ISBN: 978-3-95450-221-9 ISSN: 2226-0358 doi:10.18429/JACoW-ICALEPCS2021-THPV046

VIRTUALIZED CONTROL SYSTEM INFRASTRUCTURE AT LINAC PROJECT PINSTECH

N. U. Saqib†, F. Sher*
LINAC Project, PINSTECH, Islamabad, Pakistan

Abstract

IT infrastructure is backbone of modern big science accelerator control systems. Accelerator Controls and Electronics (ACE) Group is responsible for controls, electronics and IT infrastructure for Medical and Industrial NDT (Non-Destructive Testing) linear accelerator prototypes at LINAC Project, PINSTECH. All of the control system components such as EPICS IOCs, Operator Interfaces, Databases and various servers are virtualized using VMware vSphere and VMware Horizon technologies. This paper describes the current IT design and development structure that is supporting the control systems of the linear accelerators efficiently and effectively.

INTRODUCTION

LINAC Project, PINSTECH aims at developing indigenous RF linear accelerators for medical and industrial purposes. Along with progressive research in this field, prototypes of 6 MeV Medical and Industrial (NDT) linear accelerators are being developed. IT infrastructure provides computing, network and storage resources, as well as several services to the accelerator control system, and also to engineers and scientists involved in research and development tasks. An Ethernet based Local Area Network (LAN) is deployed at LINAC Project. The overall LAN is divided into two segments: *Technical Network* and *Office Network*. Both networks are isolated and contain independent IT infrastructure. Measurement and control devices including commercial-off-the-shelf equipment and related devices are connected to the *Technical Network* while *Office Network* consists of users related devices including scientists' and engineers' PCs, printers, scanners, test equipment etc. For compute resources, Dell EMC PowerEdge servers are configured and installed to provide reliable services for both the networks. Servers are managed remotely via Integrated Dell Remote Access Controller (iDRAC) which eliminates the need of physical presence of server administrator to configure/reconfigure a server. For network resources, Allied Telesis Gigabit Ethernet network switches are installed to provide network connectivity and high bandwidth data transfer between nodes in the networks. Three types of network switches are utilized: unmanaged, web-smart and managed according to purpose of utilization. As multi-core processors become common, virtualization is an important technology to implement full utilization of hardware resources and reduce their footprint [1]. Virtualization enables running multiple virtual PCs simultaneously on one physical machine and allows multiple operating systems to work at the same time and on the same machine. Main advantage of virtual machines is that hardware resources such as processor, memory, hard disk, device controllers, network cards etc. can be dynamically increased or decreased according to the requirements.

SERVER VIRTUALIZATION

Server virtualization divides a physical server into multiple virtual machines by means of a software layer called hypervisor. Virtualization fully utilizes a physical server by distributing workload on virtual servers. Additional benefits include less hardware to buy and manage, more efficient resources usage and improved resilience. Dell EMC PowerEdge servers [2] are virtualized using VMware vSphere 6 [3] technology which is a data center virtualization solution. VMware vSphere consists of two components: VMware ESXi which is a type 1 hypervisor installed on bare metal server and vCenter Server which provides centralized management platform for ESXi hosts, virtual machines and other dependent components. Two Dell R740 servers are deployed in the *Office Network* and one Dell R630 server is deployed in the *Technical Network*. Specifications of both types of servers are provided in Table 1 and Table 2 respectively.

Table 1: Specifications of Dell R740 Server

Component	Specification
CPU	Intel Xeon Silver @ 2.1 GHz x 2
RAM	64 GB (32 GB x 2)
HDD	8 TB (2 TB x 4)
OS	VMware ESXi 6.7

Table 2: Specifications of Dell R630 Server

Component	Specification
CPU	Intel Xeon Silver @ 2.1 GHz
RAM	32 GB (16 GB x 2)
HDD	6 TB (2 TB x 3)
OS	VMware ESXi 6.7

TECHNICAL NETWORK

All components related to control system consisting of servers, desktop computers and commercial-off-the-shelf equipment are connected to the *Technical Network* to pro-

† najm.control@gmail.com
† falaksher@gmail.com

ISBN: 978-3-95450-221-9 ISSN: 2226-0358 doi:10.18429/JACoW-ICALEPCS2021-THPV046

vide isolation, security and reliability [4]. Dell EMC PowerEdge R630 virtualized server deployed in the *Technical Network* and shown in Fig. 1 provides the following services:

EPICS IOCs

EPICS (Experimental Physics and Industrial Control System) is a software toolkit to develop distributed control systems[5]. EPICS IOCs (Input/Output Controllers) deployed in our control system are soft IOCs operating in open source CentOS 7 operating system. IOCs are suitable to be run in virtual machines because none of the devices are directly attached to the hardware. Also, serial interfaces are converted to Ethernet by means of MOXA and USR-IOT Serial-to-Ethernet converters wherever possible.

Operator Interfaces

Operator Interfaces (OPI) are developed in Phoebus Control System Studio (CSS) which is a set of tools and application for developing Graphical User Interfaces (GUI) [6]. CSS is installed in a virtual machine and OPIs are designed and developed on it. OPIs are then deployed to *Operator Computer* in the *Control Room*.

Data Archiver and Alarm Services

Data archiver for recording history of process variables is implemented using CSS Best Ever Archive Toolset, Yet (BEAUTY). Alarm services for notifications about events is implemented using CSS Best Ever Alarm System Toolkit (BEAST). Both of these services are configured in CentOS 7 OS based virtual machine.

Database

Relational database for data archiver system is provided via MySQL server running in Microsoft Windows virtual machine.

Network Services

Domain controller residing in a virtual machine provides essential network services such as Active Directory Domain Services (ADDS), Domain Name System (DNS), Dynamic Host Configuration Protocol (DHCP), Windows Deployment Services (WDS) and File Transfer Protocol (FTP) servers.

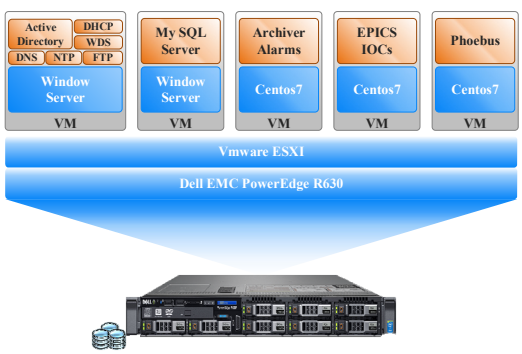

Figure 1: Technical Network Virtualization.

OFFICE NETWORK

General network consists of personal computers of engineers and scientists, workstations for simulations, servers for services and other equipment such as printers, scanners, test equipment etc. Two Dell EMC PowerEdge R740 servers deployed in the office network are virtualized using VMware ESXi 6.7 as shown in Fig. 2. These servers provide the following services:

vCenter Server

Open SUSE OS based vCenter Server appliance for managing ESXi hosts, virtual machines, network and storage.

Network Services

Domain controller provides essential network services such as ADDS, DNS, DHCP, WDS and FTP servers.

VMware Horizon Server

Microsoft Windows Server 2016 VM contains VMware Horizon View 7.11 Connection Server for providing Virtual Desktop Infrastructure (VDI). It provides a web based client interface to manage VDI. Adding/removing desktop pools, assignment of virtual machines to the pools and adding/removing of users' entitlements are few of the several important tasks managed through the client.

Nextcloud Hub

Centos 7 VM for Nextcloud Hub [7] provides collaboration platform for scientists and engineers. It provides many features such as file sharing, storage, announcements, chat, contacts, photos etc.

GitLab Server

CentOS 7 VM for GitLab server provides version control system and much more. It is a private server consisting of five users and is being tested currently. After testing, it will be integrate into the system soon as it provides essential services for software development.

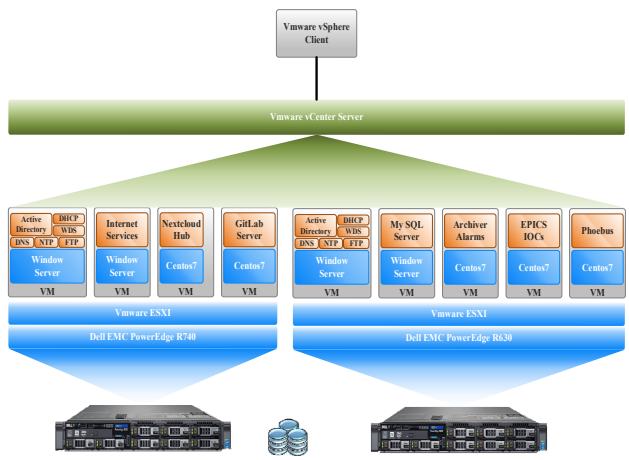

Figure 2: Office Network Virtualization.

ISBN: 978-3-95450-221-9 ISSN: 2226-0358 doi:10.18429/JACoW-ICALEPCS2021-THPV046

VIRTUAL DESKTOP INFRASTRUCTURE

Virtual Desktop Infrastructure refers to desktop hosting environment on a central server that manages and allows access of desktop and server operating systems running in virtualized machines, and deploys them to end-users on requests [8]. VMware Horizon 7 is used to provide desktop virtualization environment at our facility. Currently, main purpose of VDI is to provide internet access, and to provide remote workstations to scientists and engineers for helping out in their research and development tasks. Access to internet services is provided to users through a virtual machine that contains a dedicated network interface to a public network. HP Zero Clients and Horizon client software for Windows are used at end-user side to connect remotely to these desktops. Other desktops configured include dedicated user PCs for some users. Figure 3 presents layout of the deployed system.

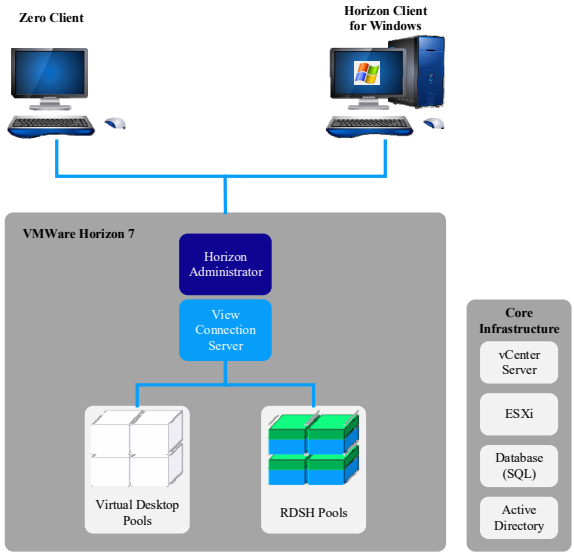

Figure 3: VDI Layout.

CONCLUSION

Virtualization technology has greatly improved development & deployment of the control system and services in terms of stability and reliability. Office Network is providing services as well as a collaboration platform for scientists and engineers. There is a room for a lot of improvement including new hardware and software technologies. We are gradually moving in the right direction but are limited with manpower and expertise. We expect significant upgrades in near future.

REFERENCES

[1] U. Felzmann, N. Hobbs, and A. C. Starritt, "Virtualisation within the Control System Environment at the Australian Synchrotron", in Proc. 15th Int. Conf. on Accelerator and Large Experimental Physics Control Systems (ICALEPCS'15), Melbourne, Australia, Oct. 2015, pp. 664-666. doi:10.18429/JACoW-ICALEPCS2015-WEM303

[2] Dell, https://www.dell.com

[3] VMware, https://www.vmware.com

[4] P. Kurdziel, "VDI (Virtual Desktop Infrastructure) Implementation for Control System - Overview and Analysis", in Proc. 16th Int. Conf. on Accelerator and Large Experimental Physics Control Systems (ICALEPCS'17), Barcelona, Spain, Oct. 2017, pp. 501-502. doi:10.18429/JACoW-ICALEPCS2017-TUPHA048

[5] EPICS, https://www.epics-controls.org

[6] Control System Studio (CSS), https://www.controlsystemstudio.org

[7] Nextcloud, https://www.nextcloud.com

[8] S. W. Kim, H. J. Choi, H. S. Kim, and W. W. Lee, "A Virtualized Beamline Control and DAQ Environment at PAL", presented at the 17th Int. Conf. on Accelerator and Large Experimental Physics Control Systems (ICALEPCS'19), New York, NY, USA, Oct. 2019, paper WEPHA078, pp.1273-1275. doi:10.18429/JACoW-ICALEPCS2019-WEPHA078