Research on Real-time Driving Method of Shearer's Remote Monitoring Platform

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Abstract—Shearer works in the abominable condition, remote monitoring for the shearer could reduce fatalness of the mining workers. In order to reappear shearer's working status and control it, the shearer's virtual prototype was built by using virtual reality technology, which makes the mining workers feel the shearer's working condition in the remote distance. Real-time driving problem of the shearer's virtual prototype is required to solve for the sake of realizing action consistency between the virtual prototype in the remote monitoring platform and the real shearer, OPC technology was applied to solve the inconsistent problem of the communication interface between the shearer's virtual reality platform and S7-300 PLC in the shearer, and the data interaction between virtual reality platform and S7-300 PLC was realized by use of C# programming. The experiment result shows that shearer's virtual reality platform is able to acquire the immediate data from S7-300 PLC in the shearer by OPC technology, which assures the reliability of the shearer's remote monitoring system.

Keywords-virtual reality; OLE for Process Control; communication interface; remote monitoring; real-time driving

I. INTRODUCTION

Shearer is one of the key equipments in the fully mechanized coal mining face, and working reliability of the shearer directly influences the economic effectiveness and safety production in the coal mine, remote monitoring and controlling for the shearer is the necessary condition to realize automation in the fully mechanized coal mining face, the necessity of remote monitoring for the shearer was introduces in [1] and [2], reference [3] and [4] researched on implementation method of OPC Client for remote monitoring System. Data access method based on OPC was studied in [5], At present, the remote monitoring systems of the shearer adopt two-dimension graphics, data and curves to display the shearer's working state, and can't reappear the shearer's working state and meet the requirement for the shearer's remote monitoring and controlling. In order to reappear the shearer's working state, virtual reality technology was used to build virtual prototype of the shearer, OLE for Process Control (OPC) technology was applied to solve inconsistent problem of the communication interface between virtual reality platform for the shearer's remote monitoring and its controller S7-300 PLC, and realized real-time data interaction.

II. OPC TECHONOLOGY

OPC technology is a kind of technical standards which is established based on Microsoft's OLE/COM specification, it defines a type of standard data interface and provides data access mechanism in the industry control field.

OPC mainly includes custom standard and OLE automatic standard interfaces. The former is a set of COM Interfaces, which mainly adopts C++ to develop communication program. The latter is a set of OLE Interfaces, which mainly utilizes script language to develop communication program. The automatic standard interface is simpler than custom standard interface in the process of developing client application, but its operation efficiency is low. The automatic standard interface has high operation efficiency, however, its development is difficult. Reference [6] and [7] described the real-time communication by use of OPC technology.

General standard provided by OPC specification realizes data communication between the server and client. It can be used as the data transmission channel between the monitoring host computer and the lower equipment in the control system, so that its connection is simple, convenient and flexible. The architecture of OPC specification is shown in Fig.1.

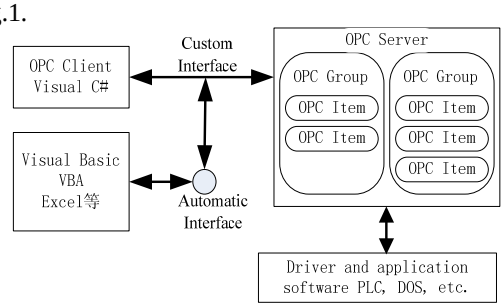

Figure 1. Architechture of OPC specification

III. DATA ACCESS METHOD BETWEEN REMOTE MONITORING PLATFORM AND S7-300 PLC OF THE SHEARER

The traditional monitoring system of the shearer displayed its working parameters by use of two-dimension figures, curves and data, and so on. These methods couldn't meet the needs of automatic production in the coal mine, the shearer's working status was really reappeared by using virtual reality technology, which makes the mining workers estimate the true shearer's working status and operate the

shearer in the remote distance safely. In order to realize action consistency between the virtual prototype in the remote monitoring platform and the real shearer, the data access method between the remote monitoring platform and S7-300 PLC should be carried out.

A. Definition of Communication Content

Virtual reality platform of remote monitoring obtained the shearer's working parameters including rising and drop height of the cutting drum, traction direction and speed, motor temperature, angle of rocker arm, and so on. The virtual prototype of the shearer was driven by these parameters in time. The parameters and its addresses of the data block in S7-300 PLC of the shearer was decided, they would be accessed by OPC method, as shown in Table 1.

TABLE I. MONITORING PARAMETERS OF THE SHEARER'S VIRTUAL REALITY PLATFORM

Variable definition	Variables name
LArmMTemp	Temperature of the left cutting motor
LArmMCurrent	Current of the left cutting motor
LArmDipAngle	Angle of the left rocker arm
LDistSensor	Displacement of the left cylinder
LArmFATemp	Temperature of the first shaft in the left rocker arm
LArmSATemp	Temperature of the second shaft in the left rocker arm
LTowMCurrent	Current of the left traction motor
RArmMTemp	Temperature of the right cutting motor
RArmMCurrent0	Current of the right cutting motor
RArmDipAngle	Angle of the right rocker arm
RDistSensor	Displacement of the right cylinder
RArmFATemp	Temperature of first shaft in the right rocker arm
…	…
RightRotateDown	Right rocker arm dropping
CrushMotorStart	Crusher starting
CrushMotorStop	Crusher stopping
AllStop	All stopping
TowStop	Traction stopping
TowStart	Traction starting

B. Classification of Communication Parameters

A large number of data accessing the OPC server would cause the server blocking at the same time. In order to reduce the communication pressure between OPC client and the OPC server, it is necessary that the communication parameters between the shearer's virtual reality platform and its S7-300 PLC are divided into different groups according to the interaction requirements between the OPC client and the OPC server.

There are three kinds of interaction patterns including synchronous, asynchronous and subscription communication between the OPC server and the OPC client. The OPC client requests the OPC server in the mode of synchronous communication, the OPC client gets answer until the OPC server completes the corresponding response. In synchronous communication, if there are a lot of data operations between the OPC client and the OPC server, the blocking phenomenon will occur inevitably, therefore, synchronous communication is suitable for the fewer OPC client and a few data. The OPC client sends a request to the OPC server in the pattern of asynchronous communication, OPC client program don't wait for the response of the OPC server, and it can perform other operations. The OPC server will inform the OPC client program after it completes the other work. Asynchronous communication is more efficient than synchronous communication, after OPC client send a request, it no longer sends requests, when the data in the group of the OPC server was changed, client's data would be refreshed automatically according to the update cycle.

The parameters of shearer were divided into three parts according to the different reading and writing ways of the OPC and the real-time response requirements of the different parameters.

1) The real-time control parameters of the shearer which included the start and stop of the shearer, rising and drop of the left and right drums, the start and stop of the left and right frequency converters, start and stop of the crushing mechanism, acceleration and deceleration of the shearer, and so on. these parameters has a small amount of data and the highly real-time requirement, so synchronous communication mode was used to carry out data transmission between the remote monitoring platform and S7-300 PLC in the shearer, which assured that remote monitoring of the shearer was safe and reliable.

2)The condition parameters of the shearer included the angle of the shearer rocker arm, displacement of the left and right hydraulic cylinder, height of the cutting drum, position of the shearer's body, pitch angle of the shearer's body, the angle of the coal seam, the number of hydraulic support, and so on. These parameters have a large amount of data and high real-time requirement. In order to make sure that the shearer's virtual prototype and the real shearer in the mine have the same actions, asynchronous communication was used, communication rate was set 0.1s.

3)The fault and alarming parameters of the shearer included temperature of the left and right traction motor, current of the left and right traction motor, temperature of the left and right cutting motor, current of l the left and right cutting motor, the concentration of gas, flow rate of the hydraulic system in the shearer, and so on. These parameters have a large number of data and low requirement for timeliness. When the shearer's parameters changed, OPC server sent the changed parameters to OPC client, otherwise the parameters in the OPC client were not updated, which reduced data communication and the pressure of the network significantly.

C. Design of the communication program

C# language based on .NET framework was used to develop communication program. Because the development of OPC.SimaticNet is on the COM platform, OPC Foundation provides OpcRcw DLL, OPC NET COM wrapper and OPC NET API to its members. It is easy to achieve data access by packaging OPC complex specification into C # class. The client program was developed by use of C# in the shearer's remote monitoring system, the client accessed the OPC server through the communication program, read and wrote the data in PLC of the shearer by this program, it is better to use a custom interface to access the OPC Server based on the language features of C #. The architecture of the program code was shown as follows:

(1) Quoting dynamic link library of the custom interface

Using OpcRcw.Comm;// Interface DLL files defined by Custom

Using OpcRcw.Da;// Custom interface DLL files provided by OPC foundation

Using OPCSienensDAAutomation;// Automation interface DLL file provided by Siemens suppliers

(2) Definition of the OPC related variable

OPC servers are divided into two patterns in general, One is the local OPC server, OPC client and OPC server program run on the same computer, which could ensure the communication between the OPC client and OPC server with no delay and high communication efficiency; another one is that OPC server is located in remote computer, there is a time delay, when OPC client read data from OPC server program. The second pattern was applied to carry out data communication between the remote monitoring platform and the local S7-300 PLC in the shearer.

```
OPCRcw.Da.IOPCServer ServerObj;  // Definition of the  OPCServer object
OPCRcw.Da.IOPCSyncIO IOPCSyncIO20bj=null; //Reading and writing object synchronously
OPCRcw.Da.IOPCAsyncIO2   IOPCAsyncIO2Obj=null; //Reading and writing object asynchronously
OPCRcw.Da.IOPCGroupStateMgt IOPCGroupStateMgtObj=null; //Management of the OPC group object
Internal const in LOCALE_ID=0x407;  // OPC group linguistic code-English
Object MyobjGroul;   //OPC group object
Int[] ItemServerHandle;  //Item array of handle
Int pSvrGroupHandle=0;  //OPC group handle
```

1) Connection to the specified OPC server

```
svrComtyp=Type.GetTypeFromProgID("OPC Server", "OPC IP")
ServerObj =
(OpcRcw.Da.IOPCServer) Activator.CreateInstance(svrComponenttyp);
// Activate the connection with OPC server
ServerObj.AddGroup("MyOPCGroup1", //Increasing group object
dwRequestedUpdateRate,  //Subscribing reading speed
hClientGroup,
hTimeBias.AddrOfPinnedObject(),
hDeadband.AddrOfPinnedObject(),
LOCALE_ID,
out pSvrGroupHandle,  //OPC group handle
out pRevUpdateRate,
ref iidRequiredInterface,
out MyobjGroup1);
```

The "OPC Group 1" was OPC object which needed to be registered, the update rate of the OPC object and the returned handle of the OPC group were included.

```
S7OpcItem1=S7OpcGroup.OPCItems.AddItem("PLC data block to be read ", The data address of the data block);// Read data from specified address of the PLC
```

2) Reading and writing data

In order to carry out reading and writing data asynchronously, the asynchronous reading function Read( ) and asynchronous reading accomplishment function OnReadComplete( ) were defined and applied.

```
IOPCAsyncIO2Obj.Read(int dwCount, int[ ] phServer,
int dwTransactionID,
out int pdwCancelID, out IntPtr ppErrors);
//dwCount: Number of the read OPC object asynchronously
//phServer: Handle array of OPC server;
//dwTransactionID: Identifier of reading data from the OPC server asynchronously;
//pdwCancelID: Identifier cancel by OPC Server;
```

The virtual function which completed asynchronous reading was defined as follows.

```
OnReadComplete(System.Int32 dwTransid,
System.Int32 hGroup,
System.Int32 hrMasterquality,
System.Int32 hrMastererror,
System.Int32 dwCount,
int[ ] phClientItems,  // Reading  data handle
object[ ] pvValues,  // Returned value
short[ ] pwQualities,  // Returned quality code
OpcRcw.Da.FILETIME[ ] pftTimeStamps,  // Returned timestamp
Int[ ] pErrors)  // Error code
```

3) Breaking the connection between the client and the OPC server

OPC server should be disconnected before the OPC client exited, if the OPC server wasn't broken connection in time, the resources used by OPC server were not released, which would result in resource depletion of the computer. The following codes were steps to disconnect from the OPC server.

```
Marshal.ReleaseComObject(IOPCSyncIO2Obj);
IOPCSyncIO2Obj = null;
ServerObj.RemoveGroup(pSvrGroupHandle, 0);
Marshal.ReleaseComObject(MyobjGroup1);
MyobjGroup1 = null;
Marshal.ReleaseComObject(ServerObj);
ServerObj = null;
```

IV. DEVELOPMENT OF THE REMOTE MONITORING PLATFORM OF THE SHEARER

The reading and writing communication interface between the virtual reality platform of the shearer's remote monitoring and S7-300 PLC in the shearer were developed, the displayed parameters in the remote monitoring platforms were shown in Fig.2.

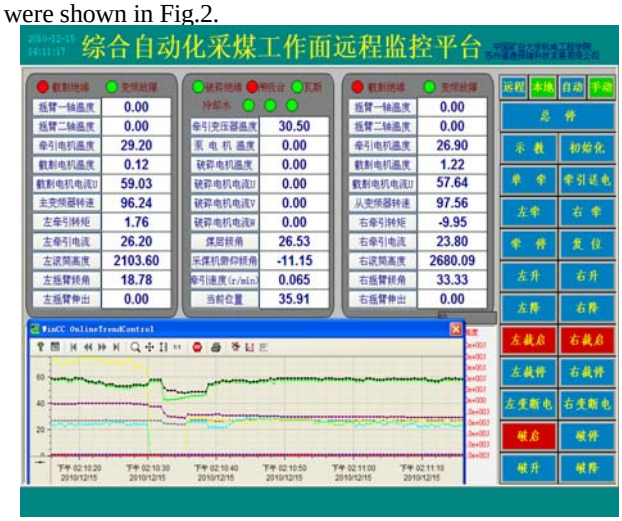

Figure 2. Displayed parameters in the remote monitoring platform by the communication Interface

The shearer's virtual prototype in the remote monitoring platform was driven by data obtained from S7-300 PLC in the shearer, its working status was the same as the true shearer in the mine, thus workers could operate the shearer in the coal mine according to moving status of the its virtual prototype. The virtual reality platform for the shearer's remote monitoring was shown in Fig.3.

Figure 3. Virtual reality platform for the shearer's remote monitoring

V. CONCLUSIONS

Working condition of the shearer is very bad in the coal mine, remote monitoring for the shearer could reduce fatalness of the workers. The traditional monitoring system of the shearer displayed its working parameters by use of two-dimension figures, curves and data, and so on, these methods couldn't meet the needs of automatic production in the fully mechanized coal mining face. The shearer's working status was reappeared by using virtual reality technology, which made the mining workers really feel the shearer's working condition in the coal mine, and dare to operate the shearer in the remote distance by virtual reality platform. In order to realize action consistency between the virtual prototype in the remote monitoring platform and the real shearer, the real-time communication between the remote monitoring platform and S7-300 PLC was carried out by use of OPC technology. In order to solve blocking problem in the OPC server communication process, the working parameters of the shearer were classified based on the different real-time response requirements, which improved the communication effectively, the communication interface was designed and developed in C # environment. The experimental result shows that the communication program based on OPC technology is running reliably, it can satisfies the stability, reliability and synchronization requirements of the real-time communication between the remote monitoring platform and S7-300 PLC in the shearer, and realize the shearer's remote monitoring and controlling.

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