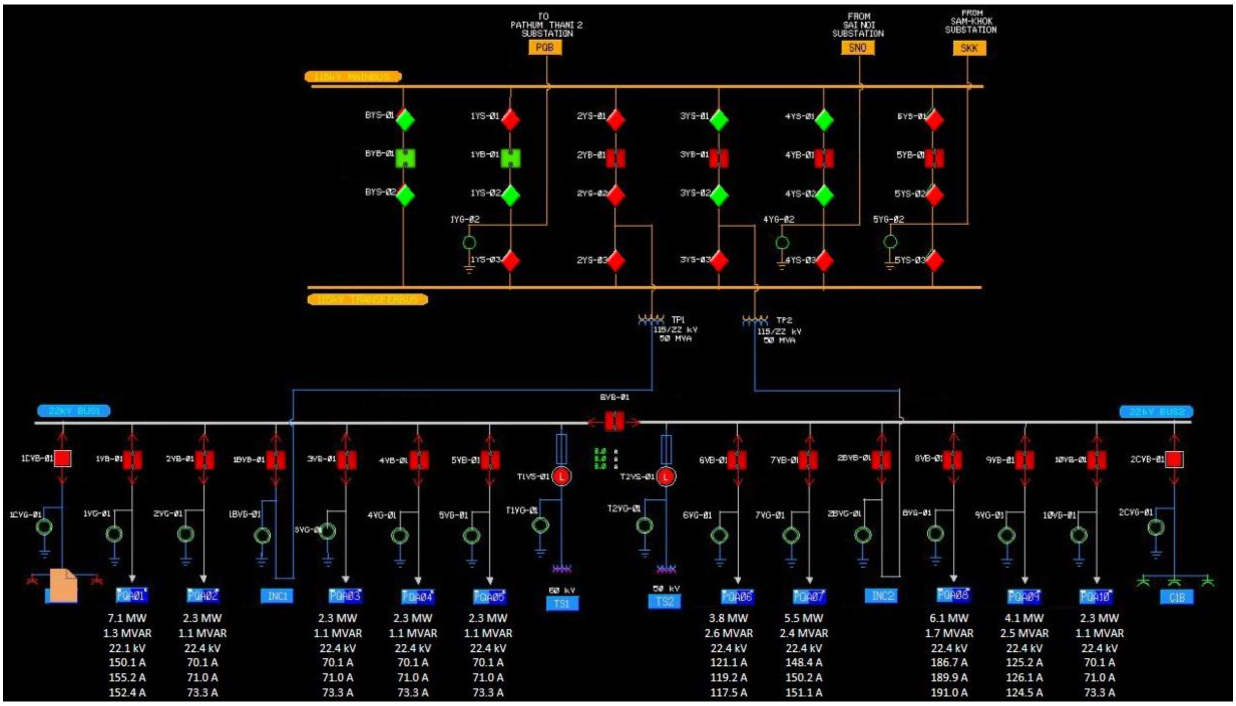

Fig. 7. The example of display screen.

The display screen or scheme is created, each display screen consists of a structure of the power system in the substation, both transmission, and distribution systems. Consisting of a power protection device, electrical device and displays the power measurements on schemes, such as active power, reactive power, voltage, and current value. This implementation has been developed with 84 substations. These require for this monitoring system make to create 84 display screens.

4. Experimental Results

This implementation is the monitoring system using the internet connection to access and monitor the status and value of device and power measurement in substation from database with web browser. The SCADA substation was developed to monitor various events or errors, such as when the power outage occurred, the circuit breaker is opened, the active power has changed, etc.

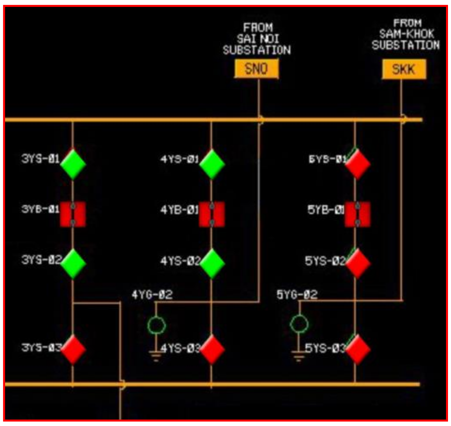

Fig. 8. The example of transmission system.

Fig. 8 is the display screen of the transmission system for online monitoring system, and the display screen of distribution system as shown in Fig. 9. In the display screen creating, it will draw the necessary device icon for each substation, such as circuit breaker, and disconnecting switch, and created the value bar for power system measurement of each time value changes, as shown in Fig. 9.

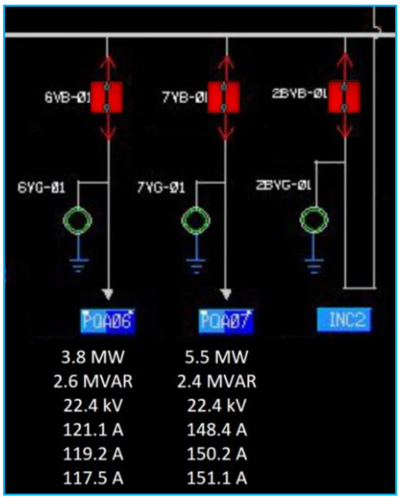

Fig. 9. The example of distribution system.

The test was conducted by applying a user request rate of thousand per minute. A linearly increasing rate of 40/s was applied to test the system performance. This performance guarantee of the cloud environment is needed. The result is shown in Fig. 10. The response time is the main performance parameter that the end user can experience directly for the available services. The average response time obtained in this test was 36.58 m seconds.

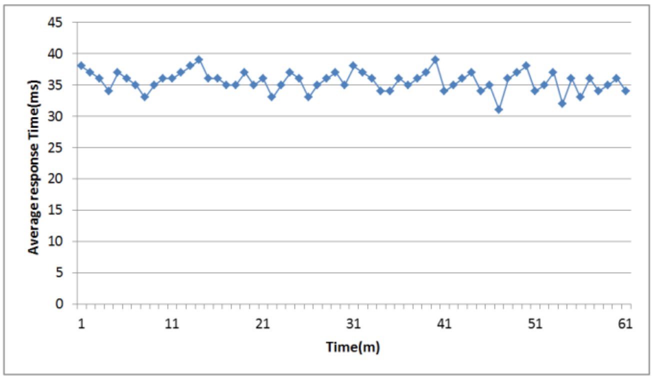

Fig. 10. Performance result of testing.

The computation for SCADA system part can scan all data from memory database, filter the concerned point only, and create files for sending to the web server within 4 seconds, and in the computation for web server part can search the update data, find the point, and push the new status to the database at web server, and display icon changes on scheme within 12 seconds.

5. Conclusion

The web-based architecture for SCADA system, this new SCADA substation online architecture monitoring in PEA, Web-based support, higher flexibility, scalability. It makes SCADA system easily achieve the information sharing and transaction-based information integration with other systems. A cloud computing architecture to realize a SCADA online monitoring application is selected. The dispatching center is designed to show the PEA SCADA substation online monitoring in the cloud computing platform. It can be used to monitored and access electric grid from anywhere at any time through internet connection.

According to almost one year trial period, this online monitoring is implemented practically, security, and accurately. This implementation will help user or operator to identify power outage, and it can reduce the duration of power outage, increase stability, and enhanced organization standards. Therefore, cloud-based system is told to be a productive automation choice in the future.

For the future works, we try to connect the GIS map to the outage management system for implementation about affect customer service using internet connection to access, monitor, identify, and notify the event, such as power outage area, recovery time, and power outage display screen zone.

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Mr. Anurak Choeichum was awarded the Distinguished Engineer Award of PEA in 2013, the PEA Young Brand Ambassador in 2010, the Distinguished Alumni Award from DPU in 2014, the Best Student Award from Engineering Department, DPU in 2011, the Best Presentation Award of PEACON 2016, the High Quality Paper Award of GMSARN 2016, the High Quality Paper of ICEFS 2017, the Best Paper Award of PEACON&INNOVATION 2017, and the Excellent Oral Presentation of ICMDM 2018.