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Providing a New Model for Partially Cloud Computing-based SCADA Systems. Case: Tehran's SCADA system

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Abstract

Cloud computing provides the ability to share a set of configurable computer resources, including networks, servers, storage applications, and services in a simple way through the network. By entering into a cloud environment, SCADA providers can reduce costs significantly and yet increase SCADA's functionality, reliability, and performance. Nowadays, SCADA systems play an important role in the control of key facilities of every metropolis. Regarding the implementation of these systems in various sectors such as water, electricity, gas, etc., their malfunction will face their users with serious and irreversible risks. Thus, the proper designing for this type of systems, in order to provide optimal reliability will be vital and expensive. This study examines the SCADA system in Tehran, which in the proposed model, the transfer of all or parts of the SCADA backup center in the cloud can cause the dramatic increase of reliability and reduce costs, and ensure the security of SCADA systems.

Key words: SCADA, Cloud Computing, Security, Reliability

Introduction

SCADA systems are now widely used in major industries such as oil and gas, electricity and water and wastewater; so that the management of these industries, without the use of SCADA systems will be difficult, or even impossible. SCADA systems consist of a set of hardware, software, and telecommunications networks. These systems are able to collect information on the status of remote industrial processes and submit them through the telecommunication network to the control center. SCADA software, which also play the human-machine interface role, provide the possibility to manage and display stored information in the control center computers [1].

1.1. SCADA Automation Levels

According to the automation pyramid in Fig. 1, the levels of automation are divided into four levels.

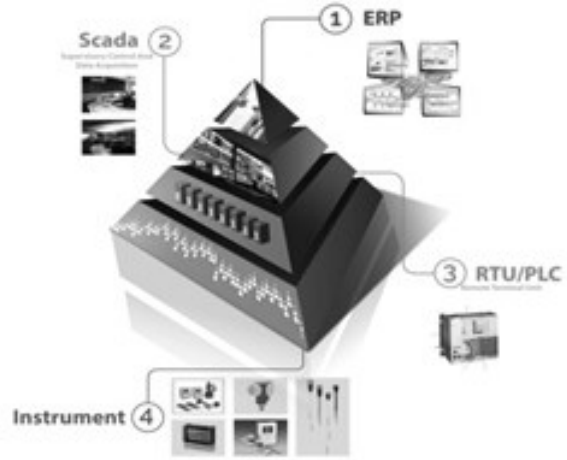

Fig. (1): Automation Pyramid

1.1.1. The Field Level

The field level includes active components such as electric drive sensors, which are used for measurement of qualitative and quantitative values such as altimetry, barometer, head meter, (input- output network and output pumping stations) remaining spots, and measurement of electrical parameters.

1. 1. 2. RTU (Remote Terminal Unit)

Each RTU is placed in a specific area and its task is to communicate with all the available tools in the area, obtain information from them and transmit data to SCADA, and receive and communicate control orders to each of the available tools in its own area.

1.1. 3. SCADA (Supervisory Control and Data Acquisition)

As shown in Fig. 2, the displayed information includes a combination of charts and data, with features such as equipment control, graphical monitoring of equipment status, display of preset parameters, providing statistical tables, planning possibility for automatic control procedures, alarm announcement, display of events and error values, energy management and consumption management and generalization of the report.

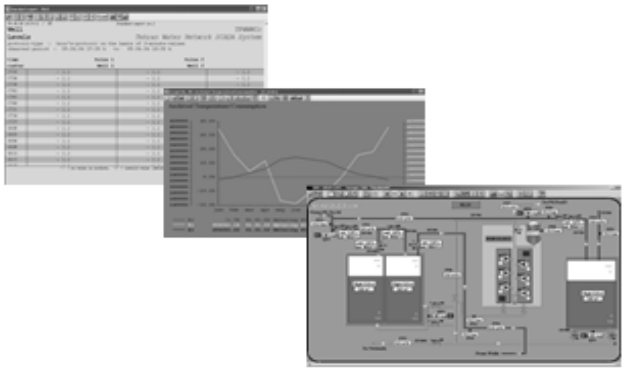

Figure (2): SCADA level

1. 1. 4. ERP (Enterprise Resource Planning)

All supplier and distributor communications are customized in ERP software. In this software, all data are taken from SCADA system's database and used in calculations that eventually lead to billing.

Recently, novel SCADA systems based on cloud computing have been introduced. These new models have their advantages and disadvantages. The National Institute of Standards and Technology (NIST) define cloud computing as follows:"An easy model to activate the network everywhere and respond to timely customer demand through access to a pool of resources (servers, networks, storage, applications, and services) that can be provided quickly and offer the desired service with minimal management effort, or release it" [2].

1.2. Characteristics of Cloud Computing

Cloud computing has six main features:

• **Requested self-service (according to order)**: The client can obtain the computer facilities of a data center, such as server and storage space on the network when needed and instantly from any provider automatically and without human intervention.

• **Comprehensive network access:** Facilities are available on the network and can be achieved with standard mechanisms. These methods are capable of supporting all strong and weak clients with heterogeneous platforms.

• **Integration of resources:** Computing resources have been integrated in cloud to serve all customers using several customer models. This is achieved dynamically by different physical or virtual resources, which resources are assigned and withdrawn at the request of the customer, and the customer usually does not have control or knowledge about the exact location of the provided resources, however, may determine the location in higher levels of abstraction.

• **Quick flexibility:** Facilities can be obtained readily and with appropriate flexibility. Facilities are rapidly expanded (from the perspective of scale) or released immediately to quickly achieve a smaller scale. From the perspective of the customer, the facilities, which are available to be obtained, often seem unlimited and can be purchased in any amount and at any time [3].

• **Measured service:** cloud systems control and optimize used resources by automatic measurement ability in the level of summarization that is appropriate for the service (e.g., storage space, processing power, bandwidth and the number of active users). The use of resources could be controlled and reported in a clear manner for both the customer and provider [4].

• **Large data computing:** Cloud computing includes setup and maintenance of large data storage centers. Traditional methods may not be sufficient to maintain the security of these systems and have a lot of overhead. Therefore, new ways to do this is needed [5].

1.3. SCADA in the Cloud

Although we have observed promotion of cloud computing for a while, using this technology for SCADA applications is greatly new. Cloud SCADA makes it possible for users to access data through devices such as smart phones and tablets [6]. Given that SCADA systems support production and distribution lines and valuable industrial processes, it is expected to have high security. Any intrusion or security flaw can result in potentially serious consequences. Opening a port to the cloud space where the Internet is located on it is still considered a serious threat [7].

1.3.1. The Advantages of Cloud Computing for SCADA

• **Easy access to data:** Data stored in the cloud server is accessible anywhere and this ability is very attractive for managers because they continuously need those data and their history.

• **Better coordination:** Since the data are stored in the cloud server, it is possible for companies to easily work together in a project, which increases the company's competitive advantage.

• **Allocating space more easily:** When a company needs more space, there is no need to add sensors and databases. You can easily allocate more space to yourself and there is no need to install or set up special hardware [8].

1.3.2. Disadvantages of Cloud Computing for SCADA Security

Security

Security is the greatest problem of companies. Important cloud suppliers such as Amazon and Microsoft have spent much time and expenditure on security in cloud systems. However, just because monitoring the security of cloud system is outside of your home network, your data may be leaked accidentally, and in this case, anyone can access the data.By putting data in the cloud servers, in fact you have put company's important data in the public network, which increases the possibility of attack by hackers.
In this regard, some issues must be considered, including:
1. If your data was leaked, what losses the company incurs.
2. How appropriate are the data put in the cloud.
3. Will you notice if someone has access to your data.

Performance

• **Increasing more than the bandwidth capacity:** To solve the problem of downtime or bandwidth or latency problems to be solved, you have to put your company in the hands of a cloud provider.
• **The latency problem:** Internet traffic can be heavy, connection can be disconnected, connections can be lost, and many other things that can cause data to move slowly and cause delays. The delay can be varied between few milliseconds to hundreds of milliseconds or even more.
• **Contradictory performance:** Variable response time is problematic in SCADA systems. When a button is pressed for an engine to turn on, if it takes one or two seconds, it is acceptable, but if it takes a few seconds, the operator may think that the button was not pressed, may press it several more times. If the delay is fixed, the operator learns to calculate the delay, but in the case of instability, it is impossible.
Issues to be considered are as follows:
1. If the performance is fluctuating, what effects will it have on your company?
2. How much do delay and variation of delay affect your experiences?
3. How much delay is acceptable; sometimes there may be no problem in delay such as reporting time.

Reliability

As cloud servers reside in unknown locations, the data of the SCADA system is always dependent on monitoring and real-time control. Therefore, loss of this performance for a moment causes dangerous damages and you do not have direct access to solve the problem. If your system crashes for some time, you have to wait for your system provider, which means you would be dependent on the provider.
Issues to be considered include:
1. If the system crashes for some time, what impact will it have on your company?
2. What if it continued for several hours?
3. If your system crashes, will you lose important data [8]?

Due to the benefits listed on SCADA, this article provides a practical model for the implementation of partial cloud computing in the SCADA, with reliability and appropriate security.

2. Our Case: Tehran's SCADA

SCADA systems are used to monitor and control chemical processes, transportation, urban water supply systems, and control of generation and distribution of electricity, gas and oil pipelines, and other wide and distributed processes.
This system is used in the water industry for monitoring, controlling facilities, storage of qualitative and quantitative data of supply lines, water transmission, and distribution and reporting processes. With regard to the distribution of water facilities in metropolises such as Tehran, today, serving and equitable distribution of water without the use of SCADA systems is almost impossible.The main components of the SCADA center in Tehran include two central processors, two data storage systems, and 11 monitoring computers. The design of redundancy in this system has been achieved via the RAP model [1]. Stations of the system (tanks and pumping stations) are in contact with the control center via UHF radio base. The configuration of this system is shown in Fig. 3.

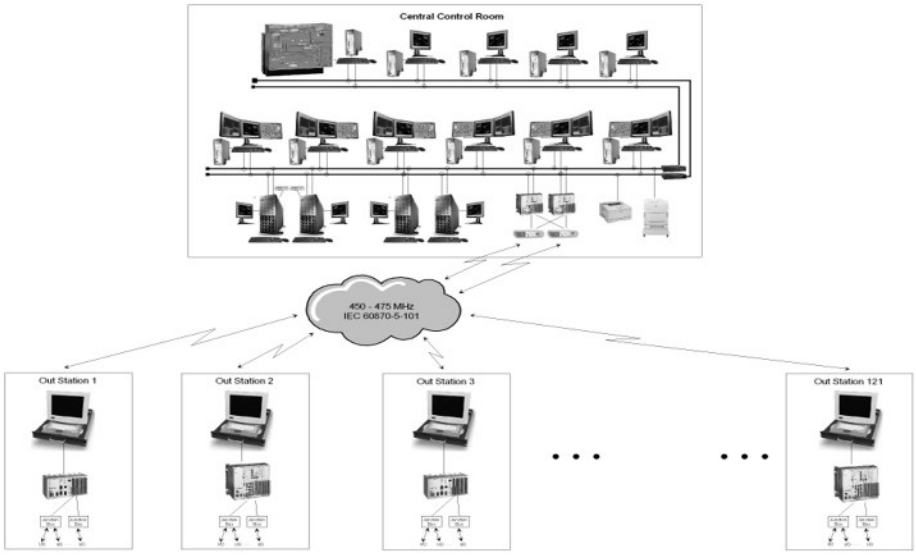

Fig. (3): Configuration of Tehran's SCADA system

2.1. Necessity of a Backup Center for SCADA

Setting up a backup center for the current SCADA is necessary. The creation of a new center requires purchase of hardware and configuration and retest of servers, software, network, etc. which requires massive investments. The idea behind the creation of the cloud backup center will help a lot to reduce costs. Table 1 shows the benefits of the cloud SCADA.

Table (1): The benefits of the cloud SCADA

SCADA With Cloud	SCADA Without Cloud
It has higher efficiency, so that work can be done with more speed and agility [9].	Doing things compared to the cloud is time consuming and requires intermediaries to do the job.
Resources can be quickly prepared and released with minimal need for management measures (if needed flexibility in adding new resources) [6].	New resources must be identified and addressed, so that adding resources is not done as easy as the other method.
There is no need to purchase hardware and software licenses, which may not be used (reducing costs) [6].	It requires high expenses to provide infrastructure and maintenance of servers (increase of costs).
It has better management and control on the IT resources [9].	Management and control of this system has risks due to the presence of intermediaries.
Cloud SCADA provides access to data for users through tablets, smart phones and ... (availability) [6].	Access to the data is not possible through the Internet, and access must be Local.
Due to multiple Internet connections and more supporting servers, it has higher reliability [2].	Because of security restrictions and a lack of large-scale internet communications, it has lower reliability.
Any change and development can be well managed (saving time) [10].	Making any changes and development in this system needs authorization by service providers (time-consuming process).
It has better performance, so that it has high capacity to improve or correct problems, and data within the cloud is easily available and quickly stored [2].	In terms of facing problems, it has lower performance.
Virtual data storage is available without limitation so that the capacity can be steadily increased for more data storage [6].	To store the data, we face limitations so that adding more data requires infrastructural provisions and a great amount of money and time.
Business can rapidly show appropriate reaction if it needs change (high-speed performance of the cloud) [9].	In case of change of requirements, the reaction of business would not be rapid and Just in time, which may cause problems.
In the case of cloud use, everyone uses the required size of resources in every moment, and therefore, less energy is consumed, which helps to protect the environment and helps to prevent global warming (environment and energy saving) [9].	Without considering cloud, a company in order to predict high-traffic time needs to purchase powerful servers that are usually idle and only use 30 percent of their resources.

3. Proposing a New Model for SCADA Systems based on Partially Cloud Computing

The introduction of any new technology to an organization brings many risks in relation to implementation and use of the technology. It is important to identify the risks associated with each technology and manage it with the best strategy. In this model, to ensure safety and data protection, the cloud-computing system is separated from the lowest layer, which is field. Exact devices data, same as Fig. (4) Transmits on both sides. On the one side, it transmits toward PLC/RTU, and on the other side, it transmits to the cloud database through the data logger and modem. There is no connection between the current SCADA and cloud server. According to Fig. 5, we have created a dashboard of information in the cloud server that it is possible for managers and decision-makers to observe the qualitative and quantitative status of reports. Present and future consumption can be predictable through tablets and mobile phones, with the cloud server. Thus, there is no control or command on the equipment, and on the other hand, given that the Cloud does not have access to the control level, the security of the system is insured in terms of control.

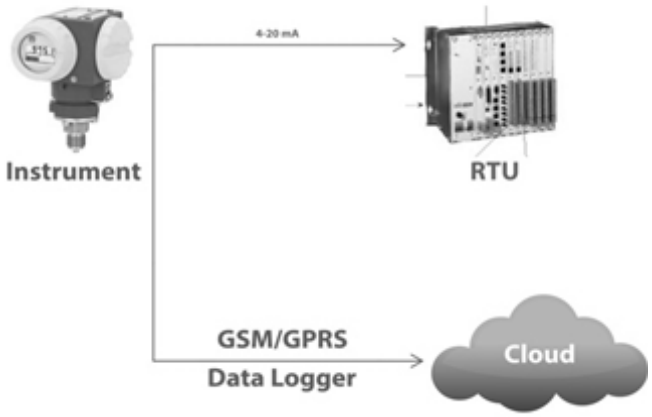

Fig. (4): Sending precise devices data in two ways

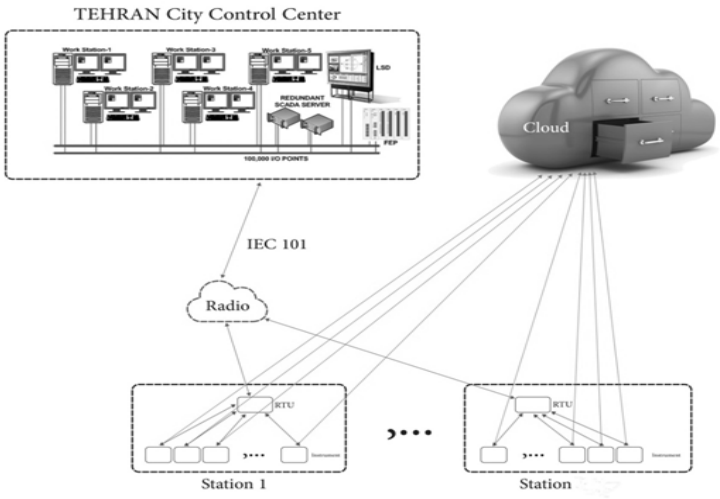

Fig. (5): The new model of cloud SCADA system

Conclusion

In this article, at first, by reviewing SCADA and cloud systems, the advantages and disadvantages of SCADA in the cloud was examined. Furthermore, in this study, by examining the SCADA system of Tehran and the company planning to create a backup system, we introduced a cloud model that provides support systems that greatly reduce costs, increase flexibility, and guarantee necessary security. This model is suitable for urban SCADA systems in which establishing a backup center is not mandatory.

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