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Design and Realization of Payload Operation and Application System of China's Space Station

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Abstract

China's Space Station will be launched in the year 2018; this space station is China's largest space science experiment and application platform until now. This paper mainly introduces the function composition of payload operation and application system of China's space station, system architecture, hardware architecture and the new technology we use to implement the payload operation and application ground system of China's space station.

Keywords: Human spaceflight; China's space station; Ground operations system; Telescience

Introduction

China's space station will be launched at year 2018; this space station is China's largest space science experiment and application platform until now. It will stay in space orbit more than a decade and have many complex scientific space experimental tasks to do step by step in the future. This would mean that we are facing many challenges for our payload operation and application ground system, including complex mission planning, high-speed mass data processing, health management, payload status monitoring, remote support for tele-Science and the ground system dynamically updates with the scientific mission changes all the time. This paper mainly introduces the function composition of payload operation and application system of China's space station, system architecture, hardware architecture and the new technology we use to implement the payload operation and application ground system of China's space station [1-4].

System Overall Design

Components and design of the system

Payload operation and application system is a very important sub system of the ground system of the China's space station. It responsible for establishing a communication link with the ground station, spacecraft control center and science center, receiving telemetry data and various types of application data, real-time processing payload data and telemetry data to monitor the health status of the payload, planning and scheduling payload work timeline According to various scientific experiments request and spacecraft resources, providing space station payload telescience support system for providing scientific experiments remote operation, remote scene and remote analysis; providing technical support for science education and international cooperation. Overall, it is a necessary infrastructure of the space station project [5,6]. Payload operation and application ground system is a typical information system, the function including front-end data communications, integrated monitoring and real-time data processing, planning and scheduling payload work plan, data simulation, health management and fault diagnosis for payload, supporting remote scientific experiments.

System architecture design

The software architecture of the payload operation and application ground system is SOA (Service oriented architecture). All system functions are designed as service components to achieve software functional reuse in the system. All system service components exchange information and data between various functional components through standardized interfaces by data distribution service bus. The feature of this system is reuse, scalability and flexibility. The payload operation and application ground system's architecture showed as below, this architecture including four layers. They are UI layer, integration layer, application layer and resource layer (Figure 1).

System hardware architecture design

Payload operation and application ground system is a typical information system, composed mainly by the computing systems, network devices, storage system, its high performance computing and mass storage devices are integrated together by virtual software technology for sharing of resources and easy to manage (Figure 2).

Seamless upgrade mechanism

China space station construction process is gradually finish by building space capsule one by one for a long time, during this time, all payload scientific experiments are done step by step, which means that payload scientific experiments on the China space station are different and change all the time.

Payload operation and application ground system needs to support new scientific experiments tasks by dynamically upgrade while the system working. So this system needs flexible system architecture to deal with this situation. System architecture design principles follow the norms modularity, encapsulation, loose coupling, and separation of concerns, reuse and composition (Figure 3).

Payload operation and application ground system's soft architecture is SOA (service-oriented architecture) , This service-oriented architecture (SOA) is an architectural pattern in computer software design in which application components provide services to other components via a communications protocol, typically over an

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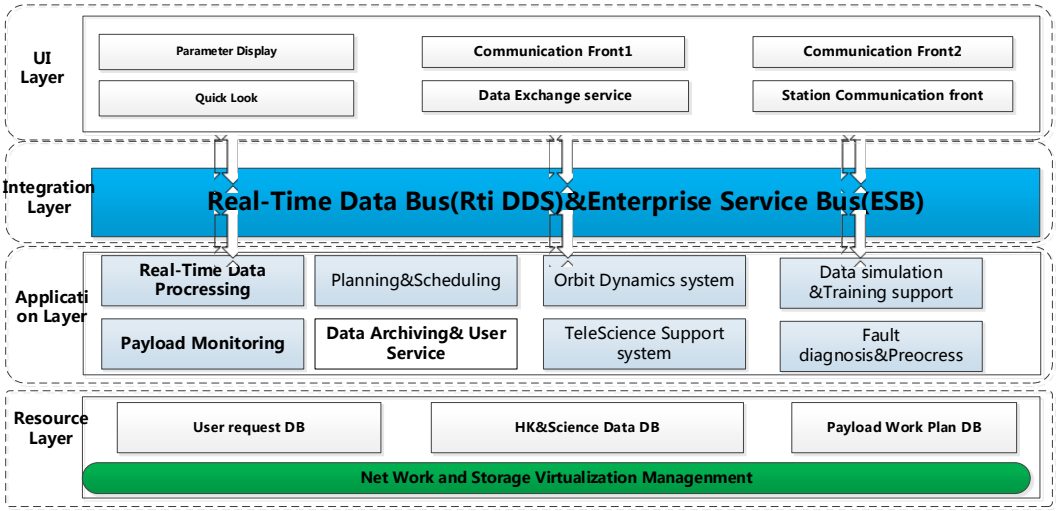

Figure 1: Architecture of the system.

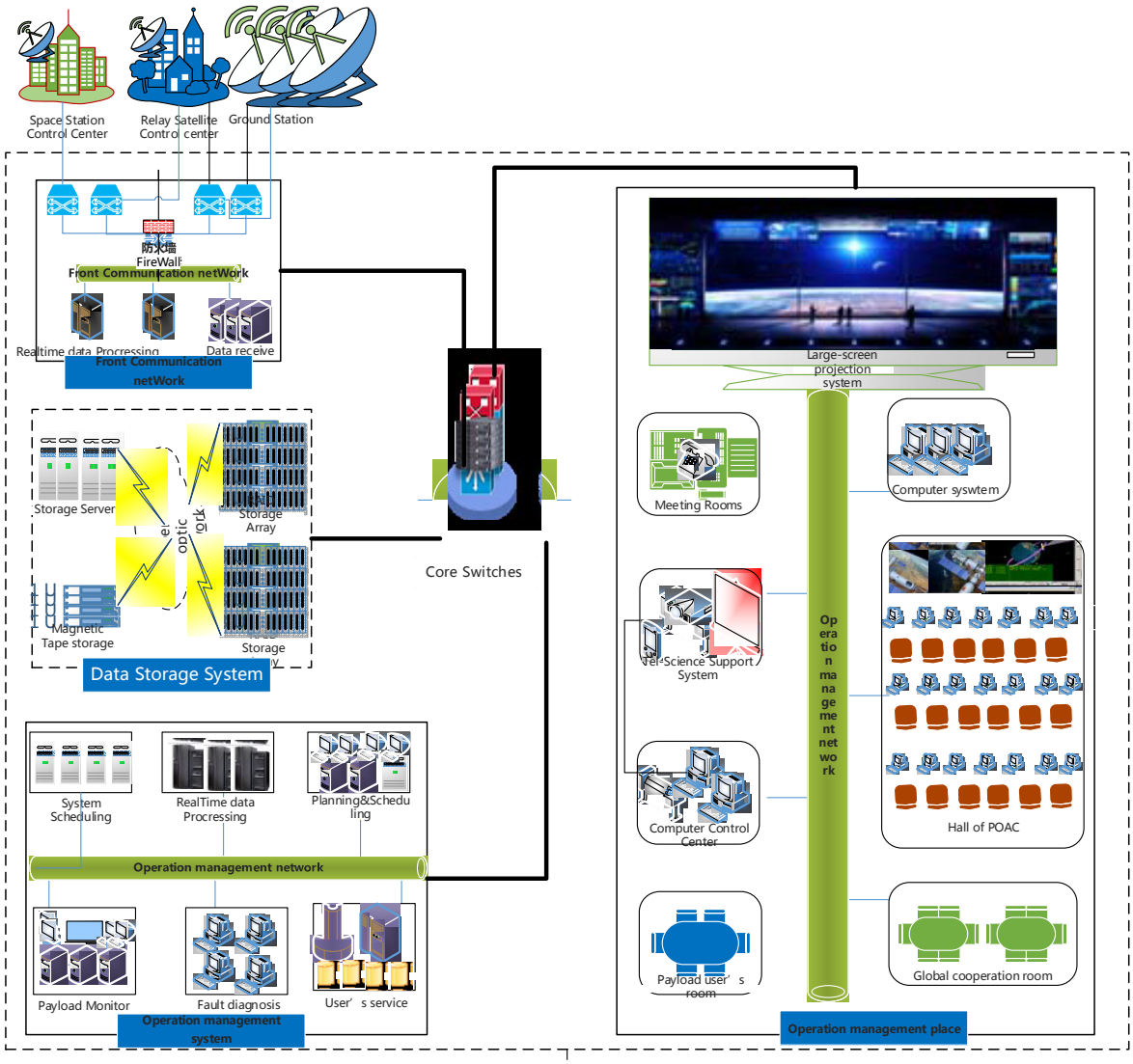

Figure 2: Design of the system hardware architecture.

enterprise service bus (ESB). The principles of service-orientation are independent of any vendor, product or technology. A service is a self-contained unit of functionality. SOA makes it easier for software components on computers connected over an ESB to cooperate. Every computer can run any number of services, and each service is built in a way that ensures that the service can exchange information with any other service in the ESB without human interaction and without the need to make changes to the underlying program itself.

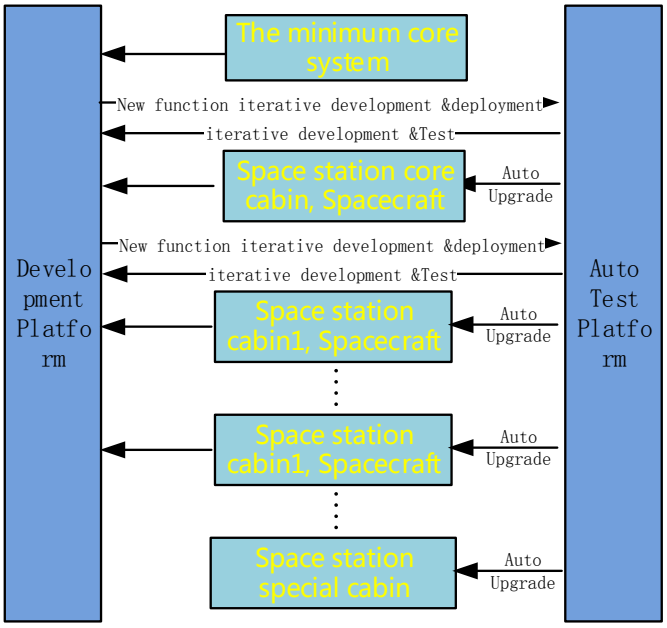

Figure 3: Seamless upgrade process of the system.

The System Data Flow

Front-end data communication software send data to real-time data processing software and integrated comprehensive monitoring software via the data bus DDS and then archive the raw data to the storage system to archive. Planning and scheduling software receiving user's application request, checking the legality and then archive the user' plan request files to the storage system via the File and data archive software. Planning and scheduling software planning and scheduling all the space and ground resources to support the payload work and make the payload work plan, then encoding work plan into instruction code and send this instruction code file to payload on orbit via the Beijing Space Flight Control Center uplink ground control stations or relay communication satellites uplink channel (Figure 4).

System Operating Mode

Payload operation and application ground system has four work modes. They are Minimum system work mode (MSWM), Normal work mode (NWM) and Emergency work mode (EWM). When the software, computer system or network device of the payload operation and application ground system are failure, the MSWM mode required to start to make sure continued space science experiments mission not stopped. The NWM mode refers to the payload monitoring and

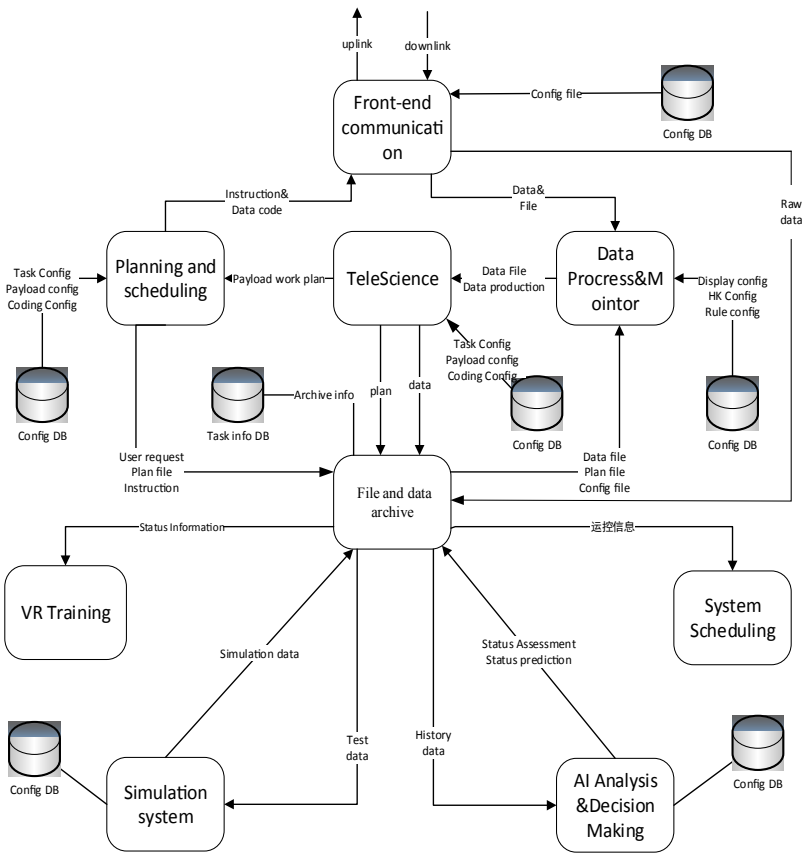

Figure 4: System data flow.

management in accordance with the normal operation control flow and data processing flow to work. It is the most conventional and most comprehensive work mode of our ground system during the space station on orbit. The EWM mode is a special work mode of our system. It will start to work when the payload of the Space station will be broken or has broken. In this mode, we will deal with temporarily interrupted the normal operation control process (Including data processing and task Planning) by fault plan manual requirement to rescue the payload equipment.

Conclusion

China's space station will be launched at year 2018; this space station is China's largest space science experiment and application platform until now. It will stay in space orbit more than a decade and have many complex scientific space experimental tasks to do step by step in the future.

The system uses a lot of new information technology and has all complete function of the payload ground support system. We hope this payload operation and application ground system of China's space station will support the payload application system to obtain significant scientific and technological achievements and improve the effectiveness of the payload work in the future.

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