Research on Application of Computer Artificial Intelligence Technology in Intelligent Substation Monitoring System

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Abstract. Aiming at the problem of the large number of devices and no backup in the intelligent substation monitoring system with the measurement and control devices configured at intervals, a new system architecture of the intelligent substation monitoring system is proposed. The article adopts the method of intelligent control to realize the accurate triggering of the data signal in the test process. The test system automatically captures and parses MMS messages and generates test reports to achieve the optimization of data processing closed-loop testing. Finally, a distributed improvement was made to the traditional centralized construction scheme of urban indoor substations, and the economic benefit analysis proved the scientific and economy of the new scheme.

Keywords: Computer, artificial intelligence technology, smart substation, substation monitoring system.

1. Introduction

With the continuous improvement of the IEC61850 standard, key technologies such as electronic transformers, merging units, intelligent terminals and process layer networks have achieved remarkable results. However, the intelligent substation monitoring system is still generally constructed according to the three-layer structure of the process layer, bay level, and station control layer, and the process layer network and bay layer network are also independently set up. Although the monitoring system scheme and operation management of this smart substation are relatively mature, there are still disadvantages such as independent subsystems, complicated monitoring and communication networks, a large number of measurement and control devices, a large amount of operation and maintenance, and no backup devices [1].

In this paper, based on the centralized installation of the original auxiliary monitoring system, it is improved to a distributed architecture. Starting from the installation and wiring of video surveillance equipment, environmental testing equipment, and the selection and application of new equipment, comprehensive consideration of actual application effects, and a comparative study of different construction plans from the perspective of economic benefits, improve the performance of the intelligent substation auxiliary monitoring system Work efficiency, saving costs for power grid companies to construct related systems [2].

2. The function and architecture of the monitoring system

The failure of the fault recording device will only affect the recall after the accident. The damage to the entire system is low. Therefore, this article focuses on the reliability assessment research of Zone I. The control of the substation monitoring system is mostly based on single-interval operation, so this article takes the single-interval monitoring system as the research object. At the same time, in order to ensure the reliability of the communication network, the redundant dual-network structure is adopted. The typical monitoring system architecture of the substation is shown in Figure 1. (Picture quoted with Authentication and Integrity in the Smart Grid: An Empirical Study in Substation Automation Systems).

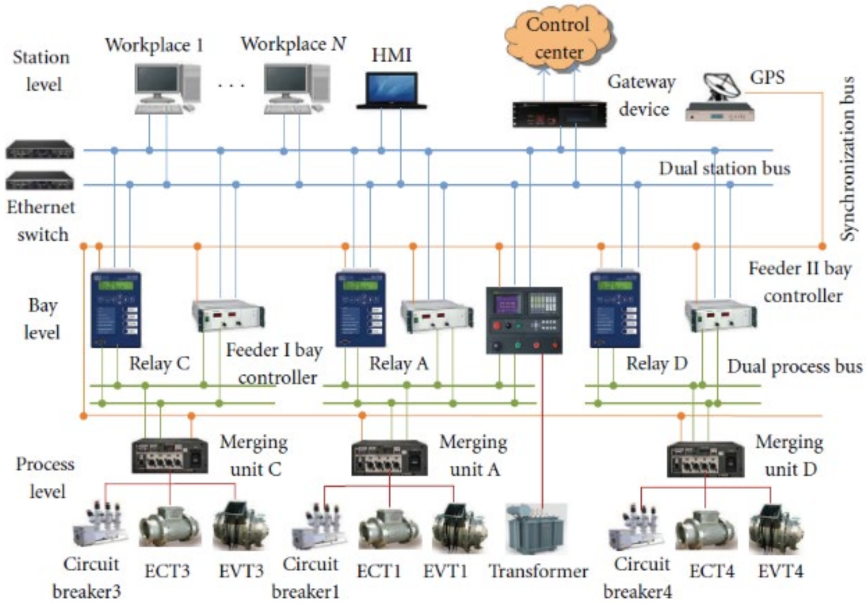

Figure 1. Substation monitoring system architecture

2.1 Optimization of the communication network within the station

The new system architecture studied in this paper integrates and optimizes the intra-station communication network of the smart substation from the overall perspective of the substation [3]. The goal of further optimizing the communication network within the station in the new system architecture is to achieve a three-layer device and one network, that is, to merge the station control layer network with the process layer network, and the whole station forms a public network [4]. This structure can achieve the most simplification of the network, but the impact of real-time response to various applications needs further study, and there are still certain difficulties in practical application.

2.2 Integration and improvement of station control layer functions

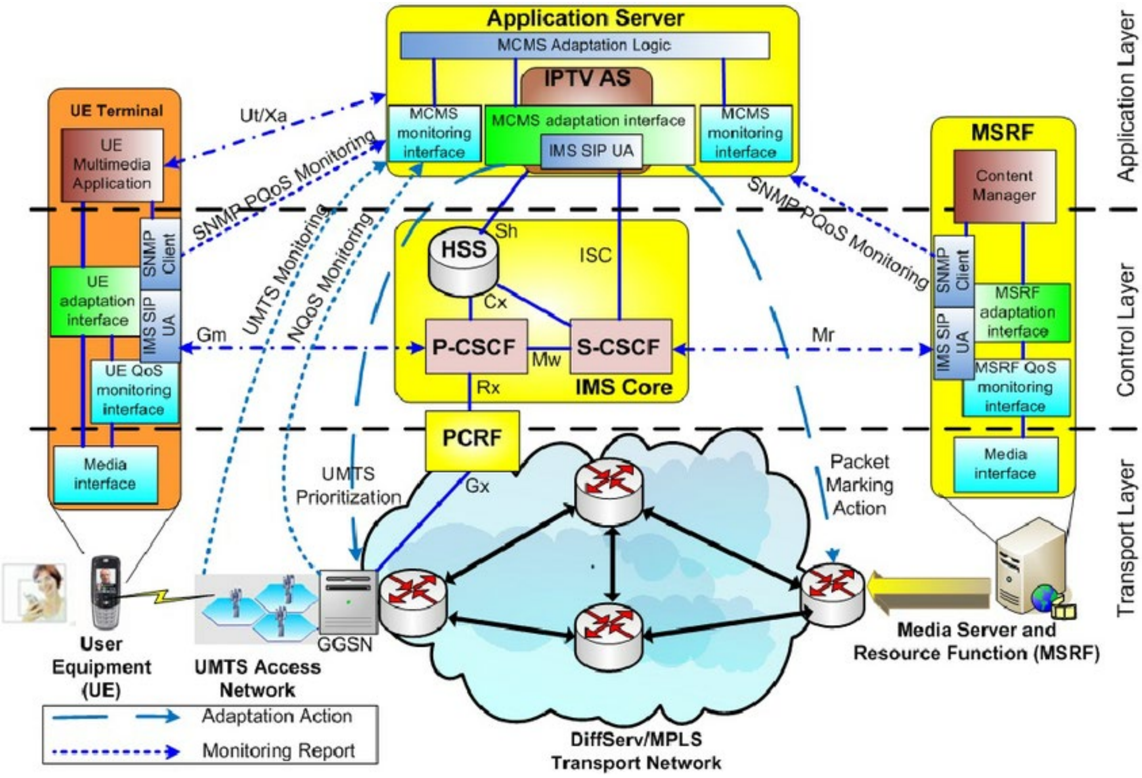

Figure 2. Functional service of the station control layer

The station control layer application function interface agent is deployed on the integrated monitoring software platform of the intelligent substation, and is connected with the service application function interface [5]. The service-oriented interface communicates with the upper-layer service agent module, service management module, and message management module using a common service protocol to realize service registration, cancellation, positioning, invocation, and status push functions. The specific implementation scheme is shown in Figure 2 (the picture is quoted from the Adapted IPTV service within novel IMS architecture.).

3. Monitoring system functional reliability model

3.1 Message reliability

This article describes the reliability of the message starting from the delay feature [6]. This paper compares the communication link with the road, and the message transmitted on the link with the driving vehicle, and describes the ability of the message to reach the specified place at the specified time, using the method of evaluating the reliability of the travel time of the road section for reference, using formula (1) Measure the reliability of the message P_{i-inf}.

$$P_{i-inf} = P\left(t \le T_{i-Delay}\right) = \Phi\left(\frac{T_{i-Delay} - T_{i-ave}}{\sigma_{i-t}}\right) \tag{1}$$

In the formula: $T_{i-Delay}$ represents the delay threshold of the i message under QoS; $P\left(t \le T_{i-Delay}\right)$ is the probability that the transmission delay of the message is not greater than the delay threshold; $\Phi(\bullet)$ is the standard normal distribution; T_{i-ave} is the average delay of the i message; The larger the two values, the lower the reliability level of the message, which is to quantify the reliability of the message.

3.2 Control function model

When it is necessary to perform related control operations on the equipment, such as changing a certain section of the line from the running state to the maintenance state, the dispatcher or the station operator can call the operation ticket through the monitoring platform to achieve "one-button" operation [7]. The functional reliability block diagram under the three operation modes is shown in Figure 3 (picture quoted from Distributed Dynamic State Estimation and Power Quality Monitoring).

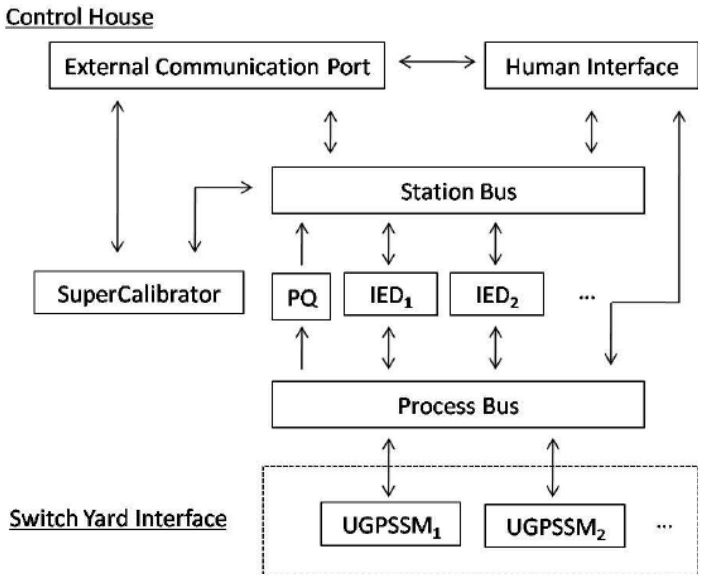

Figure 3. Block diagram of control function reliability

4. System software and hardware design

4.1 System hardware composition

In order to maximize the simulation of the on-site operating environment, the test system fully considers the structure, environment, working conditions and other factors of the on-site operation of the intelligent substation monitoring system. The device adopts the medium and high voltage independent measurement and control devices commonly used in intelligent substations, and the low-voltage line protection measurement and control device, etc., communication the protocol is based on the IEC61850 protocol. The network adopts dual Ethernet, Gigabit/100M adaptive, access to the network message analysis device, and the measurement and control input drive voltage is DC 220V, which has high versatility and easy scalability [8]. The hardware structure is shown in Figure 4 (picture quoted from Digital Electrical Substation Communications Based on Deterministic Time-Sensitive Networking Over Ethernet).

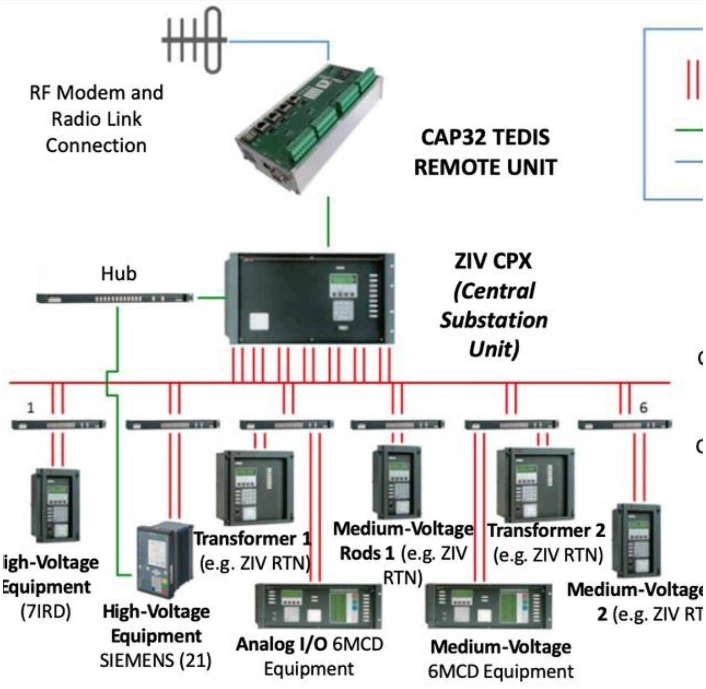

Figure 4. Hardware structure diagram of the test system

4.2 Software structure design

After analysis, the design of the automatic test system needs to complete the following functions according to the process: automatically generate the configuration file of the data information that needs to be counted in the test process according to the actual configuration information of the monitoring system; complete the automatic triggering of the data signal according to the test requirements; automatically trigger the data signal at the same time Complete the capture and analysis of MMS messages sent by all measurement and control devices; automatically query the historical alarm information of the monitoring system and compare it with the MMS message analysis and statistical results; automatically form a test report according to the test results.

5. Application status of pilot projects

The new monitoring system architecture and the new devices and equipment at the station control layer and bay layer proposed in this article have passed the factory acceptance and commissioned and put into trial operation. Due to the adoption of a new system architecture, the monitoring system is fully configured according to the final scale, equipped with monitoring host screens, cluster measurement and control screens, measurement and control operation and maintenance screens, and telecontrol communication screens [9]. The cluster measurement and control screen are equipped with 4 cluster measurement and control devices, and the physical equipment reserves the capacity of the final scale. There is no need to add physical equipment when it is to be modified or expanded, only the logical configuration needs to be modified. After comparison, the use of cluster measurement and control devices to complete the measurement and control function of the intelligent substation bay level instead of the physical single bay measurement and control device reduces the number of physical equipment at the bay level of the monitoring system to about 70% of that of the traditional smart substation, and the number of screen cabinets is also reduced accordingly.

In addition, under the new intelligent substation monitoring architecture, due to the adoption of cluster measurement and control devices, it brings great convenience to the reconstruction and expansion of substations. When the interval is increased, such as modification and expansion, it is only necessary to upgrade the SCD file of the bay-level cluster measurement and control device to complete all the interval synchronization and simultaneous upgrades involved in the upgrade. When any physical device fails, the hot standby measurement and control function can be guaranteed to be put into operation immediately. The control layer and the dispatch centre seem to be seamlessly switched. In terms of the operation and maintenance of the monitoring system, due to the panoramic visualization and the unified operation and management of the fixed value and soft pressure plate at the maintenance terminal, compared with the measurement and control device configured at intervals, the probability of mis operation is greatly reduced.

6. Conclusion

With the integrated operation of regulation and control, the amount of information connected to the regulation master station has increased sharply, increasing the workload of regulation personnel and substation inspection personnel. Based on the existing technology system, this paper follows the relevant national standards, industry standards and the State Grid Corporation corporate standards, and proposes a scheme for the intelligent substation monitoring information to be connected to the control master station. Designed the main substation information interactive automatic monitoring system architecture, and analysed the monitoring information acceptance of the application scenarios of the newly built substation and the reconstruction and expansion substation. Finally, combined with the actual engineering application, the application effect is introduced, the existing problems are analysed, the solutions are given to the existing problems, and the automatic monitoring practical interoperability verification test is carried out.

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