Research on Power System Monitoring System Based on Computer Ubiquitous Internet of Things Technology

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Abstract. This article uses the current ubiquitous power Internet of Things, sensor technology, detection technology, communication technology and the application of hierarchical distributed structure to design a set of intelligent substation online monitoring system. Real-time monitoring of the operating status of main equipment such as high-voltage switches and transformers in substations, alarms and early warnings of potential faults in the equipment, and transmission of monitoring data and alarm data to the Internet through wired or wireless means to achieve remote data monitoring. It has good reliability and flexible scalability.

Keywords: Computer, ubiquitous internet of things, power system, monitoring.

1. Introduction

According to the “Ubiquitous Power Internet of Things Construction Outline” of the State Grid Corporation of China, “Ubiquitous Internet of Things” refers to the information connection and interaction between any time, any place, anyone, and anything. The ubiquitous power Internet of Things connects power users and their equipment, power grid companies and their equipment, power generation companies and their equipment, suppliers and their equipment, and people and things to generate shared data, and use these data to provide users with comprehensive intelligent service [1]. The application of the online monitoring system of substations in the power grid has begun to take shape, but during the operation process, there is no unified standard for the data of the equipment manufacturers. The problem of information islands changes and the system loopholes occur frequently. The repair technology is difficult and takes a long time. Which brings great risks to the safe operation of the power grid. This article uses the ubiquitous power Internet of Things online monitoring system and device for substations to propose an idea to solve the above problems, which not only provides a transfer platform for data transmission, but also provides a unified interface for standardized data structure.

As a key link of the entire power supply system, the substation is of irreplaceable importance. It is responsible for changing the size of electric energy and also includes changing the distribution of electricity. It has a certain degree of impact on the efficiency, safety and stability of the entire power supply system [2]. At this stage, substations still have shortcomings in terms of detection, stable operation, and safety management. There is still a certain gap between the management method and the degree of intelligence of facility failure and detection and the requirements of smart grids for smart substations. For example, the staff are still using the more traditional way of manually recording data, which is prone to errors and is not conducive to the sharing and storage of data. There is no relatively uniform requirement in the programming of the facility and the format of the data, forming a data island. It restricts the sharing of data.

For this reason, this paper proposes a design idea of using ubiquitous Internet of Things technology to build a whole station auxiliary control and monitoring system platform in a smart substation, using this system to realize the control and monitoring of the whole station auxiliary production system, and adopting IEC61850 in the background The communication protocol realizes the coordination and linkage and remote transmission of information within and among the auxiliary production systems, so as to meet the requirements of intelligent operation and management of the auxiliary production system of the intelligent substation.

2. System Architecture

We use ubiquitous Internet of Things technology to build a sensory measurement and control network through perception of the outside world [3]. Establish an auxiliary control and monitoring system based on the sensory measurement and control network to realize the integration of image monitoring, security guards, fire alarm, fire protection, heating and ventilation and other functions, and realize the intelligent monitoring, intelligent judgment, intelligent management, intelligent verification and other functions of the auxiliary production system. The auxiliary control and monitoring system is divided into 3 layers: the first layer is the remote centralized control station management host, the second layer is the station control host, and the third layer is the auxiliary production subsystems of the substation composed of the Internet of Things (the system architecture is shown in Figure 1, The picture is quoted from Prospective Smart Distribution Substation in Bangladesh: Modelling and Analysis).

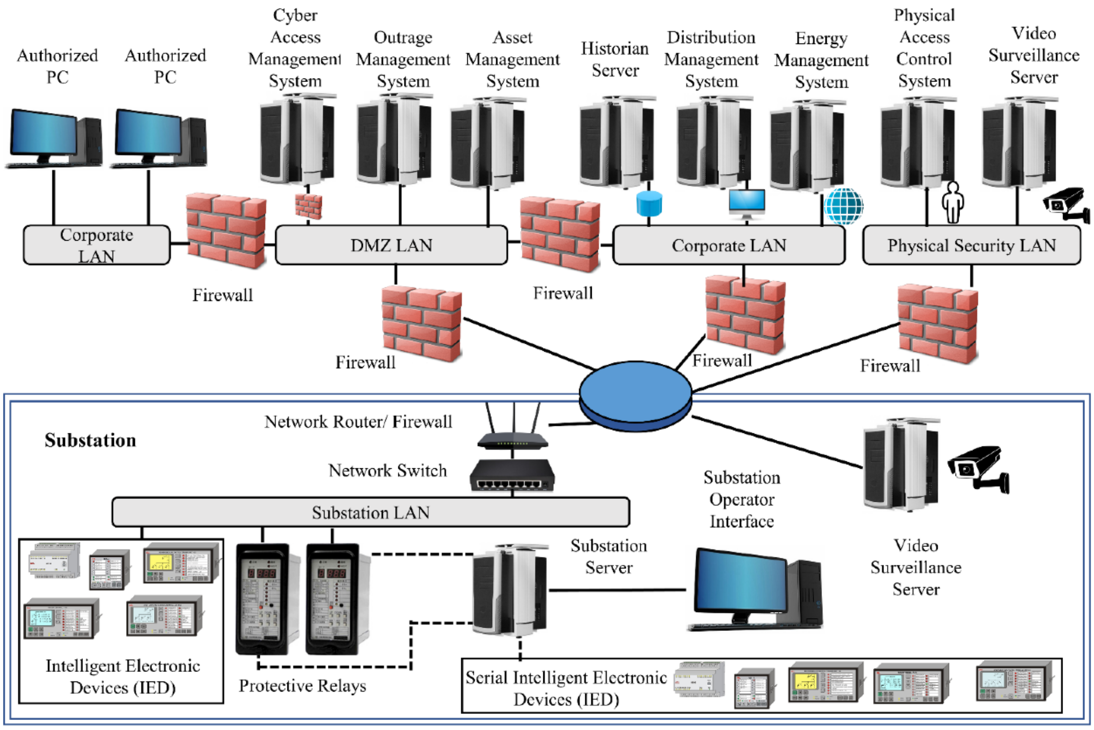

Figure 1. Auxiliary control and monitoring system architecture diagram of smart substation

3. Handling of abnormal state of power system

3.1 Abnormal and missing current information sampling

The thesis is equipped with a dual monitoring device in a 220KV substation. The station domain host can combine the sampling current of the monitoring equipment, carry out information troubleshooting, and eliminate the abnormal current sampling information caused by wiring errors or other faults [4]. The station domain host uses the current sampling data obtained by the measuring equipment to locate the system abnormality. The electrical equipment uploads the sampled data to the SV network through the "three-in-one" line monitoring. The station domain host judges whether the current information is abnormal. The judgment formula is as follows.

$$I_{ct1} - I_{ct2} \geq I_{yuzhi} \tag{1}$$

In the formula, I_{ct1} represents the current value collected by the first set of equipment; I_{ct2} represents the current value collected by the second set of equipment; I_{yuzhi} represents the default value of the system, with a size of 50mA. After establishing the inequality of the above formula (1), the station domain master can determine the sampling abnormality of one of the two sets of line equipment by using the relevant information between the sampling currents. In a 110KV voltage substation, usually only one set of monitoring equipment is needed, and the station domain host cannot determine the sampling data of the monitoring system [5]. Therefore, it is necessary to obtain sampling data with the help of measurement and control devices to determine whether there is a sampling abnormality in the monitoring system.

It can be seen in Fig. 2 that the GKCL method can still be used to realize the current sampling abnormality monitoring after the bus interval has passed the check of formula (1) of the line interval, and the bus interval is used to obtain the sampling current of the channel.

$$I_1+I_2+I_3+I_4=0 \tag{2}$$

I_1, I_2, I_3, I_4 represent branch L_1, L_2, L_3, L_4 current

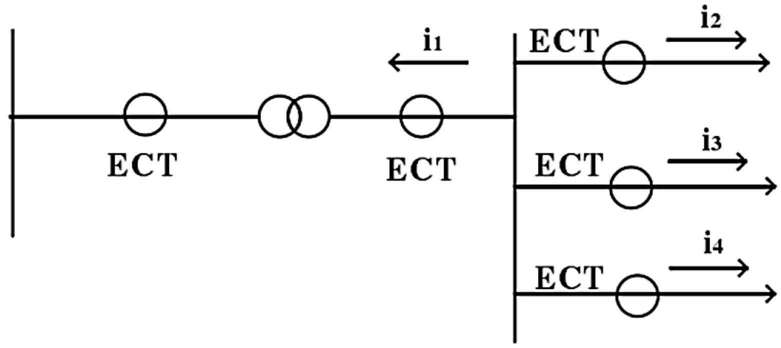

Figure 2. System network structure

Due to the error of CT detection, the current may not fully satisfy the above formula. For this reason, the following formula can be used to verify whether there is an abnormality in the sampling of the bus interval.

$$\left|I_1+I_2+I_3+I_4\right| \leq I_{ctyu} \tag{3}$$

In the formula, I_{ctyu} represents the established value of the system. When the system is in normal operation or maintenance period, the value is usually very small. Different voltage levels and CT devices of different manufacturers have different values [6]. When the above formula is established, it can be judged that the bus interval sampling is in a normal state, otherwise it is abnormal.

3.2 Abnormal and missing voltage information sampling

According to the relevant regulations of system monitoring, the zero-phase small bus unit voltage transformer passes through the control room, and the circuit should ground the small bus at one point]. $3\dot{U}_{z0}$ represents the three-phase voltage vector and $3\dot{U}_{k0}$ represents the external open delta voltage

If the voltage drop on the voltage loop is negligible, $3\dot{U}_{z0}$ is equal to $3\dot{U}_{k0}$. Once the voltage loop fails, the two are not equal. The station domain host detects the difference between the two voltage phasors in real time. Once the difference exceeds the predetermined value, the station domain host sends an alarm for abnormal voltage loop.

$$\left|3\dot{U}_{z0}-3\dot{U}_{k0}\right|>U_e \tag{4}$$

In the formula, U_e represents the predetermined value of the system, which can be 3V. The normal operation of the power grid is stable, and the voltage of each outlet from the same bus of the system remains the same. Once a certain voltage has lost information, it can be judged whether the voltage sample has an abnormal state associated with other voltages. After the abnormality is eliminated, the sampled voltage value is compensated according to the correlation [7]. The collected voltage values of all the spacer devices on the same bus are compared to determine whether the voltage collection loop is abnormal. If the difference between the measured voltage obtained by a certain monitoring system and the voltage of other devices is greater than the predetermined value of the system, the voltage acquisition channel is abnormal.

3.3 On-line monitoring structure of self-check factor status

Microcomputer methods generally use various self-test methods, such as coding methods, comparison methods, and verification methods, limited by the processing power of the computer and the limited data storage space of the CPU, and the microcomputer self-test function has been restricted and cannot be obtained. Further improvements and enhancements. The domain name host of this station obtains the microcomputer self-check, realizes the online monitoring of the status, so as to be able to fully monitor the system. As shown in Table 1 below.

Table 1. Device self-check information table

Monitoring object and content	Upload (T/F)	Remark
Software and hardware version information	T	
Check code	T	
Settings & area code	T	
Internal temperature of equipment	T	Add
RAM operation check	T	
FLASH erase times	T	
A/D converter self-check data	T	
Switching power supply internal temperature	T	Add
Switching power supply Operating time	T	Add
LCD lighting time	T	Add
The control circuit is disconnected	T	
Power failure alarm	Upload empty contacts	
Channel monitoring	T	
Communication port status monitoring	T	

In order to consider the failures caused by the loss of Switch China, the temperature of the switching power supply and the working time of the switching power supply are uploaded, and the service life of the equipment can be estimated by detecting the relationship between the temperature curve and the time and combining the data recorded in the past. Considering the high possibility of liquid crystal display failure in existing devices, the power time of the liquid crystal screen will be uploaded to find out the relationship between its failure and the operating time, so as to infer its service life.

4. Multi-interval system information online monitoring layer

Figure 3 below shows the system configuration diagram of the host domain that receives the multi-interval monitoring information of the entire network (the picture is quoted from Research on Time-Dependent Component Importance Measures Considering State Duration and Common Cause Failure). Based on the distance monitoring as the starting information, the online monitoring program of the multi-interval system is started.

In the station domain master, through the substation's full station information, a matrix A is established to represent the disconnection and adjacency relationship of each circuit breaker. The diagonal element represents the closing and opening conditions of the circuit breaker, instead of the diagonal element representing two the adjacent state relationship between circuit breakers.

$A_{ii}=\begin{cases}1\\0\end{cases}$, the value is 1, the circuit breaker is closed; the value is 0, the circuit breaker is open. $A_{ij}=\begin{cases}1\\0\end{cases}$, the value is 1, the circuit breaker i and j are directly connected; the value is 0, the circuit breaker i and j are not directly connected. When A_{ii}, A_{jj}, A_{ij} are equal to 1 at the same time, it means that the circuit between circuit breakers i and j is in a connected state. Regarding the distance between each circuit breaker, upload 3 distances to monitor the startup status, and store them and define it as a matrix P. The definitions of its elements are as follows.

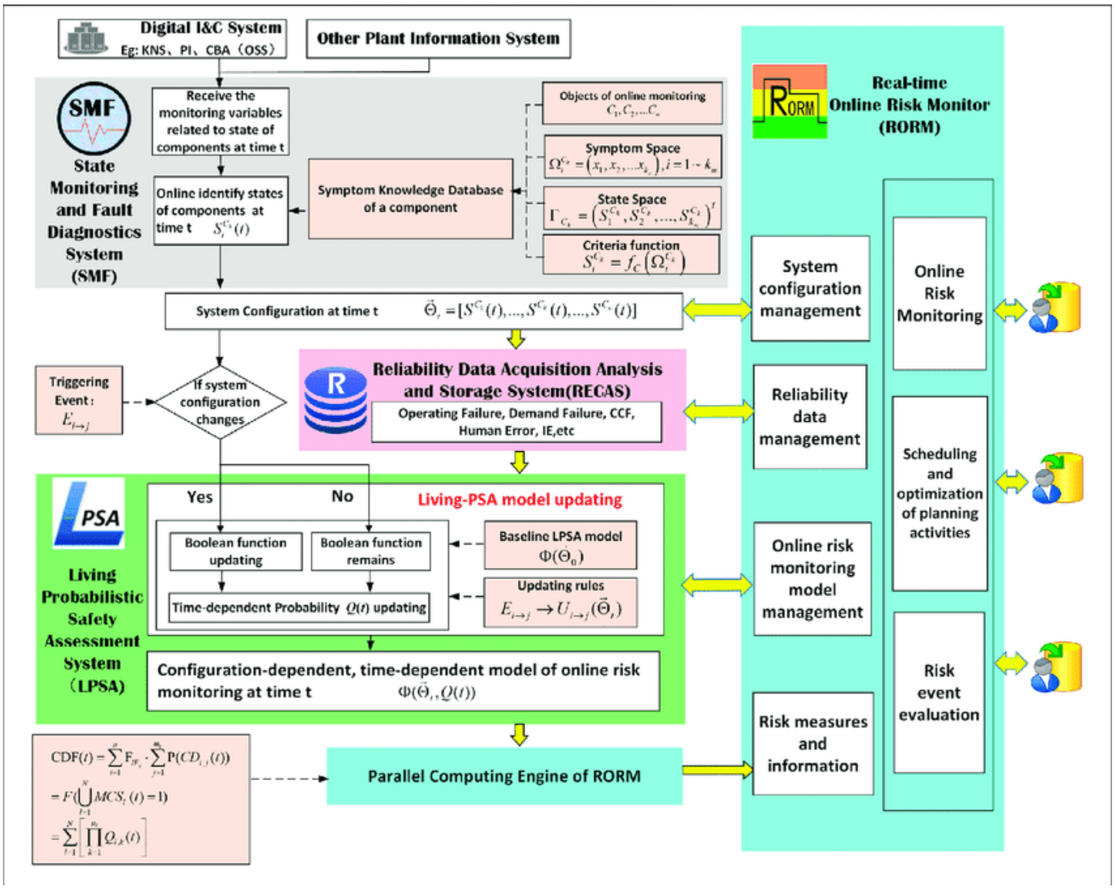

Figure 3. Online monitoring function structure diagram of multi-interval monitoring information

$$P=\left(P_1,P_2,\ldots P_k\ldots P_n\right) \tag{5}$$

$$P_k=\left(B_{kI},B_{kII},B_{kIII}\right)^T \tag{6}$$

Among them, the element B_{kI},B_{kII},B_{kIII} respectively represents the starting state of the first to the third section of the distance monitoring corresponding to the circuit breaker K. With B_{kI} =1, the first stage starts, B_{kI} =0, the first stage does not start; B_{kII} =1, the second stage starts, B_{kII} =0, the second stage does not start; B_{kIII} =1, the third stage starts, B_{kIII} = 0, the third segment does not start.

At the same time, according to the distance formed by the matrix P, the starting information matrix of the first to third segments is monitored, and the expression is as follows:

$$C=\left(B_{1I},B_{2I},\ldots B_{kI},\ldots,B_{nI}\right)=\left(c_1,c_2,\ldots c_k,\ldots,c_n\right) \tag{7}$$

In order to make the expression clearer, C_j is chosen to represent B_{iI}, and c_i represents the distance matched by circuit breaker i to monitor the start information of the first segment.

$$D=\left(B_{1II},B_{2II},\ldots B_{kII},\ldots,B_{nII}\right)=\left(d_1,d_2,\ldots d_k,\ldots,d_n\right) \tag{8}$$

In order to make the expression clearer, d_i is chosen to represent B_{iII}, and d_i represents the distance matched by the circuit breaker i to monitor the start information of the second stage.

$$E=\left(B_{1III},B_{2III},\ldots B_{kIII},\ldots,B_{nIII}\right)=\left(e_1,e_2,\ldots e_k,\ldots,e_n\right) \tag{9}$$

In order to make the expression clearer, e_i is chosen to represent B_{iIII}, then e_i represents the distance to match the circuit breaker i to monitor the start information of the third segment. At the same time, based on the start-up information records of the first segment to the third segment of the distance monitoring, a matrix $F_P=\left(F_{ij}\right)_{n\times n}$ is constructed to realize the rapid fault location, and strive to remove the fault in the shortest time and monitor the power system fault information.

5. Conclusion

As an important part of the power system, the stable operation and safety management of the substation have an important impact on the power system and the power grid. According to the suggestions and measures, a four-tier application architecture system for the Internet of Things technology in substations is proposed. The device layer is to solve the heterogeneity problem of the communication interface. As the reprocessing centre of data integration, the data layer is conducive to data sharing and information utilization. Equipment status monitoring can not only improve the reliability of the power supply. Through online monitoring and real-time capture of abnormal signals, the operating status of the power supply equipment can be predicted in advance, and the status can be maintained to avoid failures. It can also reduce costs and avoid losses through failure prediction, and online the data is relatively objective, which can greatly reduce the possibility of losing important reference information due to the window period.

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