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Full Length Research Paper

Research of the remote and real-time data collection platform toward distributed greenhouse structure

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In order to elevate the whole management level of distributed greenhouse systems, research into the data with different network conditions. Analysis into the requirement of distributed greenhouse system, an OPC-based remote and real-time data collected platform was suggested for different network conditions. The system was realized by OPC XML including the client, server, software integration and hardware deployment. Judged by this experiment, we can safely conclude that data integration based on OPC XML is the best solution for the distributed greenhouse system. Experiment result shows that relative errors can be decreased from 60 to 4% by using this integrated platform. Data similarity can be 93.3%. By accelerating data requiring time, the efficiency of greenhouse cultivation can be elevated to 13%.

Key words: Greenhouse management system, distributed greenhouse system, OPC XML, data collection.

INTRODUCTION

The main role of greenhouse management system is to accomplish the whole cultivation management process from order issued to crop package and transportation. Meanwhile, it responds rapidly to the emergency accidents during crop cultivation process including pesticides diseases and insects damages. As a result, it is very important for the greenhouse management system to acquire real-time information from cultivation scene more precisely. However, almost all of the equipments used in the cultivation process have their own drive program and the network condition is different. It is hard for the greenhouse management system to form a universal interface (Reinhard, 2002). In addition, network condition between cultivation scene and management department is different. For instance: normal network conditions used in cultivation scene is industrial ethernet while the management layer used is the Internet. Different network conditions will lead to the difficulties of information communication between cultivation scene and management department (Jim, 2002).

The existence of OPC (OLE for Process Control) can effectively solve the problem of information exchange between different cultivation equipments. However, it cannot meet the requirement of the information integration under the circumstance of remote distance. Liang GU realized system integration used OPC. Net tools (Liang et al., 2006). However, it still remains a problem under the circumstance of different network conditions. In some specific areas like the electricity industry or the chemical industry, one kind of remote monitoring system was put into use which was based on OPC XML (Zhang et al., 2002). Focus on the agricultural cultivation environment, we used web service, OPC XML technology and B/S structure to install remote data collected platform. The result of the experiment shows that relative errors can be decreased from 60 to 4%. Data similarity can be 93.3% after data transformation. By accelerating data requiring time, the efficiency of greenhouse cultivation can be elevated to 13%.

MATERIALS AND METHODS

Description of the integrated platform

By analysis to the crop growth process under the circumstance of

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distributed greenhouse environment, we can conclude the designed platform need to meet the following requirement:

1. The requirement of acquiring data from the cultivation spot: Greenhouse management system needs to collect a mass of data about the crop growth process and quickly response to the emergency accident like the diseases and insect damages (Marc and Johannes, 2008). This is also the basic requirement for the greenhouse management system to optimize the industrial seedling process.
2. The requirement of information integration between different cultivation equipments: Greenhouse management system requires the format of the cultivation equipment which must be uniform; so as to facilitate the information acquiring and feedback. As a result, when facing the different structure of cultivation equipment, the platform need to make all of the cultivation equipment must strictly conform to one specific format.
3. Data transmission between different network conditions: The network environment in the cultivation spot is industrial ethernet. However, the network condition in the greenhouse management system is Internet. Different network conditions will lead to the difficulties in data transmission problems.
4. Basic data filter for the greenhouse management system: Compared to the normal monitoring platform, greenhouse management system will not only restore the data transmitted by the cultivation spot but also need to filter all the data. Then it will send the valid data to the top greenhouse management system. This is the special requirement of the information integration toward greenhouse management system.
(5) Platform integration between enterprise software: Modern structure of the enterprise software is based on B/S. By doing this, it can not only avoid the problem of different operation structure but also bring the facilities in deploying and maintaining the software. As a result, this is the realistic requirement of this platform demonstrated in this paper.

Key technologies of the whole system

OPC is the component object model standard interface including OLE (Object Linking and Embedding), COM (Component Object Model) and DCOM (Distribute Component Object Model). It can offer information integration and interactive standard for the industrial applied program (Ji-Suk et al., 2005). OPC standard requires all of the hardware supplier need to package the entire hardware device driver program into independent OPC server. By this way, the system can transmit all of the data which came from the cultivation spot to any client application program. As a result, it can solve the problem of information integration between cultivation devices with different network conditions.

One of the services of the OPC standard is subscription method. It updates the data according to the certain interval which is called update rate (Chilingargyan and Eppler, 2005). Once there is existing some changes between the data OPC server will inform the application about the data change accident. By doing this, it can ensure the data collection process. However, traditional OPC cannot realize the information integration between the cultivation spot and the greenhouse management system especially if it has some problems when under the circumstance of crossing the firewall. With the emergence of modern OPC technology, it cannot only remain the functions mentioned previously but also has some advantages under the circumstance of visiting the remote systems (OPC XML Data Access Specification version, 2004). The main technologies included in modern OPC technology can be concluded as follows:

1. XML (Extensible Markup Language) is based on the texts. XML cannot only express the content of the data but also the structure. By XML, different systems can interchange data more easily. Because the transmission protocol based on Internet is SOAP/HTTP. Thus, OPC XML Web service can operate in the Internet/Intranet. In fact, this is the most effective method in information interchanges between different network conditions.
2. Web service is the background for OPC XML-DA technology. Web service can offer all kinds of service to the network users by the standard network protocol. As a result, all of the client user can access the services no matter when or where the client user is. Thus, this facilitates the data share and interchange process more easily.

Considering all of the advantages mentioned earlier, OPC XML technologies were chosen to design the remote and real-time platform for the greenhouse management systems. This platform will publish the cultivation data by OPC XML server. The users can visit the data by the Internet. As a result, the crop cultivate devices locate in different places can communication with the greenhouse management systems more conveniently.

Design of the platform structure

The whole structure of the remote and real-time data collection platform can be shown from Figure 1. It was composed of crop cultivation devices, OPC XML server, client server and the database system. The main role of this system is used for acquiring real-time data for the greenhouse management system. Platform will collect all of the valid data to the greenhouse management system. The valid data are including the order start time, device waiting time, device actual working time, and the number of crops and the damaged crop which was damaged by the insects or the diseases, etc. After the platform successfully handled with the information, it will send the useful information to the upper management information system. This information includes the work order status or performance, start time, resources, work information, practical planting information, etc. The servers of the designed platform are composed of OPC server, OPC client server, XML transformation, and XML-DA server which can be shown from Figure 2.

The main principle of these servers is to integrate the OPC COM services by adopting the XML DA standard. The servers will visit the OPC data server by COM/DCOM interface which act as the client interface. It will get the data from the cultivation devices. As adopting OPC standard, the OPC server interfaces of the cultivation devices are using the uniform standard. By adding different servers to different client serves which was in accordance with the standard of the groups and the item name. As a result, the designed platform can simultaneously visit all of the data which were come from different devices with different structure. The platform used subscription communications protocols in order to guarantee the real-time information for the greenhouse management system. Service can provide data exchange service as SOAP message formats outside. According to the OPC data standard the server can visit the user interface. In addition, the platform can access the OPC data automation interface, the XML code and the SOAP protocol.

Finally, the platform can publish all of the desired data as a web server, for remote or cross network conditions transmission. Thus, the users can use the Internet to access the data conveniently. By all of the work the server's done, the heterogeneous structure of crop cultivation devices can be shielded, and then the real-time access to data in XML format can be remotely sent for cross – network conditions. The client is developed as one of cultivation data acquisition modules for the distributed greenhouse management system which was based on B/S structure. Therefore, it has a double identity, namely greenhouse management system services and OPC XML client. On one hand, by connecting OPC XML client to the Web server the data can be published. It can

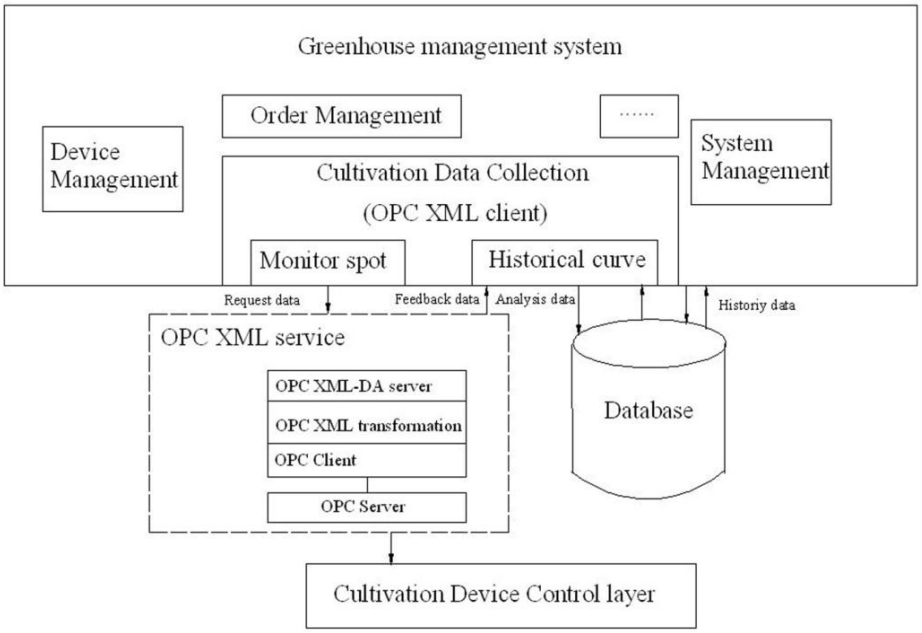

Figure 1. Remote and real-time data collection platform for the information integration structure of the distributed greenhouse management system.

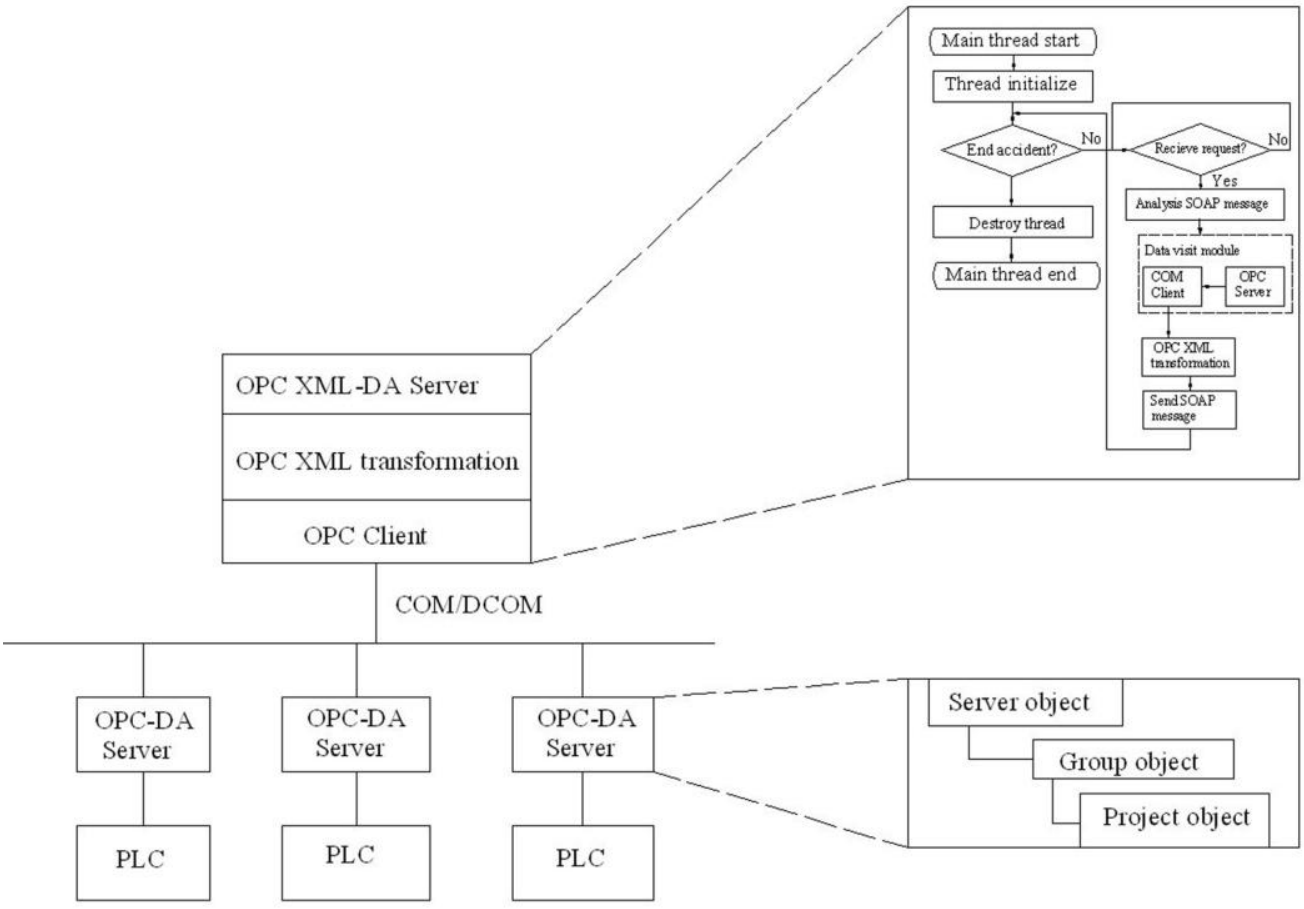

Figure 2. Structure model of the Server.

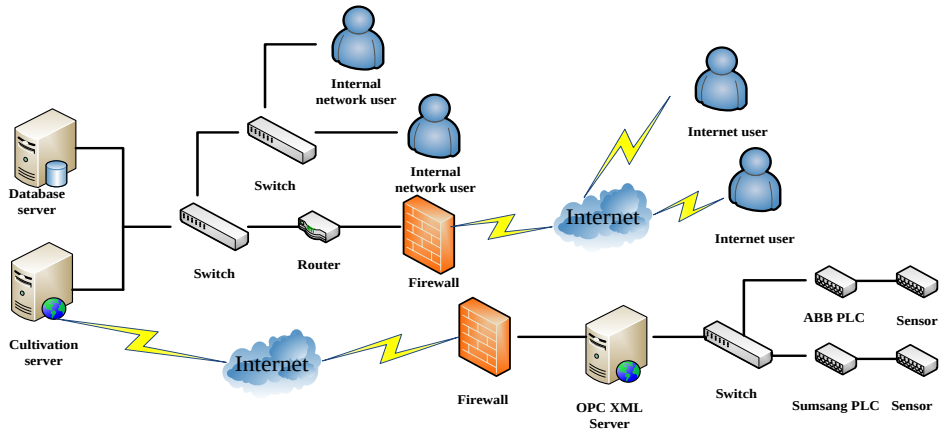

Figure 3. Device structure of the remote data collection platform.

Figure 4. Monitor parameters from cultivation scene.

complete the process of OPC XML-DA data receiving, sending and the realization of real-time data acquisition for the cultivation field.

On the other hand, in order to meet greenhouse management system's requirements for obtaining the useful data, the client server will analyse, filter and restore the useful data in the database which can be easily accessed by the other modules of the platform. To go further, the data will be published through the web service for terminal users to access. As a result, this part will be integrated and developed with the greenhouse management system software, so that the remote and real - time data acquisition platform is better integrated into the whole greenhouse management system to facilitate the enterprise information integration.

Platform realizations

Hardware platform

The hard structure of the remote data collection platform can be seen from Figure 3. Divided by the firewall, the whole platform can be divided into three parts including crop cultivation layer, the enterprise management layer and the terminal Internet users. In the crop cultivation layer, the structure of devices can be different to each other and they can be linked to each other by industrial Ethernet. The users can random choose any sever as the Internet interface to communicate with the Internet. The enterprise management layer and outside can use Internet as the link method. The platform can choose the database server as the interface for the Internet. This database server can not only communicate with the server in the crop cultivation layer but also publish the crop growth data to the Internet.

The measure equipment from the cultivation scene can be seen from Figure 4. The remote control system can be seen from Figures 5 and 6. By using this platform, the terminal users can visit the crop cultivation layer data by the Internet even under this complex circumstance of different network conditions.

OPC XML Server port

The software of OPC XML Server was realized by C#.Net and ASP.Net under the circumstance of Visual Studio 2008. OPC client port can load the file whose name is OPCNetWrapper.dll and using its interface function to get the OPC server's name which is in correspondence to the crop cultivation layers. By doing this, the platform can Shield the structure of the hardware and meet the requirement of the information integration requirement of different devices. OPCNetWrapper.dll integrated all of the OPC standards and the interface definition including the subscription methods. As a result, it can also meet the requirement of the real-time data. The development environment can offer the method which is called Web Method. This method can publish all of the handled XML documents to facilitate the data transmissions between different network conditions.

Figure 5. Remote management system.

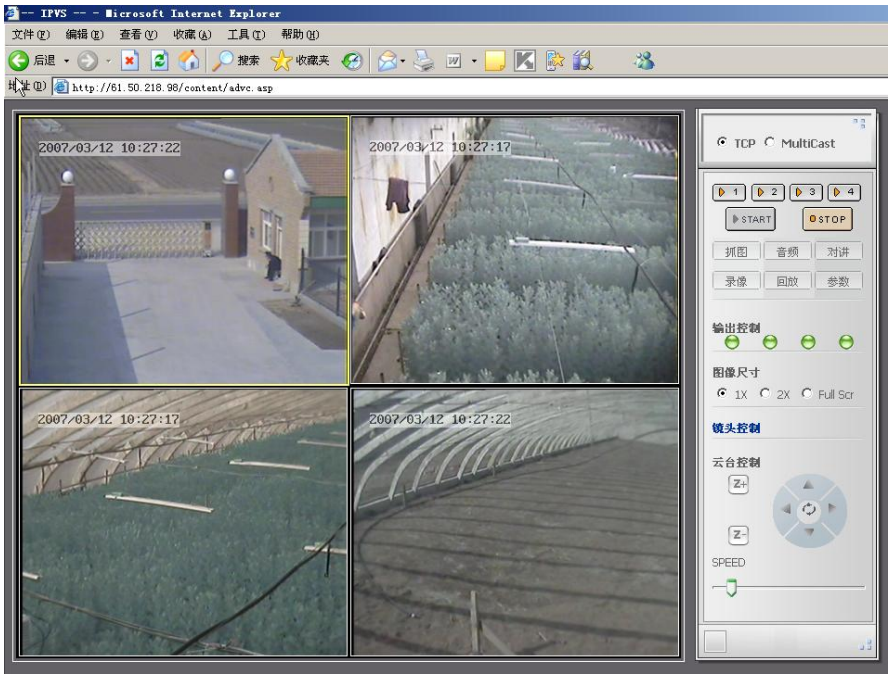

Figure 6. Remote management software.

The information flows of the server can be seen from Figure 7. When the server port starts a new thread it will monitor the user's request. After the Web service project succeeding in reading the SOAP request which came from the client, it begins to analyse the SOAP messages and start the data visit module. COM client program will get the data from the OPC server by OPC automatic interface service. In the same time, it will transform the XML protocol document into the OPC interface standard. According to

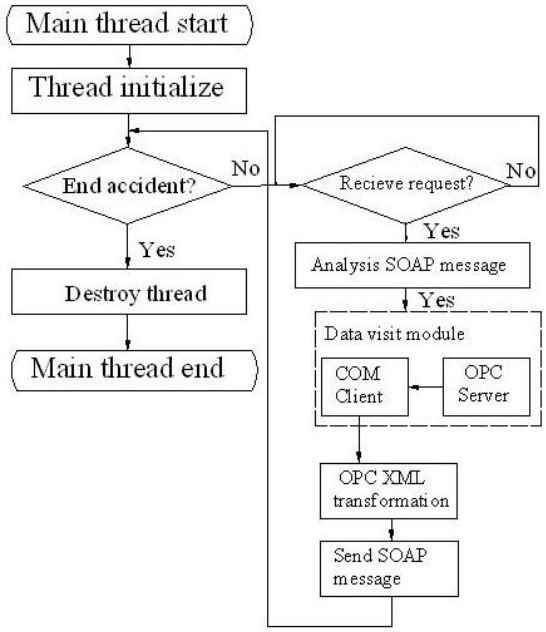

Figure 7. Information flows of the server.

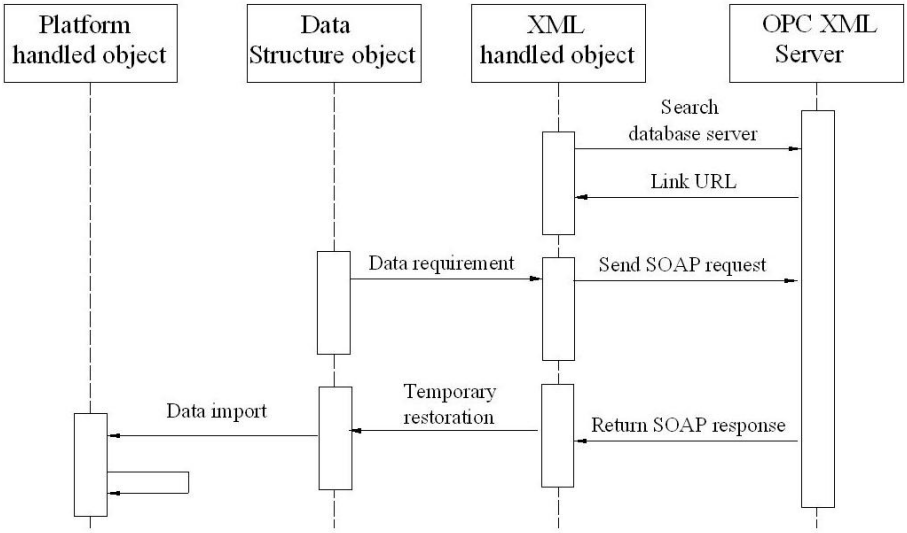

Figure 8. Information flows of the server.

the request of the communication, the COM client program will handle the transmission between the XML document and the OPC data formation including data package and analysis. After it succeeds in finishing this, it will publish the SOAP messages according to XML formation. The terminal users can visit the data by the Internet. The information flows will end if the users close the server or an accident was end, etc.

OPC XML client port

The software of OPC XML Client was realized by C#.Net and ASP.Net under the circumstance of Visual Studio 2008. It will combine with the greenhouse management system to facilitate the information integration with other enterprise software. A WSDL document was used to format the web service using OPC XML standard. The software can set up an agent class. The client can execute the service by using these methods in the agent class. The information flows of the client can be seen from Figure 8. When the system start a client thread, the system will link the server by starting the URL link method. XML object will send the SOAP message according to OPC data standard. The client server can get the data by analysis the SOAP messages. After it succeeds in handling with all of the data, the handled data will be restored in the

Table 1. Comparison between the actual measure method and data from integrated platform.

ID	Actual measure method	Data from the integrated platform
1	82.64	81.56
2	89.56	89.24
3	89.27	89.02
4	89.41	89.79
5	81.54	81.25
6	82.85	82.96

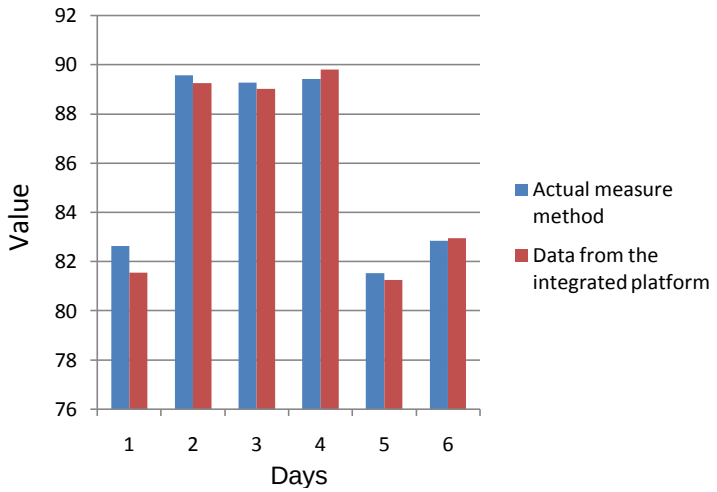

Figure 9. Data similarity.

temporary variables. This communication process will never be influenced by any network conditions or the operation systems.

Thus, it can meet the requirement of data transmissions between different network conditions. Data structure object will unpack the data according to OPC standard and transform it into the format data structure. After finishing doing this, the data will be sent to the greenhouse management system. The main role of the greenhouse management system is to analyse the data and filters the valid data into the database. All of the handled data including the real-time order status and the equipment status can be the background for the other module analysis and computation.

RESULTS AND DISCUSSION

Table 1 shows the actual measure method and data from the integrated platform. We measure the diameters of the melon for 6 days both from the actual measure method and data from the integrated platform in June, 2011.

Error analysis of the whole system

Figure 9 shows the data similarity between the actual measure method and data from integrated platform. The relative errors can decrease from 60 to 4%. Data similarity can be 93.3%.

Conclusion

In this paper, OPC XML technology was designed to realize the information integration model and set up the remote and real-time data collection platform. OPC standard was used in this platform and solve the problem of different device structures. In addition, by using web service, the platform can solve the problem of data transmission between different network communications.

The greenhouse management system and the platform can be designed independently. The user's role is like the bridge between the platform and the greenhouse management system. When this platform is put into application, the users can only define part of the modules. As a result, this platform can be used in some related areas.

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