World Academy of Science, Engineering and Technology
International Journal of Computer and Information Engineering
Vol:10, No:10, 2016

Working Mode and Key Technology of Thermal Vacuum Test Software for Spacecraft Test

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***Abstract*—**A universal software platform is developed for improving the defects in the practical one. This software platform has distinct advantages in modularization, information management, and the interfaces. Several technologies such as computer technology, virtualization technology, network technology, etc. are combined together in this software platform, and four working modes are introduced in this article including single mode, distributed mode, cloud mode, and the centralized mode. The application area of the software platform is extended through the switch between these working modes. The software platform can arrange the thermal vacuum test process automatically. This function can improve the reliability of thermal vacuum test.

***Keywords*—**Software platform, thermal vacuum test, control and measurement, work mode.

I. Introduction

THERMAL Vacuum Test (TVT) facility is used to simulate the environment in space as vacuum, cold, black, and the solar radiation. The main purpose is to verify the satellite performance and reliability in orbit, the accuracy of satellite thermal models, and the applicable temperature range for the on-board equipment. Five complex subsystems are configured in the TVT facility including chamber, vacuum subsystem, cryogenic subsystem, control system, measurement, and flux simulation subsystem. The last subsystem has the functions to measure the specimen temperature and to simulate the heat flux [1]. The application software is the most important part in this subsystem. The performance of this application software is related to the quality and success of TVT.

Along with the satellite quantity booming and the instrument technology progressing, the data acquisition instruments, the heater programmable power, and the other hardware are growing both in quantity and type. These developing needs update the related software. Nowadays, different instrument hardware has different interface and software product. The location of the instruments is decentralized, the relation between different software parts is excessively correlated, the new control arithmetic cannot be added easily, and the TVT process management needs a hand record. The above status needs improving of the application software.

Aiming at the status of the measurement and flux simulation subsystem, the software platform for TVT is developed. The traits of the software platform include:

- Universal suitability for different type instruments hardware and different scale;
- Modularized design for function modifying;
- Centralized management;
- Libraries can be modified easily;
- TVT progress management automatable.

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II. Working Mode

The software platform for TVT combined several technologies together such as computer technology, virtualization technology, network technology, and so on. The whole process of the TVT can be automated including test preparation, test running, data display, and the data analysis. This software platform has four working modes: single mode, distributed mode, cloud mode, and the centralized mode. The single mode is used in small or middle size of TVT facility. Distributed mode is used in large size of TVT facility. The cloud mode is used in giant size of TVT facility. The centralized mode is used in centralized control of TVT facilities.

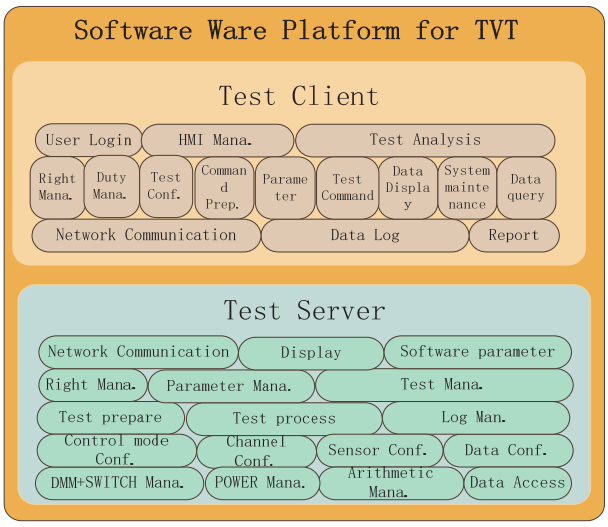

Fig. 1 The Structure of the Software platform for TVT

The software platform realized the four working modes through assembling and dissembling the modules in itself. It has two large modules, which are Test Server (TS) and the Test Client (TC), as shown in Fig. 1. The two modules form the C/S structure. TS makes server in C/S. TC makes the client in C/S. The server module is used to drive the instruments and control through the control arithmetic. The client is used to be the human machine interface, which has the functions to provide the interface to configure the TVT, read back the data

feed through TS. The four working modes are shown in Fig. 1.

A. Single Mode

The single mode is used in small or middle size of TVT facility. It is the most simplified appearance of the software. In this mode, the data acquisition channel quantity is not bigger than 200, and the programmable power channel quantity is not bigger than 100. The TS and the TC are installed in the same computer. It is shown in Fig. 2. The whole works of TVT are realized in the same computer, including test process management and the hardware control.

B. Distributed Mode

Distributed mode is used in large size of TVT facility. In this mode, the data acquisition channel quantity is not bigger than 1000, and the programmable power channel quantity is not bigger than 500. The working structure is shown in Fig. 3. In this mode, two servers are configured for the TS. One is in working, and the other one is in hot backup. The TS has the functions of instruments drive, control strategy using, and so on. Several TCs are configured in the control room, which has the functions of HMI, data exchange, test management, etc. The data server is an option for saving into the database [2]. If it is without the data server, the test data are saved in the TS server. In the remote level, TCs are also installed in the computers. The remote TCs are used to control the TVT facility, when the operators are far away from the TVT facility in the location.

In the distributed mode, different functions are arranged in different computers. The synchronization of different parts is insured by the network. Though this method, operator can realize the monitor of the TVT facility in local or remote.

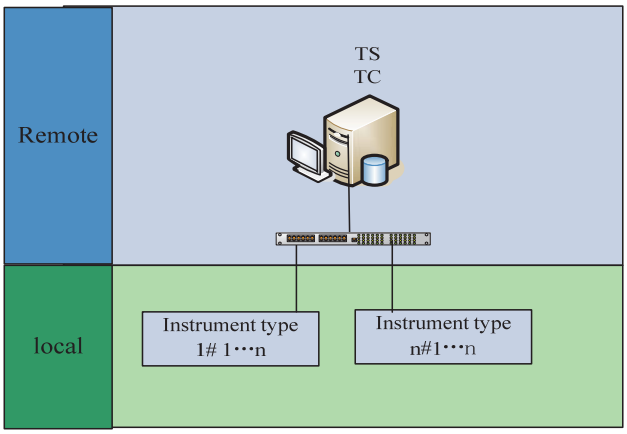

Fig. 2 Single mode

C. Cloud Mode

Distributed mode is used in giant size of TVT facility. In this mode, the data acquisition channel quantity is not bigger than 3000, and the programmable power channel quantity is not bigger than 1000. In this mode, more servers are configured to realize the function of instruments driving. The new servers/computer can be added in to participate the duty when the compute duty is too heavy, or an existing server/computer can be removed for the network when the compute duty is light in real time. The new server/computer should install TS software. The structure is shown in Fig. 4. All the clients should be install TC software. In this network, the clients can be added or removed in real time, without any effects on the other parts. The above-mentioned server/ computer are not limited by the location, if the location has available network.

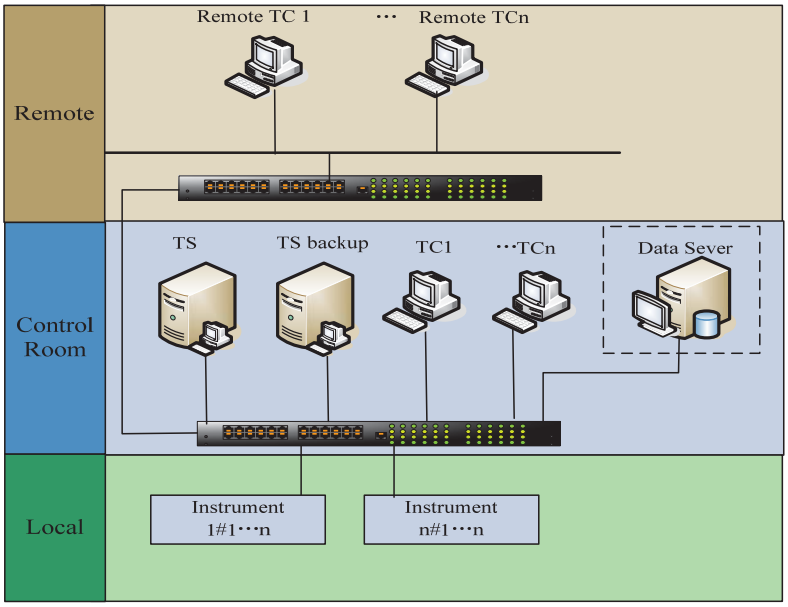

Fig. 3 Distributed mode

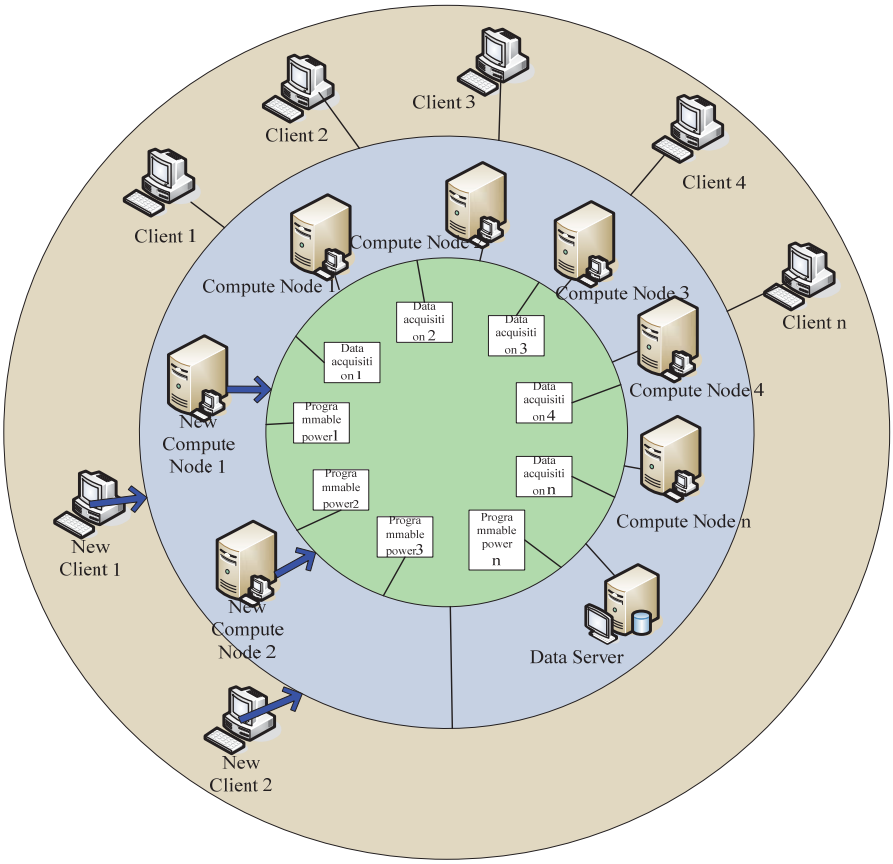

Fig. 4 Cloud mode

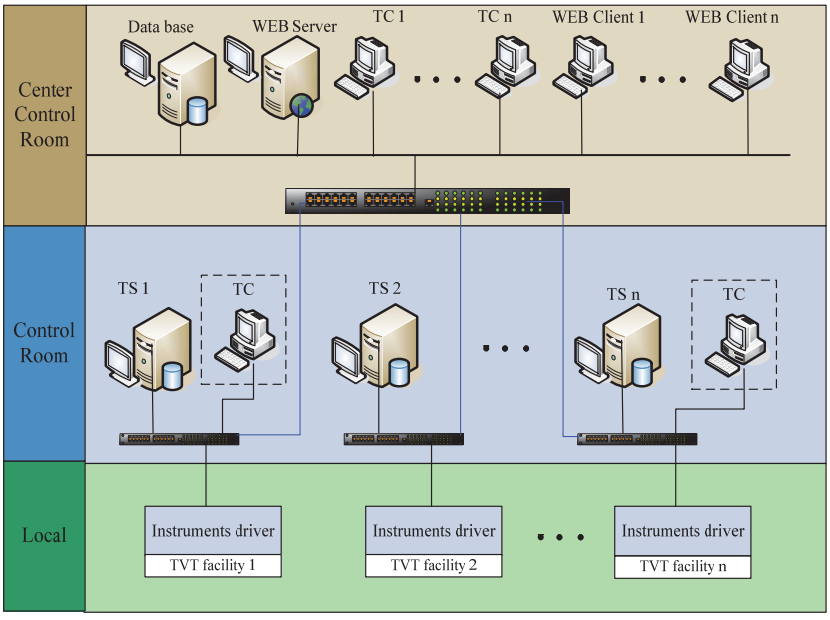

Fig. 5 Centralized mode

D. Centralized Mode

The centralized mode is used in centralized control of TVT facilities. Each TVT facility has its own servers. The data can be stored in each server of itself, or in an optional data base. The server quantity can be costumed by the working condition. In this mode, a center control room is needed. A center data base and web server is needed too. It is shown in Fig. 5.

III. Key Technologies

Compare with the existing software, this software platform has lots of advantages. For instance, the software platform is usable for TVT facilities located far away. For these new functions, the software platform needs some key technologies and designs.

A. Universal Design

The software platform mainly focuses on instruments driven universal, which using IVI (Interchangeable Virtual Instruments) technology to build the instrument driven library. Any interfaces of instruments can be driven through transfer to the IVI [4]. Besides, many other libraries can be called easily for different types of TVT test. These libraries consist of test control mode library, control algorithm library, user information library, and so on. This software platform can be suitable for different types of TVT test through operating these libraries.

B. Modularity Design

This software platform divides unique functions into modules through simplifying the interactive interfaces to keep the relatively independence. For instance, data acquisition instrument driven module is independent from power instrument driven module, data curve display module, and the data alarm module. The function modularity trait gives the software platform more extendibility.

C. Multithreading Technology

The software platform assigns different threads for different type instruments driven, or different sets of instruments. Between the threads, the running mode is parallel to increase the process speed. The server applies multithread method to communicate with the clients to insure the communication efficacy.

D. Centralization Design

The software platform has the special structure for dividing into two parts, the TS and the TC. This structure can easily be configured into C/S and B/S network. These two network operation modes can be combined together to realize the centralized control function [5].

E. Distributing Compute

In the large TVT test, single computer cannot finish the instruments driven, control computing, and data communication in a period of time. So, the distributing compute is needed. For example, the instruments driven function and the control computing function are running in the TS. The HMI is running in the TC. Through distributing, the working speed of the software platform can be improved.

F. Instant Access Technology

In the large TVT test, new instruments or computers can be added into the test system without stopping the test process or any bad effect on the existing control loops. With the instant access function, in the test process, new server computer can be put into the network to share parts of computing duty to realize the cloud computer function.

G. Token Right Technology

In this software platform, the token right technology is used to attribute the operating right competition from servers to the same instrument. With this technology, each instrument is assigned to a unique token. The server with the correlative token can operate the instrument.

H. Interface Customizable

The HMI can be customizable by the user with the administrator rights.

IV. Main Function

The main functions of the software platform are as follows [3].

- Control the access of the software, management of the users, attribution of the control right, and management of the signature verification;
- Manage the TCT test including adding, modifying, parallel running, deleting, etc.;
- Configure the TVT test including instruments measurement channel, sensor, heater loop, test temperature status, etc.;
- Preparing for the TVT test, including heater loop cable check, measurement channel cable check, resistance test, etc.;
- Monitor the VT test process including data acquisition instrument, power instrument, control arithmetic configuration, parameter modification, data display, curve plot, etc.;
- Save the TVT test information and the test data into the TS and the data server. These data are saved in the TS server in file format, and save in the data server in data base format. The clients in the TC can get the data from both the TS and the data server;
- Provide user management interface, data base management interface, control arithmetic library management, instrument library management;
- Provide the WEB server to publish the IE pages to monitor the TVT test status in remote.

V. Conclusions

The software platform for TVT test can conclude all the functions about the TVT test, and is suitable for any size of thermal vacuum facility. This software platform has more distinct advantages than the existing one. This software platform has widely using areas.

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