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Implementation of Fault Information Standardized Description and Network Transmission Based on LabVIEW

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This paper introduced the detailed planning and implementation method based on LabVIEW (Laboratory Virtual Instrument Engineering Workbench) for the sake of satisfying the need of cross platform, fault information standard description and network transmission in the network fault diagnosis. Relevant researches were based on the capacities of LabVIEW cross platform and of XML (Extensive Markup Language) standard description. The XML description method of typical fault information was given. Network transmission of fault information was realized by means of the client/server mode in a LAN through TCP protocol. The technique of VI (Virtual Instrument) Scripting was adopted to create and run software module dynamically in the server to transmit and process different fault information in the future. In the client, the producer and consumer mode was used to enhance the security to avoid data loss. A constructed simulation system verified the feasibility of planning. The research production is useful for implementing practical networked fault diagnosis system in the future.

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1. Introduction

Modern weapon and equipment's technical level have been largely improved. The fault reasons of function unit are complex. Networked fault diagnosis system transfers and processes fault information, combines spot personnel with remote experts, and makes use of different region knowledge processing system in order to improve accuracy and efficiency of fault diagnosis.

The development of networked fault diagnosis system includes a lot of key technologies: cross platform, fault information standard description and network transmission, etc. Diagnosis methods were discussed in different research fields [1]~[4]. Developed system didn't support the cross platform and the fault information standard description. On the basis of contrast research, LabVIEW can support the cross platform and the rapid development. XML can also support cross platform and be independent of hardware and software. Applying LabVIEW and XML to the development of networked fault diagnosis system can make system very flexible and long-life. The basic method of creating and accessing XML file in LabVIEW was given [5]. But, it lacked flexibility as to different information. The basic method of remote data transmission in LabVIEW was discussed [6]; however, it can't avoid the data loss. These problems have to be solved.

General planning is given in the second part of this paper. The design process of planning is discussed in detail. The detailed design of server and client program is given in the third part. In this part, the typical fault information FMEA (Failure Mode Effect Analysis) is described by XML. To make use of VI Scripting technology can realize and run the program dynamically. Data transmission is realized by TCP protocol. Producer and consumer mode is used to enhance the security to avoid the data loss. A demo simulation system is constructed. The simulation test result is discussed. In the last part, the summary of this paper is given.

2.General Planning

To choose and optimize relevant technologies to realize feasible planning is discussed in cross platform, fault information standard description, and network transmission.

2.1 Choose Software Development Platform

Cross platform is the programming language, application software or hardware device, which can work in multiple operating systems. It can improve software reuse.

JAVA is a programming language of Sun Corporation. JAVA utilizes virtual machine technique to fulfill cross platform, but the development efficiency is not high.

LabVIEW can support the cross platform perfectly, whose code needn't changing to run three common operating systems. In addition, LabVIEW can realize rapid development. LabVIEW programmer spent 1/5 time of C programmer to develop the same large application according to a large number of statistics; therefore, LabVIEW is chosen to develop the networked demo simulation system.

2.2 Choose Information Description Language and Its Implementation Way in LabVIEW

XML is a markup language based on text, which applies understandable tags and structured format to save data. XML can support cross platform, which has become a data exchange standard. XML is expandable. By contrast, HTML only has a fixed tag set. Therefore, XML is chosen to describe fault information.

There are two approaches of realizing the information's XML description in LabVIEW. One is LabVIEW pattern. The other is XML parser. LabVIEW pattern transforms data according to predefined XML Schema. Simple several functions can fulfill basic XML operations. XML parser is Xerces 2.7, depending on DOM (Document object model). XML parser provides lots of functions to process XML data flexibly, but it doesn't support other languages except English.; therefore, LabVIEW pattern is chosen to realize the fault information's XML description. At the same time, some technical measures are adapted to improve flexibility of LabVIEW pattern. Flatted to XML function in LabVIEW pattern gives the XML transformation result of string as follows:

```
<String>
<Name>Function</Name>
<Val>Propellant Storage</Val>
</String>
```

String tag indicates that input data type is string. Name tag shows that the name of input is Function. Val tag indicates that the content of Function is Propellant Storage.

2.3Usual Form of Fault Information and Its Dynamic Description Method in LabVIEW

The styles and forms of fault information are various. The typical fault information FMEA is described and transmitted in order for demo validation of general planning. FMEA gives a table of fault information, including product name, function, failure mode, reason, influence and detection method, etc. The designed program can process usual table information in order to make the program expandable.

Usual table information's field name and content aren't fixed. Dynamic programming approach is used to realize usual table information's XML description in LabVIEW. VI Scripting technology is applied to create VI, controls, functions and run program through programming control. VI Scripting depends on local LabVIEW VI server's service. The client is the local LabVIEW program.

2.4Choose Network Communication Protocol and Method of Avoiding Loss of Data in LabVIEW

TCP and UDP are two important network communication protocols. TCP defines that reliable data transfer format and method between two computers. UDP is a simple datagram-orientated protocol, which provides the unreliable transmission service; but the transfer speed of UDP is high. The transmission of fault information needs high reliability. Consequently, TCP is chosen as the communication protocol of demo simulation system. The server describes and sends information. The client receives and processes information.

If the client receives and processes information in the manner of sequence loop, the data won't be received in time and the loss of data will take place because much time is spent on data processing. The producer and consumer mode can improve the security of data transmission, which makes use of several loops to realize different functions of producer and consumer in parallel. The producer and consumer mode adopts the data storage manner of queue. The queue works according to First-In First-Out (FIFO). The loss of data can be avoided.

2.5 Specific Planning

The specific planning of demo simulation system is designed based on above analysis. The simulation system consists of the server and the client. The server realizes the fault information FMEA XML description and sends the description results to the network. The client implements the connection with the server, receives the network data, extracts and displays the fault information. The workflows of the server and client are shown in Figure 1~2. The situation of interactive workflow of the server and the client is shown in Figure 3. The implementation techniques of the simulation system are shown in Figure 4.

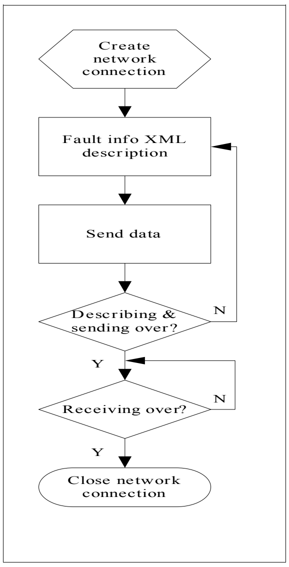


Figure 1: Server Workflow

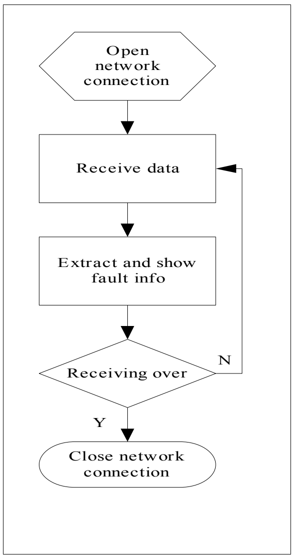


Figure 2: Client Workflow

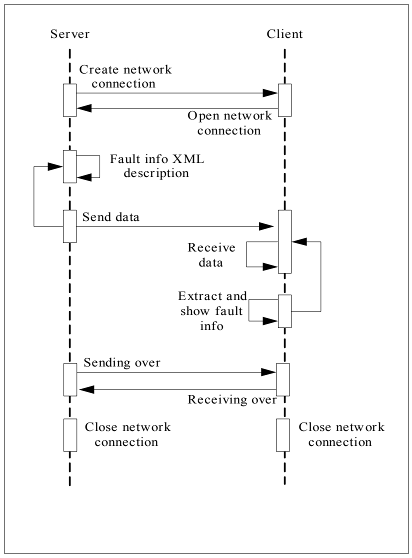


Figure 3: Interactive Workflow

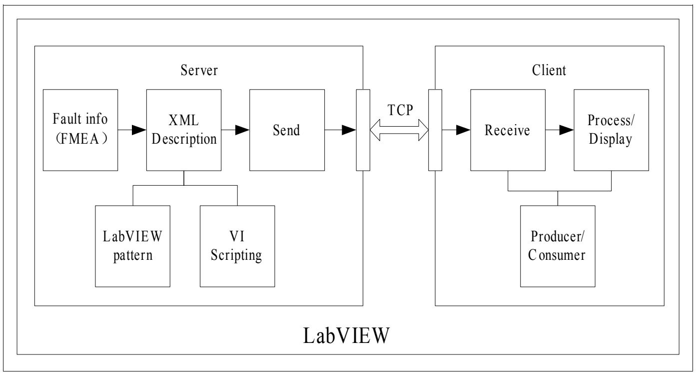


Figure 4: Implementation Technique

3.Realization of Planning

The key technologies in general planning are discussed as follows.

3.1 Server

The panel of the server is shown in Figure 5. FMEA table displays the fault information to be sent. Sending XML textbox shows the description result of a record in the FMEA table. The server takes advantage of XML to describe a record of FMEA and sends the description result to the network, one record at a time.

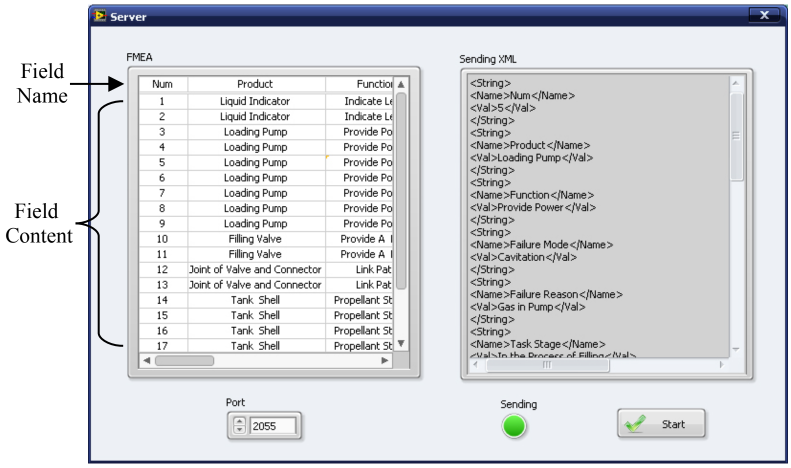


Figure 5: Panel of the Server

The block diagram of the server is shown in Figure 6. The outer part of the diagram is the loop event structure responding to the action of Start button. The inner part of the diagram consists of five modules: 1. create TCP connection, 2. XML description and send data, 3. send Sending Over string, 4. wait for Receiving Over string, 5. close TCP connection.

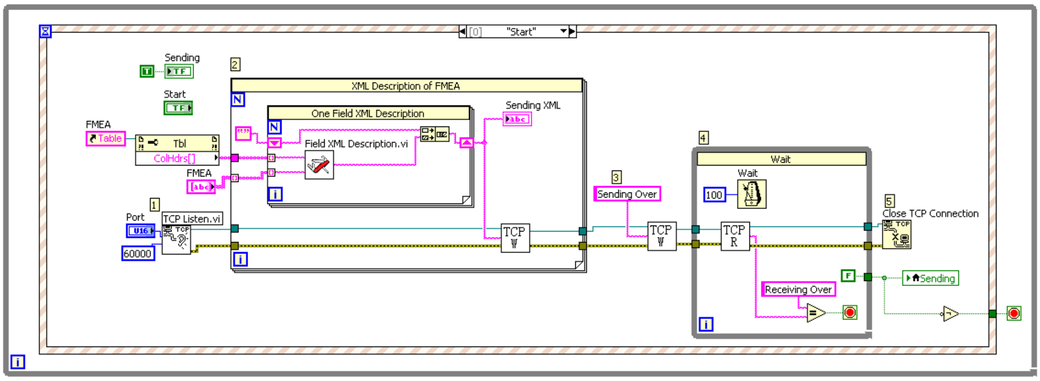
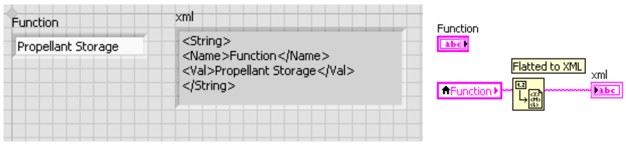


Figure 6: Block Diagram of the Sever

In the first module, a listener is created and the program waits for the TCP connection on port from the client. The waiting time is 1min. In the second module, FMEA table is the data source. FMEA is described with XML one field by one field in one record, one record by one record. After one record is described and sent to network, next record begins to be described. When a field in a record of FMEA is described in LabVIEW, VI Scripting technology is adopted in order to meet the need of description of different fault information, whose field names are not fixed. A new VI need to be created, as shown in Figure 7 in order that the description result of every field is consistent with the format of the example in LabVIEW pattern in Section 2.2. The panel consists of two textboxes. One is for inputting the field name and the field content. The other shows the description result of the field. The block diagram mainly comprises the local variable of input textbox and the Flatted to XML function.



(a) Panel (b) Block Diagram

Figure 7: Create VI through VI Scripting

VI Scripting technology is adopted to design a new VI: Field XML Description in order to create the above VI. The block diagram of Field XML Description is composed of 5 modules: create VI, create input control and its local variable, create function and wire, create output control and wire, run VI and get the result, as shown in Figure 8. It is complicated to design a VI through the VI Scripting. And running the VI expends more time about 80 milliseconds under 2GHz Intel i5 CPU, 2G memory, Windows XP, LabVIEW 2012. But the VI Scripting realizes the automation of designing a VI, and improves the software flexibility to satisfy the different needs. Field XML Description VI makes use of many properties and methods about VI Scripting. These properties and methods are not discussed in detail because of limited length of the paper.

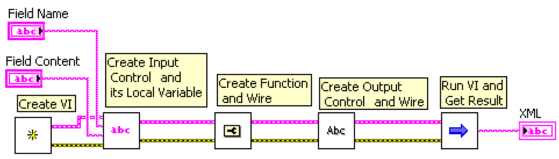


Figure 8: Block Diagram of Field XML Description VI

The modules 2~4 in the server block diagram contain sending network data and reading network data. Two VIs are created for convenience: one is TCP W(Write), the other is TCP R(Read). The two VIs realize the above two functions separately. In the two VIs, the length of string ready to be read or written needs inputting. The reentrant property of the two VIs is the reentrant work of distribution copy in advance to avoid the data competition, because the server and the client are likely to make use of the two VIs at the same time.

After all of FMEA information's XML descriptions are sent, Sending Over string is sent in order to help the client identify the sending end in the third module. In the fourth module, the sever waits for the Receiving Over string from the client, after the client receives all the data. The TCP connection is closed at last.

3.2 Client

The panel of the client is shown in Figure 9. Receiving XML textbox shows the received XML description record. XML File textbox displays the XML file saving the record. FMEA table shows the fault information extracted from the XML description. Because the client makes use of the producer and consumer mode containing a queue, No. of Elements in Queue control shows the number of the elements in the queue. The client receives one XML record of from the network, extracts and displays the fault information, one record at a time.

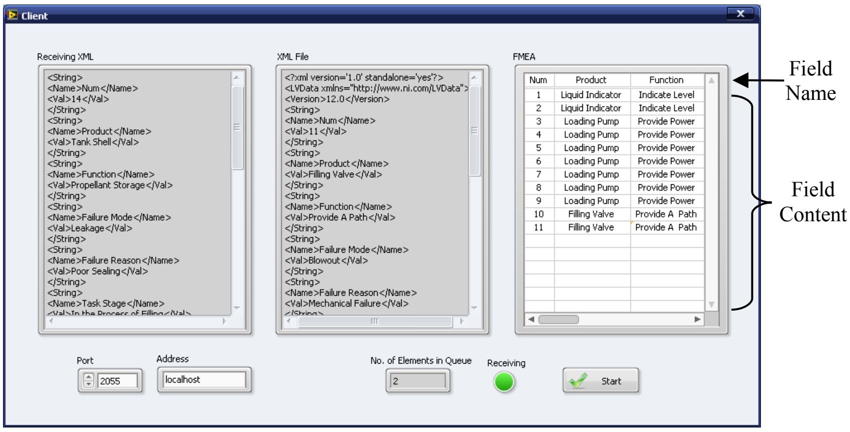


Figure 9: Panel of the Client

The block diagram of the client is shown in Figure 10~11, including the producer loop and the consumer loop. The producer is in charge of receiving the network data and making the data into the queue. The consumer is responsible for fetching the data from the queue and extracting the fault information. The two loops are independent. It doesn't take place in the producer and consumer mode that all the data are incompletely received because of the long time of processing the data, when receiving and processing the data work sequentially and cyclically.

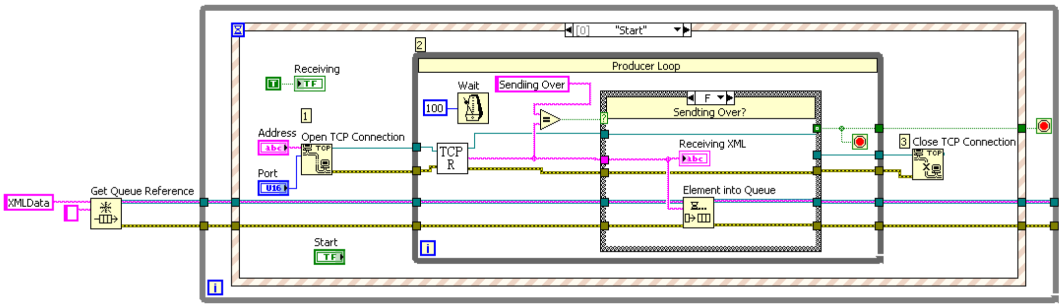


Figure 10: Producer Loop

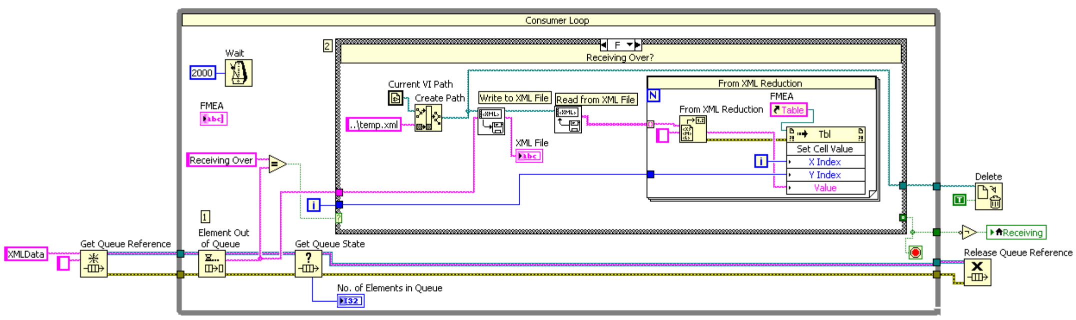


Figure 11: Consumer Loop

3.3 Simulation Result

The 20 records of fault information need transfer in the server. The server and the client program run in the local computer. The port number is 2055. The server runs at first. The client runs afterwards. The server and the client work as are shown in Figure 5 and Figure 9. When the program runs one time, the number of the elements in the queue in the client is shown in Figure 12. Firstly, the number is 0. The received data can be processed in time. After that, the number increases gradually. The maximum of the number is 7 in 18 seconds. At the moment, all the data from the server are completely sent. Afterwards, the elements of the queue are processed one by one. The number of elements decreases gradually. The whole program spends about 32.5 seconds under 2GHz Intel i5 CPU, 2G memory, Windows XP, LabVIEW 2012.

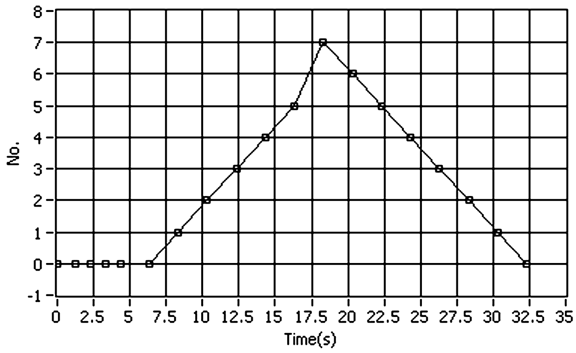


Figure 12: Number of Elements in the Queue

On the basis of the simulation test, the server and the client works normally. The result is identical with expectation. The feasibility of the general planning is verified.

4. Conclusion

In order to satisfy the need of cross platform, fault information standard description, network transmission in networked fault diagnosis, the specific program in LabVIEW is given. The feasibility of the general planning is verified through adopting several technologies. The research production is conducive to implement practical cross platform networked fault diagnosis system further in the future and relevant development of LabVIEW. Next, the description and transmission of complicated fault information will be studied.

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