

# VIRTUALIZATION IN CONTROL SYSTEM ENVIRONMENT

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## Abstract

In large scale distribute control system, there are lots of common service composed an environment for the entire control system, such as the server system for the common software base library, application server, archive server and so on. This paper gave a description of a virtualization realization for control system environment include the virtualization for server, storage, network system and application for the control system. With a virtualization instance of the epics based control system environment that built by the VMware vSphere v4 [1], we tested the whole functionality of this virtualization environment in the SSRF [2] control system, include the common server of the NFS, NIS, NTP, Boot and EPICS base and extension library tools, we also virtualization the application server such as the Archive, Alarm, EPICS gateway and all of the network based IOC. Specially, we test the high availability (HA) and VMotion for EPICS asynchronous IOC successful under the different VLAN configuration of the current SSRF control system network.

## THE SSRF CONTROL SYSTEM ENVIRONMENT

A uniform environment which based on PC Linux system had been set up for the system development and operation in SSRF control system [3]. It composed with sets of server system that running Centos system and supplying the EPICS development and high level physics application environment. NIS and NFS server were used to manage user account and share resource. As part of runtime environment, the database server, boot server, Soft IOC server and EPICS application server such archive and alarm handler were installed at the server room.

Several versions (from v3.13.x to v3.14.8.2) of EPICS based with cross-compiler support were installed in the runtime environment and the base 3.14.8.2 is used currently. The target include the Linux-x86 and ppc-604\_long architecture which is defined in EPICS.

Moreover in this environment, the EPICS extensions had been installed includes all the tools we needed like the EPICS tools like sequencer, ALH, EDM, MEDM, archive engine and so on. A standard directory structure of the entire environment was defined for all users in a centre NFS server, looks like the "/usr/local/epics/base-3.xx.xxx" for epics base, "/opt/matlab" for the MatLab.

During the operation in past years at SSRF, there were several times of the server system crash in control system environment and brought the accelerator shutdown accident. At the once of most serious it generated the shutdown more than 24 hours waiting for resume the server system normal at the once of most serious. Especially, there were many centralized IOC servers used

for large amounts of asynchronous devices in SSRF control system. It will cause the beam lost frequently when these IOC servers down. A step further, the server crash will cause the data lost permanently and consume more time to reinstall the IOC server.

Based on these problem above, we think about the virtualization of the whole control system environment to reduce the failure rate and increase the MTBF of control system environment though the high availability and auto migration on fault brought by the virtualization.

## VIRTUALIZATION OF SSRF CONTROL SYSTEM ENVIRONMENT

SSRF controls system environment was used for operation, management and maintenance of the whole SSRF facility. The server system achieved the application of control system and the user management. For the long time stability of server system and satisfy of the requirement of 7X24 hour running, we adopted the virtualization technique and tested in control system environment [4] Include the server system virtualization and the application virtualization.

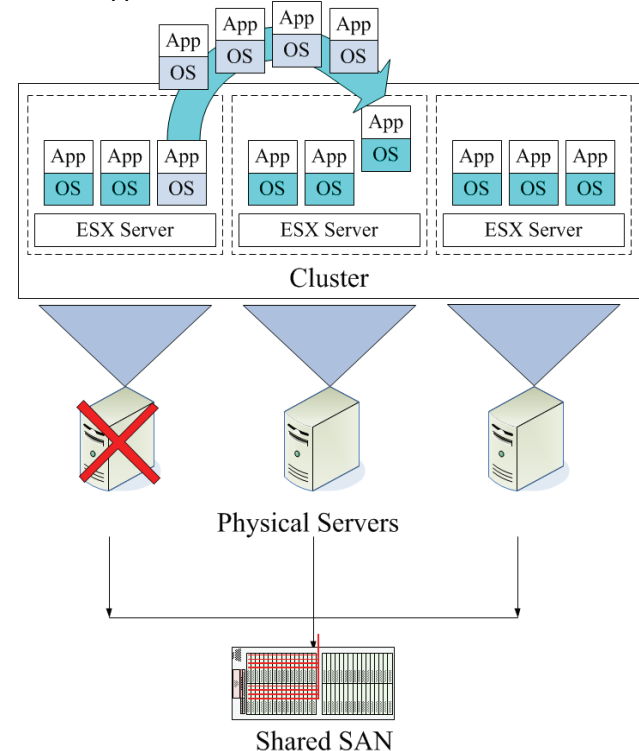


Figure 1: Structure of the virtual server system.

The SSRF virtual server system composed with 16 Dell PowerEdge 2950 PC rack server and a EMC CX-320 SAN storage system, every server used a HBA card connect to the centralized SAN storage system that realized the high availability virtual machine system with online migration capability (see Fig. 1). Another thing

need to noticed was that all the virtual machines operation system also must be installed on the SAN storage system to get the auto migration ability when the hardware fault. Cause we did not need the 100% availability. We did not use dual HBA link connection redundancy, just keep a SAN switch and some HBA card as the replacement part. The only risk is the replacement time of SAN switch when it on fault. The estimated time of change of SAN switch is about 10 minutes.

### Hardware Resource Allocation Principle of Virtual Machine

According to the current status of the SSRF server system, the CPU and memory utilization is very low. For some typical system in SSRF, the memory used of archive engine is 484M, YUM and NFS is 1.2G, IOC Server is 338M. So we make the hardware resource allocation rule as below:

- Type1: 1 CPU, 2G memory, 20G hard disk; Used for NIS, IOC server
- Type2: 2 CPU, 4G memory, hard disk based on requirement;
- Used for NFS, Archive server
- Type3: custom type, hardware resource was custom defined on demand.
- Used for some application such as Yum server, not need the high CPU and RAM utilization but may be need more hard disk.

For some special requirement for example the CA gateway, all the virtual machines used a single network adapter (virtual network adapter).

### The Template of the Virtual Machine

According to the principle of hardware resource allocation above, we made several different kinds of virtual machine template so that we can create new virtual server on demand. The frequently used templates were the application server and IOC server that help the administrator make a new application or IOC server quickly and easily. Because all the EPICS base library, IOC software and environment were preinstall and configured in the template, so do not need any install and configured process, the administrator just need to click mouse several times then a new application or IOC server was created and operation immediately.

The template also carry with the storage and network information so we can add new application server has specially depended and dive into use immediately, such as add new EPICS gate way or the archive server when expand the system.

### The VLAN setting for the IOC virtual machine

SSRF control system use VLAN to instead of device subnet. There are many asynchronous IOC server used for different sub system in different VLAN, such as the MPS IOC and the Vacuum IOC [5]. Before the virtualization, we need to run multiple IOC servers at one physical server, so we need to config VLAN setting for every physical server. After the virtualization we can run IOC

on virtual server one by one. The VMWare HA characteristic need to move these IOCs move from one physical machine to another physical machine, so we need to configure virtual switch with multiple VLAN on same physical server. In the physical machine network configure, we add virtual switch port group one by one and assigned with different VLAN ID of subnet to the virtual switch (see Fig. 2).



Figure 2: VLAN configure in virtual switch.

Except the IOC server, the EPICS gateway server is also across two different VLAN and need to configure virtual network switch that suit for different VLAN so that the virtual machine of EPICS gateway can migration between the different physical machine.

### The Implement of the Virtual Control System

We install the VMware vSphere v4 on all of the physical machines and build a virtual cluster system. On the virtual machine system, we created some storage group for virtual machine for different type of application in centralized storage, typically one special small IOC storage group for all virtual IOC servers, two big storage group for NFS server and the Archive server. Before the storage group created, we built the virtual machine templates and installed the EPICS and application software with system configure of SSRF control system environment, include the EPICS environment, network with VLAN setting. Finally we create all of virtual server in the current SSRF control system from the template, include the Yum, NFS, NIS, Boot, Archive, Database, IOC and so on.

### Testing of virtual control system environment

We have tested the virtual control system environment at the SSRF machine study time successful. All the functionality of control system environment can be operated normal and virtual IOC servers also work fine

with large numbers of network data transfers through the virtual network adapter, the maximal number of packets

can reach about ten thousand per second. Except the mainly target of the virtual machine system, we also

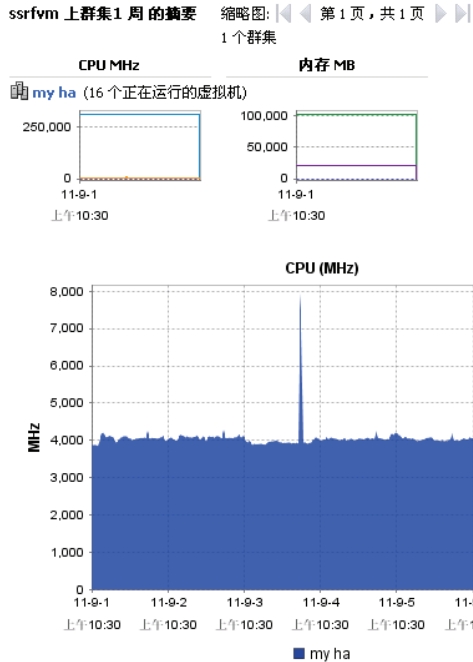


Figure 3: The resource average utilization of virtual machine cluster in one week.

tested the NFS and Archive disk read/write speed and all of results indicated the good performance of the virtualization, Fig. 3 shows the CPU and memory utilization in one week period. Include all the virtual server and application system, the online migration and physical machine crash simulation were tested and the fault migration were successful. The virtual machine and application all can be moved from the crashed physical machine it existed to other normal physical machine.

During the running in couple of month, we met some of hardware failure situation such as the hard disk and network fault, even cause the physics server crashed, all the virtual servers were still work continually and the virtual control system environment also keep normal running. After fixed the physical server, it can add to the virtual cluster quickly and seemed nothing happened.

### THE BENEFIT

The control system environment virtualization can integrate the hardware resource and raise the hardware utilization such as CPU and memory. The most direct results are we saved the servers and consume of power through the virtualization, we reduce the numbers of server in SSRF control system from more than 40 to 16.

The most import point is it can large improves the reliability of the control system environment and the MTBF of the whole facility by the high availability (HA) and VMotion characteristics of virtual machine system.

Other benefit is we can deploy virtual machine from the preconfigured virtual machine template easy and rapidly, that's bring more flexibility for the control system environment, all the work are the configuration of virtual system and no more any hardware work.

### CONCLUSION

We have built a virtual control system environment with high availability and auto migration on fault characteristics and used in normal operation of SSRF successfully. From the beginning to now, it works more than half of year and got the result of very stable operation with good improvement of MTBF for control system.

Used virtualization for EPICS IOCs of many asynchronous devices and application server in SSRF control system got the more flexibility and stability.

The virtualization bring benefits such as save hardware resource and achieve the high availability goal and demonstrated the virtualization technical that applied in the larger scale control system environment.

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