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A high availability application service platform for nuclear power enterprises

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Abstract

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Keywords

power, nuclear, platform, enterprises, service, high, application, availability

Disciplines

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A High Availability Application Service Platform for Nuclear Power Enterprises

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Abstract—This paper presents a High Availability Application Service Platform (HAASP) and analyses its high availability. The architecture of this platform contains application server platform and high availability architecture. Application server platform consists of three major components, application release platform, which is implemented with WebLogic and WebSphere cluster, application and database platforms, which are built with Oracle RAC, and IBM Domino cluster. High availability architecture is constructed by virtual machines, distributed switches and storage pools. It employs virtualization technology to integrate physical servers and storages, where physical servers are responsible for the creation of virtual server cluster, distributed switches, storage pool and management of storages. Application server platform runs on the high availability architecture and our experiment result shows that HAASP, as a scalable and flexible architecture, could offer more persistent service compared with traditional application service platforms.

Keywords: Virtualization, High availability, Cluster

I. INTRODUCTION

Nuclear power companies are energy enterprises aiming to provide clean energy. Nuclear safety is a paramount goal than any other issues, therefore all manufacturing operations should focus on ensuring nuclear safety. Nowadays, with the constructional progress of nuclear power projects, developments in related businesses and advancements of information system among the nuclear power enterprises, the constructional and operational management of nuclear power companies are strongly supported by their information systems. In the meantime, the safety and stability of information systems directly influences the operation of nuclear power companies. The information security of nuclear power industry has become an integral part of nuclear security, and it has become more important with the deep combination of nuclear power business and information systems.

Shangdong Shidao Bay Nuclear Power Co., Ltd, the owner of approximately twenty applications and a variety of databases, has published numerous Web application services through a variety of application platforms. Secure access measures of these applications, and whether or not they are able to provide sustainable services, are important issues which need to be considered by information management department. In addition, it is necessary for data centers of nuclear power companies to pay attention to operation and management related data storage, emergency data recovery and disaster recovery of their information systems. Therefore, one of the most important objectives of Shidao Bay Nuclear Power Co., Ltd is to build a highly available application service platform to ensure the safety of nuclear power business.

With the extensive development of virtualization and clustering technologies, the goal of building a HAASP (namely High Availability Application Service Platform) can be achieved through combining the advantages of virtualization and clustering technology. This article will look through x86 server architecture to describe how to design and build the HAASP. This article is organized as follows: section two introduces related work, section three describes the design and implementation of the system, section four is performance assessment of the

system, section five is the conclusion.

II. RELATED WORKS

In information technology field, "high availability" refers to a system that is specially designed to provide high availability services and reduce downtime. The core objective of building HAASP is to achieve "zero" downtime and rapid emergency recovery. The HAASP described in this article is specifically designed to meet high stability and performance requirements, and its capability of rapid recovery and immunity of hardware malfunction are also novel if compared with other application systems. The virtualization product such as VMware vSphere [1], cloud computing products like Google GFS [2] and Hadoop HDFS [3] and cloud storage products like DeDu [4][5] are specifically designed for high availability information systems. However, the meaning of term "high availability design" is completely different between virtualization and cloud computing technology. This article is going to briefly introduce the technology model of HAASP in following sections.

A. Application release system

WebLogic [6] and WebSphere [7] are the application release systems of mainstream enterprises. WebLogic is a Web server which is launched by Oracle, and it is primarily used for Web systems developed in Java programming language. WebLogic is a full implementation of the J2EE 1.5 Specifications - the latest Web service standard and the most advanced interoperability standards. Its kernel provides unified security, transaction and management services in an executable, extensible, and reliable way. WebLogic server supports deploying applications in highly available and scalable environments. Via configuring its server instance cluster, WebLogic can balance its server load, handle hardware and network related issues without delay. Its extensible security features preserve secure data access, ensure enterprise data security and prevent malicious attacks. WebLogic server provides a suite of management tools, which can help system administrators to monitor and optimize the performance of Web applications or server itself. Furthermore, those tools can automatically monitor and optimize applications for server via proper cluster configurations. WebLogic provides robust and secure environment for users to deploy large number of applications.

WebSphere application server is an open and full-featured Web application server, which is based on servlets and Java Web application runtime environment. WebSphere application server contains Express Web Traffic, Network Dispatcher, and AFS distributed file system. Besides, WebSphere is an application server which can work with or extend IIS, Apache and Netscape HTTP Web servers.

B. Virtualization technology

In recent years, virtualization technology has made significant progress. Popular virtualization products include VMware vSphere5, Citrix Xen [8] and Microsoft Hyper-V [9]. VMware vSphere5 consists of components like ESXi, vCenter and Data Protection. It ensures dynamic migration and high availability of virtual machines by building virtual resource pool with ESXi, managing virtual machines with vCenter and backing up virtual machines online with Data Protection. Citrix Xen is an open source, x86 architecture based virtual machine manager developed by Cambridge University. Multiple virtual machines with different operating systems can run parallel on Xen. It presents great performance by using para-virtualization method to modify virtual machine kernel and work coordinately with virtual machine monitor. Microsoft Hyper-V is a system management virtualization platform based on Windows Server. And widespread use of Windows Server has made Hyper-V more popular. Hyper-V employs microkernel architecture to let application processes run on ring 3, virtual machine kernel and driver processes run on ring 0 and Hypervisor run on ring -1. This architecture does not involve any binary privileged instruction translation, therefore, it guarantees both performance and security.

C. Database

Distributed databases like Google Bigtable [10] and Hadoop Hbase [11] have similar design concepts, and they both have good adaptabilities with cloud computing platforms. However, the corresponding products are not being widely used. Regardless of using X86 Servers or IBM Power series, most of the large and medium enterprises choose Oracle as their main database system. It seems to be a more reasonable choice to construct cloud computing platform based on Oracle products. Oracle RAC [12] technology greatly enhances the availability of our databases, and Oracle Clusterware enables database cluster to run on multiple platforms. Oracle RAC uses real-time application cluster to construct database grid, and the real-time application cluster can change its size without modifying the application, it manages its size by adding or removing server nodes. Oracle 10g/11g supports popular platforms via Clusterware, and forms an end-to-end solution which can provide real "high availability", fault tolerance and seamless switching function to minimize negative effects of hardware or software errors. The architecture of Oracle RAC is

shown in figure 1.

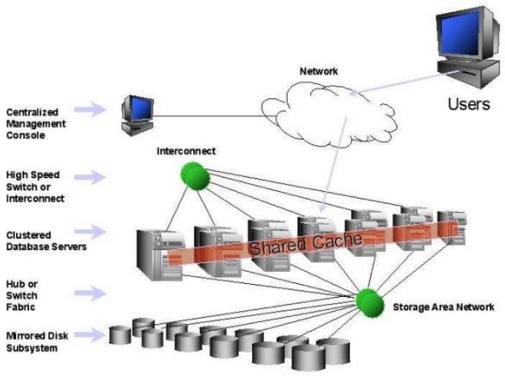

Figure 1. Oracle RAC Architecture

Domino database cluster [13] is a server group consists of two or more database servers. It can provide continuous data access, load balancing and better server performance. The server cluster provides copies of the database which are available to users at any time. If a user tries to access an unavailable database in the cluster database, Lotus Domino will open a mirror copy of this database on another server in the cluster if a copy does exist. Lotus Domino constantly synchronizes its databases to make sure all users can have exactly the same copy of certain data. By doing this, it assures the high availability of its important databases. The cluster provides a failover methods for business-critical databases and servers. These methods include transferring the load of a failed server to another server in the cluster, balancing server load and synchronizing data between database nodes. The architecture of Domino cluster is shown in figure 2.

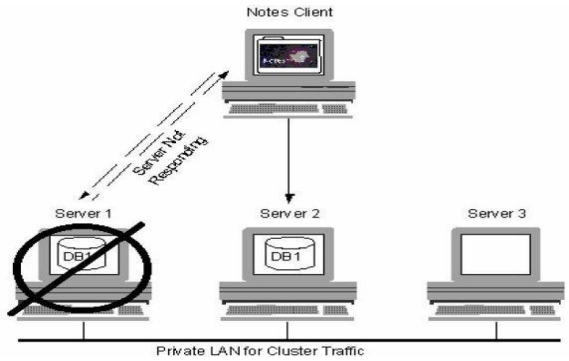

Figure 2. Domino Cluster Architecture

Single node failure of servers will not affect the performance of database cluster. However, how to remove the failed server node from the cluster and re-deploy new server node quickly in order to assure database security and performance becomes a new problem. Just relying on cluster technology is not enough for nuclear enterprises, which require extreme stability and reliability. Therefore, we combine the virtualization and clustering technology to construct a HAASP in order to meet the high availability needs of nuclear power industry.

III. SYSTEMS DESIGN AND IMPLEMENTATION

A. System architecture design

The theoretical model of HAASP is based on the cluster technology and virtualization platform. This platform consists of two layers: the first layer is high availability architecture and the other layer is the application service platform. High availability architecture is built up by virtualization technology and physical server cluster. It utilizes virtualization technology to integrate physical servers and creates multiple virtual machine clusters. When a physical server collapses, high availability architecture can migrate all its virtual machines and finish rebooting them in a short time through Fault Tolerant mechanism of virtualization technology and High Availability features.

Application publishing platform, application system and database platform are three main parts of application service platform. According to the design of platform architecture, the application-publishing platform and database platform are both deployed using cluster mode, if an application system doesn't support cluster mode, then it is deployed using Fault Tolerant or High Availability mode. In order to achieve a high availability application service platform, application service platform should run on the high availability architecture, the example is shown in figure 3.

In a HAASP, the high availability architecture and application service platform should collaborate with each other to ensure safe and stable operation of high availability servers. Therefore,

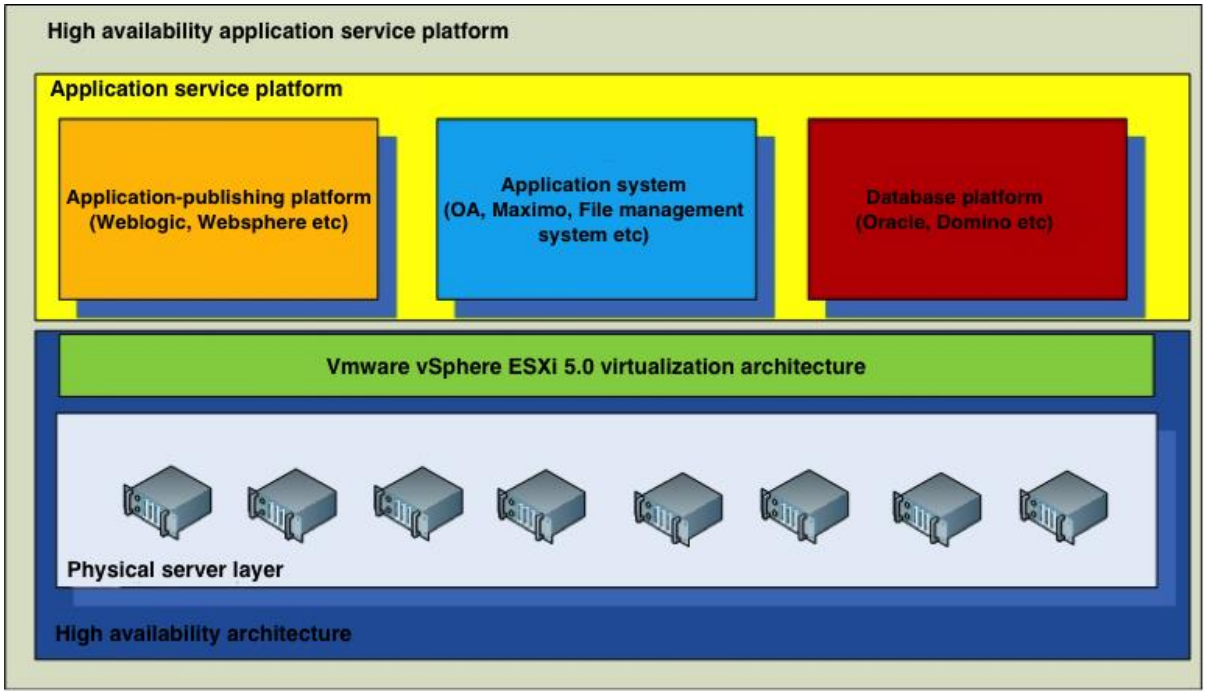

Figure 3. HAASP Architecture

application-publishing server cluster, application system cluster and database cluster are deployed to virtual machines on different physical servers. Virtualization architecture can be configured for high-availability, where all the business systems use Oracle or Domino databases and they are published on WebLogic or WebSphere. From the aspect of application systems, all the applications are using clustered deployment method; therefore, whenever either a virtual machine or a physical machine goes down, the operation of the whole system will not be affected. In addition, the clustered deployment of the application system allows us to increase server nodes for application and database servers at any time to balance their load according to their work load. From the aspect of performance, the virtualization architecture, which is based on vSphere, consolidates multiple physical devices and storages, constructs distributed switch through its own network interfaces. It distributes computation, storage access and network access needs of the application systems into different physical servers and distributed switches, and makes servers back up and monitor each other. Once a physical server, a storage or a network interface failure is spotted, another physical server or local storage will take over the current works instantly to ensure the continuity of the ongoing business process.

B. System Implementation

In our implementation, application-publishing platform uses Oracle WebLogic server 11g R1 which is running on Windows Server 2008 Enterprise R2 and it takes on clustered deployment. Database platform uses Domino Server Cluster and Oracle 10g RAC. Domino Server Cluster is running on Windows Server 2008 Enterprise R2 as well, but Oracle 10g RAC is running on Oracle Enterprise Linux. High availability architecture is supported by virtualization platform named VMware vSphere 5.1, which integrates four IBM3850X5 physical servers and one EMC VNX storage. Each physical server has four Xeon E4830 2.13GHz 8 core CPUs, one 256GB RAM and three 320GB hard disks. Above physical server is powerful enough to meet the performance requirements of multiple virtual machines.

The deployment view of virtual machines is shown in figure 4. Oracle RAC virtual server **a** and Oracle RAC virtual server **b** are distributed on the first and second physical servers, using the disk array to store the ‘virtual disk file’ and communicating between virtual machines through Distributed Switch. Similarly, the Domino Server Cluster, WebLogic, WebSphere, OA, internal Web sites and other systems are also deployed through this way. The HA feature of the virtualization architecture ensures that the virtual machine in the cluster can reboot and restore the full functionality of the cluster within a very short time after a node goes down.

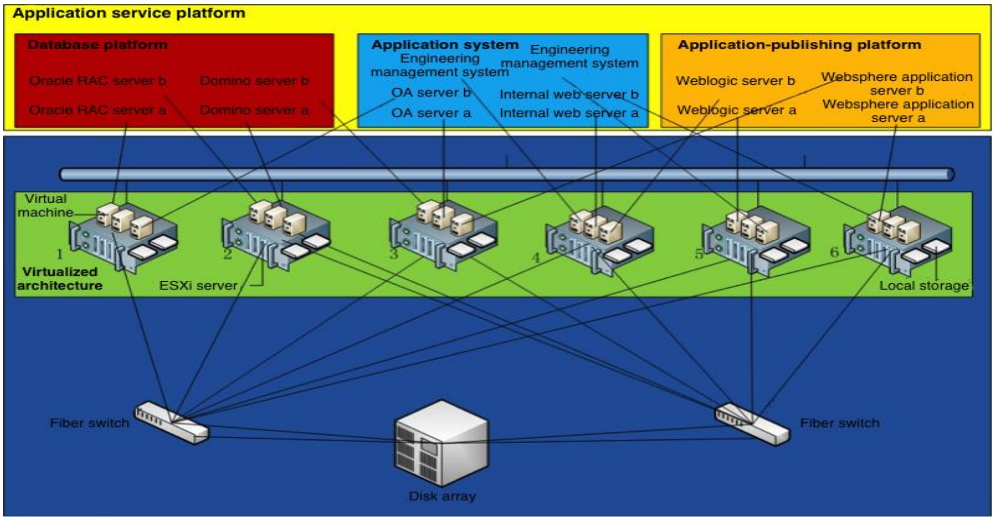

Figure 4. Deployment view of HAASP

In the application system, some applications like "engineering management system" do not provide cluster deployment. Therefore, we have to build up Fault Tolerant features to the virtual machine of engineering management system. We deployed a master node virtual machine on a physical server, and deployed a mirror node on another physical server. The mirror node does not provide any service but it will copy real time tasks and data from the master node, and when the master node goes down, the mirror node automatically takes over the master node's tasks and completes a seamless node switch.

IV. HAASP PERFOTMANCE ANALYSIS

A. Oracle RAC node switch test

We tested node switch operations under Oracle RAC architecture and traditional master-backup database. The below test result shows that switch operation under Oracle RAC architecture requires much less time compared with traditional master-backup architecture when node failure occurs. Table 1 shows detailed comparison between two types of databases.

Oracle node switch operation	**RAC**	**Traditional master-backup database**
Re-configuring group members	15 seconds	0 second(not mentioned)
Re-configuring distributed lock	5 seconds	0 second(not mentioned)
Switching hard disk	0 second	≥20 minutes
Restarting Oracle	0 second	5 to 20 minutes
Re-building cache	0 second	20 minutes
Total switch operation time	≤60 seconds	≥35 minutes

Table 1. Node switch time comparison between Oracle RAC and traditional master-backup database

B. Startup time test

Starting up a server takes two steps, verifying hardware and starting the operating system. For physical server, we chose IBM 3850X5 which had four Xeon E4830 2.13GHz 8 core CPUs, 256GB RAM and four 320GB hard disk. At startup time, the physical server will verify its hardware and if there are external storage devices, the system will continue to recognize them, after that, the operating system is started. According to our test, average time for performing self verification was 2 minutes 40 seconds, average time for starting operating system was 1 minute 10 seconds, so the average of total startup time was 3 minutes 50 seconds.

As for virtual machines (quad-core CPU, 8GB memory and 50GB disk space), since it does not have any concrete hardware, the system only needs to check configuration files other than verifying physical devices at startup. Furthermore, virtual machines have non-volatile memories, so the startup time is significantly reduced compared with physical servers, and it will also reduce troubleshooting time. According to our test, average time for a virtual machine (described above) to perform self verification was 5 seconds, average time for starting operating system was 45 seconds, so the average of total startup time was 50 seconds.

C. New node deployment

In real world environment, there should be one or more standby servers, which can replace breakdown server nodes. It is waste of resource if we use physical devices as standby servers, because these devices are not accessible unless some server node goes down. Moreover, in order to deploy a physical

server into an existing cluster, much configuration and debugging work should be conducted. In contrast, if we use virtual machines as standby servers, we can use templates to configure and deploy servers into existing cluster easily. In normal cases, the virtual machines are switched off and managed as normal files in storage devices, but in emergency, the virtual machines can be started in one minute and added into the preset cluster. This approach can save much time, effort and resource.

V. CONCLUSION

This paper presents a High Availability Application Service Platform(HAASP), which benefits from the combination of application server and high availability architecture to efficiently avoid system collapse caused by hardware or virtual machine failure. High availability and security of the business system is ensured by HAASP. With the help of virtualization and unified storage, we can build up high availability architecture by creating multiple virtual machines, distributed switches and storage pool. We take advantage of High Availability and Fault Tolerant features of WebLogic cluster, Oracle RAC and virtualization to build up application server platform, and use high availability architecture to support operation of the platform. Test results show that our HAASP is more robust and it can offer better persistent service compared with traditional application servers. Furthermore, HAASP is also an extensible and flexible architecture. Our HAASP is robust enough to meet business's persistency and security requirements in nuclear power industry. It can remove breakdown server nodes and add new server nodes to the cluster in a short time. In future research, we will focus on implementing automated replacement of breakdown database servers and optimizing the performance of the high availability cloud storage system.

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