Research of Network Communication Key Technology Based On Multi-core Multi-thread Digital Substation

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Abstract—Power system has higher and higher requirement on equipment miniaturization, intelligence and reliability with growing demand for high-performance computing requirements. Conventional substation automation system has many deficiencies in the application, which cannot meet power grid development and electricity market needs. Meanwhile, since communication software client can be connected with server, real-time binary data can be received, and data tabular form can be analyzed. Multi-core processor is widely popularized in high-performance computing. Balance between computing and communications should be maintained in order to ensure efficiency of high-performance computer system, widespread use of multi-core has higher requirement on system efficiency. Collective communication is regarded as an important part in multi-core communication system, research of efficient collective communication under multi-core environment has very important significance. Therefore, multi-threaded realization process based on TCP/IP protocol communication under client/server mode is mainly discussed in the paper, timing diagrams and activity diagrams are adopted for concrete description. The author discusses how to solve client crash problem, asynchronous data between client and server, and few data, influence of competition is lowered, collective communication performance and scalability under multi-core environment is improved, and it is proved that the system can be operated well according to test.

Keywords-component;Multi-core;Multi-thread;TCP; communication; Digital substation .

I. INTRODUCTION

Communication software is an important part of monitoring system in all fields, which integrates data acquisition, communication and display functions, which belongs to a key link to realize intelligent traffic. Timeliness, accuracy and efficiency of communication software directly affect performance of monitoring system. Multi-thread technology can be adopted order to improve the efficiency of communications software. Many tasks should be implemented simultaneously in the same procedure; the whole task can be divided into several threads, which can be implemented by the operation system at the same time, thereby improving implementation efficiency of program. Intelligent switches, photoelectric transformer and primary operation equipment online testing and other technology become mature gradually; computer high-speed network is developed and applied in real-time system, thereby all-digital substation automation systems have emerged[1-3]. Visible communication software has higher requirement on monitoring system under hardware conditions, however collective communication algorithm in traditional SMP cluster only can optimize aiming at features of communication network and sharing memory communication. Structural characteristics of multi-core are not considered. Direct use of these algorithms will lead to problems in collective communication performance and scalability. Since collective performance is critical for parallel applications, influence of multi-core environment on collective communication should be researched; the corresponding collective communication algorithms should be optimized aiming at characteristics of multi-core environment, which has become a hot research topic[4-7].

In the paper, influence of multi-core environment on collective communications is analyzed in details. Two-conflict effect of multi-core on communication performance is discovered. Optimization methods of hierarchical algorithm, limiting concurrency, NUMA conception and Cache friendliness are proposed aiming at multi-core features. The optimization methods can be used for improving sharing-Cache utilization rate and lowering influence from memory competition, thereby improving the performance of collective communications[8]. Program of realizing communication software with TCP/IP protocol and multi-thread technology is proposed on the basis. Meanwhile, object-oriented approach is adopted for system analysis and design. Solution of system key technical problems and software operation effect are provided.

II. COLLECTIVE COMMUNICATION

MPI collective communication composes a communicator) as a group process for communication operations between processes. It is used for data distribution and synchronous operation. Since collective communication uses more and more process quantity with expansion of parallel program scale, more

synchronization and data interaction operation are demanded among programs. If collective communication algorithm does not have better performance and scalability, overall communication performance can be lowered under large-scale situation, thereby lowering efficiency of parallel applications. Therefore, study of collective communication performance and scalability has been a very important research direction [9].

Traditional collective communication realization belongs to MPI-based point-to-point message transfer interface realization. Semantics of collective communications are finally completed through message transfer between processes. Collective communication optimization algorithm based on sharing memory is generally adopted in order to improve performance of collective communication under SMP cluster environment. Sharing memory is utilized for data exchange operation in the node. Data transfer is achieved by high performance network among nodes. Sharing memory is adopted for communication by the mode, meanwhile, message on communication network is reduced, and performance is improved compared with high communication performance by communication network.

III. GENERAL DESIGN OF COMMUNICATION SOFTWARE

VS 2005 is adopted as development tool for communication software on server and client. SQL Server database is adopted as server database. Embedded database SQLITE is adopted on the client[10]. Critical links of network communication are realized by TCP/IP protocol, including how to establish communication with server on client, how to maintain connected client list by server, and how to rapidly restore system operation under the condition of communication failure, server re-start and other condition. Solutions of the system by the system are described by the following activity diagram and sequence diagram. Connection process activity program between server and client is shown on the left part of Fig . 1. Client application program operation process sequence diagram is shown in the right of Fig .1. Client application program can start connection thread, which is responsible for establishing connection with server and reconnecting with it under the condition of network failure or server restart, etc. Reading data thread is started after successful connection, thereby directly reading data in network card buffer area, which is written into a variable-length list, thereby avoiding data loss. Data processing process is started in initialization updating module of the view, data can be read from message list, which is analyzed one by one, data in the database can be inserted or updated, which can be displayed on the interface, and processed data should be completely deleted.

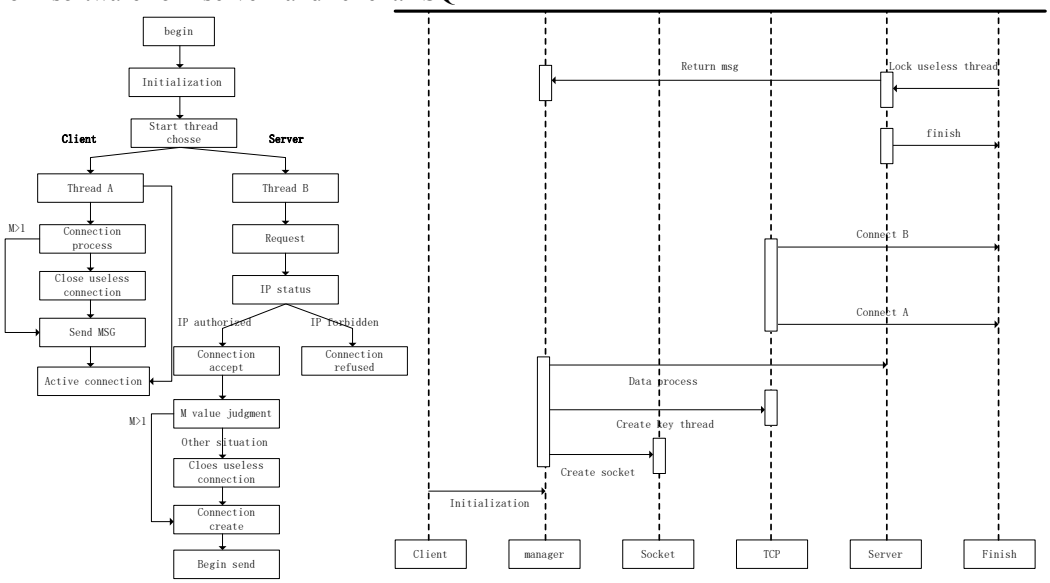

Figure 1. Interactive Mechanism and Squence

IV. REQUIREMENT OF COMMUNICATION NETWORK FUNCTION

Communication network has fundamental task of solving real-time information exchange in integrated automation system and among other systems. Network is indispensable function vector, it is critical for communication system to construct a reliable, real-time and efficient network system. Communication network is a link to connect various intelligent electronic devices (IED) in the station, therefore it can support various communication interfaces, and meet communication network standardization. With unmanned substation development and increasing automation amount, communication network must be provided with sufficient space and speed for storing and transmitting event, battery, operation, failure, recorded wave and other data. Unmanned substation requires that the communication network should be provided with voltage reactive automatic adjustment function, system timing function, etc. in order to improve the quality of voltage operation. In addition, self-diagnosis, self-

healing, distant diagnosis and online state detection belong to several function requirement proposed aiming at operation maintenance.

V. REQUIREMENT OF COMMUNICATION NETWORK PERFORMANCE

Performance requirements of communications network are mainly reflected in the following aspects: (1) Reliability: reliability of intra-station communication network is critical due to electricity production continuity and importance, damage of individual devices should be avoided, thereby leading to interruption o communication in the station, monitoring more and more depends on communication network with application of digital and image information multimedia technology, thereby a reliable communication network is the primary requirement. (2) Openness: intra-station communication network is regarded as a subsystem of scheduling automation. It not only should ensure IED equipment interconnection in the station and facilitate scalability, but also should be subject to overall design of power dispatching automation. Hardware interface should meet international standards; international standard communication protocols should be selected, thereby facilitating user system integration. (3) Real-time performance: since real-time transmission is required by monitoring data, protecting signal, remotely commanding, etc. Data in the station is low during normal operation, massive data should be transmitted during failure, it is required that the information can be rapidly transmitted by communication network in the station.

VI. DATA SYNCHRONIZATION

If client data is not synchronized with server data during commissioning and operation process, namely data is updated faster on the client, data in the database can be displayed for several seconds at the beginning, the updated received data is displaced then, the client data is updated slower, many data belong to historical data, data quantity on the client is different from that on the server by dozens or more. Normal operating effect: data can be synchronously updated within several minutes after software starting on the server and client, and the quantity on both ends should be equivalent, the operation should made effort in the following aspects in order to solve the problem. (1) The operator should check whether the data transmitted from the server to the client is lost or not according to the following methods: after the server sends data, the transmitted data should be recorded into a text file, after the client receive the data, the data is also recorded in a text document, size and contents in the two document should be compared, the result is completely the same, and it is proved that the data are not lost in the transmission process. (2) The operator should check whether the data transmitted by the server is consistent with the data recorded in the server database or not according to the following methods: data in the server database and the data actually sent by the server should be recorded in two different text document, thereby it is proved that data is not missed by the server.

Communication standard and bus mode design

Digital substation communication system is based on common standards in the field. Communication networks and systems of substation are established in accordance with the standard, which is effective approach for constructing digital substation. Release of the standard provides solid foundation for establishing digital substation. Substation functions should be divided into control layer, spacer layer and process layer according to the standard. Separated communication system of controlling and measuring data will be merged together, and the standard is considered based on process bus, and the application mode is shown in right of Fig .2. Complexity of interval wiring is reduced by integration of control and measuring data, but spacer layer IED equipment requires that two Ethernet devices are respectively connected with process bus and substation bus. Since instantaneous value of digitized electrical measurement system from integration unit is transmitted, the communication mode is faster than the first communication mode, 100 Mbit/s Ethernet should be used according to the reason, and trip command of protective devices can be transmitted to the circuit breaker through process bus.

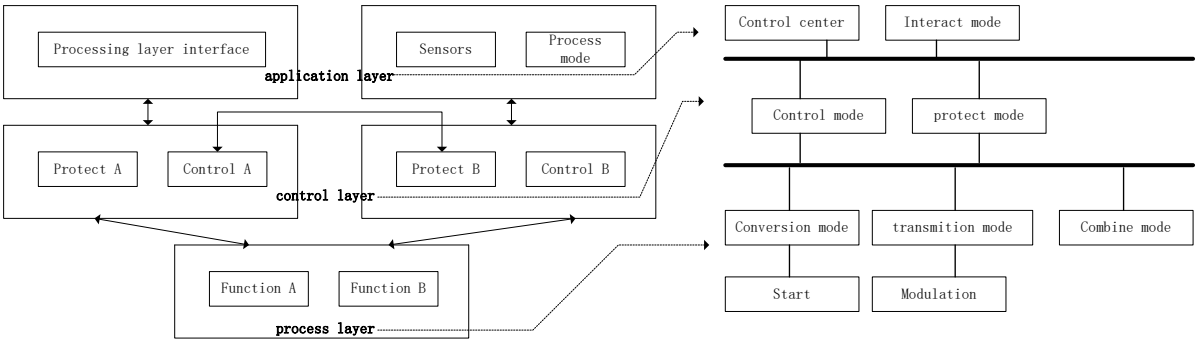

Figure 2. Communication System Interface and Communication Mode

VII. TEST OF INFLUENCE OF MULTI-CORE MULTI-THREAD ON COMMUNICATION PERFORMANCE

Since shared memory leads to performance influence of two conflicts on communication system, integration communications belong to a process that multiple processes are involved in communication, competition can be produced under multi-core environment more easily, meanwhile, since existing operation system can be used on multi-core SMP system, sharing memory is supported by the same mode in SMP system, therefore integration communication optimization algorithm based

on sharing memory on SMP machine group can be smoothly transplanted into multi-core SMP systems. However, since on-chip communication and intra-chip communication under multi-core environment are not distinguished by existing integration communication optimization algorithm, performance bottlenecks of collective communication may be caused, it is necessary to study the influence of multi-core environment on collective communication, which has important guiding significance for optimizing the collective communication.

The test results are shown in Fig .2. It can be seen from the results that more processes are concentrated within the chip in case of small message since multi-core internal data path is utilized; high-speed on-chip communication can be used. Therefore, 1 × 4 delay in case of small message is lower than 4 × 1. Serious performance decline can be caused due to multi-core shared Cache and memory competition, thereby finally leading to performance decline of collective communication, processes are distributed in different chips, independent Cache and memory bandwidth can be utilized, therefore the performance is better than concentration of many processes on one chip, therefore, delay of 8MB 1 × 4 in the figure is much higher than that under 4 × 1. In summary, rapid on-chip communication should be used as much as possible aiming at small message in order to achieve efficient collective communication under multi-core environment. Performance decrease due to Cache and memory competition should be lowered as much as possible aiming at large message. Fig .3 shows that the communication performance after multi-core multi-thread design is significantly improved.

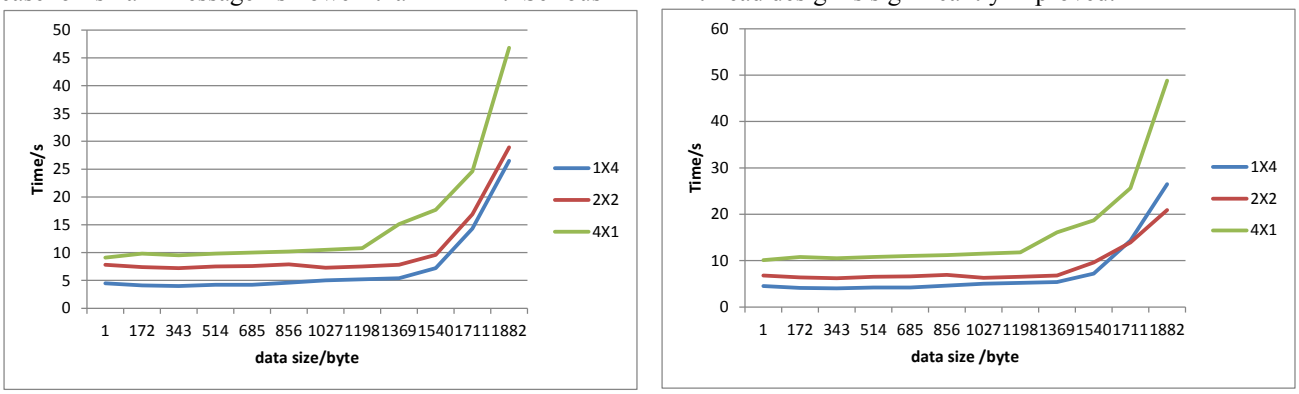

Figure 3. Performance Test

VIII. CONCLUSION

In the paper, multi-core technology development and advantages are analyzed firstly; multi- thread technology is integrated into substation communication. Software overall design architecture of the whole communication process is proposed, client crash problem and data synchronization problem are analyzed in detailed according to concrete network function demand and performance demand of digital communication, a substation standard communication mode is designed and realized, cohesion between classes can be enhanced through design mode concept, coupling performance is weakened, system reusability and scalability are improved, and finally influence of multi-core multi-thread technology on communication performance is analyzed in details through actual test. The following conclusions can be obtained through actual test: improved network communication mechanism can significantly improve reliability and efficiency of data transmission, which has certain reference value on automation system application and most network communication field. The paper has the following shortcomings: influence of the multi-core multi-thread on communication process performance is analyzed, but various indicators to judge advantages and disadvantages of communication performance are not clearly proposed, therefore the data obtained from test can be accurate, we should consider to propose a set of perfect communication performance judgment mechanism in the future, criterion should be proposed for further improving communication mechanism.

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