ROLE OF CLOUD COMPUTING IN THE FUTURE OF SUBSTATION AUTOMATION

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Abstract: Substation Automation provides monitoring and controlling of electrical substations. Currently electrical substation consists of their in-house database servers and applications. These applications are meant to run 24*7*365 as substations are the most crucial part of utilities network. Every substation has its own dedicated communication network and these networks are generally works in isolation to avoid any major security risks. As the Cloud computing offers very high computing power at a very low cost this paper examines if cloud computing can be used in real time systems applications which are meant for substation automation. This paper is aimed at the recent developments in computing fields like cloud computing which can be harnessed in the Substation automation. The substation automation is a very challenging area of applications in which the computing demands are increasing day by day, to overcome this Cloud computing is very promising. The Use of Cloud can break the barrier of hardware and provide the useful data at every level of operations from any remote location.

Keywords—Substation Automation; cloud; monitoring; control

I. INTRODUCTION

Substation Automation provides monitoring and controlling of electrical substations. An Electric substation consists of four basic levels: Process Level, Bay level and Substation Level and Control Center Level.

Process Level: It includes the working of all the electrical primary equipments such as circuit breaker, isolators and transformers etc.

Bay Level: It includes intelligent electronic devices which are installed in the substation to monitor and protect certain number of physical level devices. These devices interact with the control center to control the equipments and also with different other devices to send back the status to the control center. This function is known as Data Acquisition.

Substation Level: It includes the overall upkeep of substation level activities like Time synchronization, monitoring of power, alarms and time trends etc.

Control Center Level: The activities at the control center mainly involves management of all the substations under that center which includes time to time sending of the control to substations, monitoring of critical alarms and overall power management.

In substations there is generally lot of data which is getting generated and in order to process this data there is a demand of lot of hardware which generally is industrial grade hardware and pushes the cost of automation in the substations. So primarily the Role of cloud can be to reduce the cost of this hardware by offering cheap computing power, at the time of substation design it is observed that due to this hardware limitations as well as limited bandwidth not all the data is sent to the control centre. So the granular data is only available inside a substation where generally it is not possible to analyze this data. Now let’s see the different approaches that can be used.

II. MONITORING AND CONTROL OF SUBSTATION DATA

A. Control of Devices Remotely in Substation

In this any device inside a substation can be controlled remotely from the control centre. The Control is basically for maintenance purpose.

B. Monitoring data in Substation Events

Events are available all the time in substations. These are generated due to any change in the status of the substation devices. This can be due to any abnormal behavior (Tripping of Circuit breaker by protection relays) or after a execution of control.

Analog Data:
The analog is generated while monitoring analog values. This can be voltage, current, phase, frequency, power, energy which is related to electrical systems .Then Temperature, pressure, oil level related to normal working conditions of the substation devices.

Disturbance Records:
Records related to any kind of abnormal condition inside substations.
Derived Data:
Alarms
The Alarms are generated from the selected events or the selected triggers which are set on the analog threshold values.
Trends
These are generated from analog values. This may be real time or historian.

III. APPLICATION WHICH HANDLES MONITORING DATA INSIDE SUBSTATION

Data Acquisition Service: (DA)
The main role of this service is to collect all the data of equipments which are present inside substation. The Data is Real Time status of the all the equipments and networks.

Alarm Management Application:
The role of this application is to receive the data from DA server and Control the different types of Alarms. These Alarms are then passed on to the upper layer of applications which can be HMI’s or SCADA.

Current Architecture of this involves an application which is running inside substation 24*7 monitoring alarms. This is generally kept as a redundant application so that if one of the systems goes down the redundant system takes over.

Trends Management
Trending is one of the most important features inside a substation. It relies on the DA server and provides a very in depth view of analog as well as digital data. With the help of Real Time Trends the Management of substation becomes easier for operators.

Historian
It is the Central Database which keeps all the data that has been generated in the above applications. This Data is relational in nature and is kept in RDBMS.

Advantages: The Limitation here is of Hardware which makes it impossible to keep very high volumes of data. It is also made redundant to avoid any risk of data loss.

The above mentioned data and Applications are very critical in nature and are suppose perform without any major issues throughout the life

IV. CLOUD COMPUTING AT DIFFERENT LEVEL OF SUBSTATION

C. Cloud Computing at Process Level

At process and bay level the data is actually getting generated and process level is generally not directly exposed to communication layer. So the implementation of cloud based approach here is very limited here. Although it is very much possible if the devices which are generating the Data can directly put the data on cloud and interface each other.

D. Cloud computing at Substation level

Approach 1: Partial use of cloud

This is the most practical solution currently because of low risk. In this it is proposed that the Data that we store inside the archiver can be directly stored on the Cloud. With this the Cost of maintaining a database on the premise will get reduced and the data will be available to the control center team and they can analyze the data with special tools.

This can be replicated to the whole clusters of substations and also at the grid level. With this approach the data will be centrally stored on the cloud and will be available round the clock.

Advantage: The requirement to create special database will be overcome inside substations. The database will be free from failures.

Limitations: it can be the Availability of the cloud or the reliance on service provide.

Security Risk: Low (Because this is only monitoring data).

Approach 2: Full System on Cloud

In the Full System on Cloud the whole Core Applications will be deployed on the Cloud virtual servers. This includes the applications which are described above.

Now to make a Full Cloud based System following challenges lies ahead:
- Remote Data Acquisitions
- Processing of Acquired Data and Data Storage
- Types of Clients to Utilize the Cloud based systems
- Sending of the control via Cloud systems

And there will be special techniques to provide the data acquisition service to all these cloud hosted applications. These techniques will involve remote data acquisition directly on cloud servers.

Remote Data Acquisition: In this The Data will be taken from equipments and will be directly mapped to the cloud servers, with this all the related tasks will be performed on the cloud servers. The Remote Data acquisition will make use of a special coupler that will act between the current DA service and Cloud .This Coupler will also have benefits like security control and firewall features which will be discussed in the coming sections.
Once the data [Events, Analog Values and DR] reaches the cloud servers, the processing will happen according to the volume of the data. In this way the elasticity of the cloud can be utilized to the fullest. The processing applications can be upgraded in real time and it will allow troubleshooting these applications or any substation related issue. These issues can be analyzed by experts without even going to substation. The data will also be saved on the cloud servers without any physical limitations. This will allow the reference of this data in future requirements.

In the cloud, multiple instances of these applications will be running which will take care of the redundancy part. So in case of any instance not responding the load can be shifted to the other instance. The capability of the computing power in terms of RAM or number of processors can be decided as per need.

### Types of Interfaces to Utilize the Cloud-based systems

**Business Interface:** These types of clients will be purely web based and will be accessible from mobile devices. The data in these clients will only be used for health monitoring of the Substation and broad status of the substation.

**Analyst Interface:**
This type of client will be used by the data analysis teams to gather useful information of the data present inside substation like metering.

**Operator Interface:**
This client will be designed in keeping mind the operator needs. It will have all the functionality of an HMI and it will work as it is.

### Sending of the control via Cloud systems

Sending of the control involves very big risks like latency problem, network congestion and security threats. Keeping these factors in mind the sending of the control needs to be designed in a very careful way. We will propose two ways of handling control

1) **Multiple times user validation**

   In this approach, the user needs to send the control command and then forward it to his superior for approval inside the application itself. The user will need to pass a passkey to do that and will also require certain system rights.

   It will be the job of the superior to grant the approval for the control command. Once the control command is approved, it will be passed on to the cloud system and will be kept in the buffer (to be discussed below) for execution at the right time to overcome the latency issues.

2) **Buffer:**

   The Buffer will be a special application pool where the incoming control requests will be parked and will be executed with the time to start mentioned in the control requests.

   The best approach will be to combine these two methods and implement as a single solution.

These two methods solve the problem related to the security and latency issues to some extent.

### E. Security in Cloud

Currently, the Security is one of the biggest factors in any cloud-based application because the servers are exposed to the internet which increases the associated risks.

With public cloud providers generally having their own dedicated security analyst around the clock and guarding their clouds for any threats.

In terms of substation, the above method of multiple times user validation is a reliable way of controlling.

### F. Types of Cloud

Three Types of Cloud are there

**Public**

It is generally public cloud service providers and these service providers are the real owners of the infrastructure and they provide service to others. This type of cloud is the most cost-effective.

These Clouds till date guarantee only 99.99% of Uptime. Because recently it has been observed that there is some downtime involved. The security concern for this type of cloud is huge because the sensitive and real time data is stored somewhere outside the customer territory.

For substation automation, the Monitoring application can be directly hosted on a public cloud to maximize the cost reduction.

This type of cloud offers maximum elasticity.

**Private**

This type of cloud stays in the customer premises and all the infrastructure is owned by the customer.

From the security prospects, this type of cloud are very safe in terms of outside attacks. The data is also present in the hand of the customer which is sometimes preferred by the customer.

This type of cloud is more expensive than the public cloud.

**Hybrid**

Hybrid model is actually the combination of private and public cloud.

### G. Reliability, Performance and Latency Issues

Reliability from substation point of view is the network service provider. To overcome this, we can go for two service providers.
Latency is one of the biggest challenges in terms of today cloud because the substation is dependent on the response time of the data. This can be controlled by the use of high broadband and by putting more and more protection and decision automation logic at bay level.

With the Help of Cloud computing we will be making the critical substation data and tasks easily manageable in terms of better analysis and better support from different teams sitting in different locations.

REFERENCES: