

A Study on Building a VMware-based Virtual Network

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1. Introduction

KHNP is working on the APR1400 MMIS digital twin R&D project using virtualization technology. [1]

APR1400 MMIS is divided into a case where Korean digital MMIS is applied and a case where Westinghouse MMIS is applied. The goal of the research carried out by KHNP is to develop a digital twin of Korean digital MMIS. [2]

One of the advantages of digital twin is that it can monitor and control all the information in the virtualization target. This is the same for virtual networks. In the case of physical power plants, it is difficult to acquire and analyze network packets due to issues such as cybersecurity. However, in a virtual network environment, it is possible with a simple setup.

This paper presents a method for building a virtual network in the MMIS digital twin and a method for acquiring and monitoring network packets in a virtual network.

2. Methods and Results

In this section, we will explain the structure of the Korean digital MMIS network and how to implement it in the VMware environment, which is a virtualization software.

2.1 Characteristics of MMIS Network

Figure 1 is a diagram of the structure of the APR1400 MMIS network. In the structure of the MMIS network, the root switch is located at the top, and the fan-out switches are located at the bottom.

All controllers and servers are distributed in the root switch and fan-out switch, respectively, according to the system characteristics.

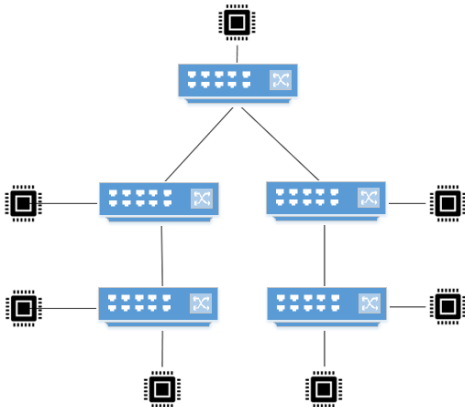


Fig. 1. Diagram of APR1400 MMIS Network Topology

2.2 Characteristics of VMware-based Virtual Network

The virtualization solution used vSphere from VMware. When using vSphere, the types of vSwitch (Virtual Switch) can be divided into Virtual Standard Switch (VSS) and Virtual Distributed Switch (VDS).

VSS is the basic vSwitch that allows connectivity to VMware environment and is an L2 switch with general functions. However, VDS is more powerful and has many features, especially mirroring. Therefore, to mirror the packets of the virtual network in the MMIS digital twin, VDS must be used. However, to use VDS, all VMware software licenses must be upgraded to Enterprise Plus level. This has a problem of greatly increasing the overall project cost.

Table I: Terminology of Virtual Network Component

Term	Content
NIC	Network adapter cards used in traditional servers
pNIC	The network adapter cards used in traditional servers are called pNIC in server virtualization
vNIC	Virtual machine's network adapter card
vSwitch	A virtual network switch located inside the physical server
Port Group	A logical group on a virtual switch(the unit to which security rules and policies can be applied)
VMKernel Port	Ports that can be connected to a port group and have IP settings
Uplink Port	The port used by the virtual switch to send traffic out of the physical server
Virtual Network	Network for communication between virtual machines inside the server and communication to the outside

2.3 VMware-based Virtual Network Limitation

Virtual network design in a digital twin requires a change in the physical network topology. In particular, the network of APR1400 MMIS has a hierarchical topology, but VMware's virtual network does not support the hierarchical topology. The limitations of VMware virtual network are as follows.

- 1) A vNIC can only be connected to one Port Group
- 2) A Port Group can be created in one vSwitch, and it is not possible to create duplicates in a Port Group with the same name

- 3) vSwitch and vSwitch cannot be directly connected
- 4) One vSwitch can have multiple Uplink Port
- 5) One Uplink Port can only be connected to one vSwitch
- 6) A VMKernel NIC can only be connected to one Port Group

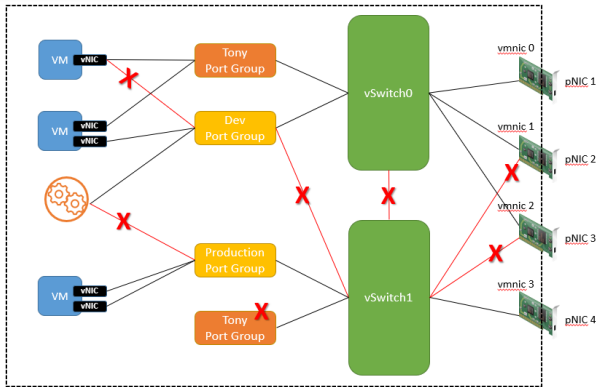


Fig. 2. Diagram of VMware-based Virtual Network Limitations

2.4 How to build a virtual network

It is impossible to make the hierarchical topology of the MMIS network into a physically identical topology in the VMware virtual network due to VMware network constraints. However it is possible to configure a virtual network having the same logical topology.

MMIS digital twin plans to create a GUI of physically identical topology and match the GUI with a virtual network with a logical topology to show it. Through the virtual network GUI, the user can acquire network information and packets of points that are symmetrical with the physical MMIS.

Network monitoring is necessary to detect and prepare for problems that degrade network performance or changes in the controller's status or network availability. VMware's own tools can be used to collect the status of virtual networks. Network monitoring can be acquired through GUI and CLI methods. VMware can acquire a lot of information such as network speed, link connection status, packets transmitted per second, megabits transmitted per second, and packets transmitted and received dropped.

vSphere can use the `pktcap-uw` utility to acquire packets in a virtual network. The `pktcap-uw` can be used without upgrading VMware's license for installing additional programs, and it enables packet capture at multiple points in a virtual network.

Network packets can be saved as files in the host's storage using the `pktcap-uw` command, and the saved files can be analyzed using network analysis tools such as Wireshark. With VDS, it is also possible to send acquired packets remotely, but VSS can only simply acquire packets.

Virtual network packets can be obtained by accessing the DCUI (Direct Console User Interface) of ESXi, enabling Shell and SSH, and using the `pktcap-uw` command. The `pktcap-uw` command can use various options, and it is possible to capture packets of a virtual network in one direction. Figure 3 shows the locations where packet acquisition is possible using `pktcap-uw`.

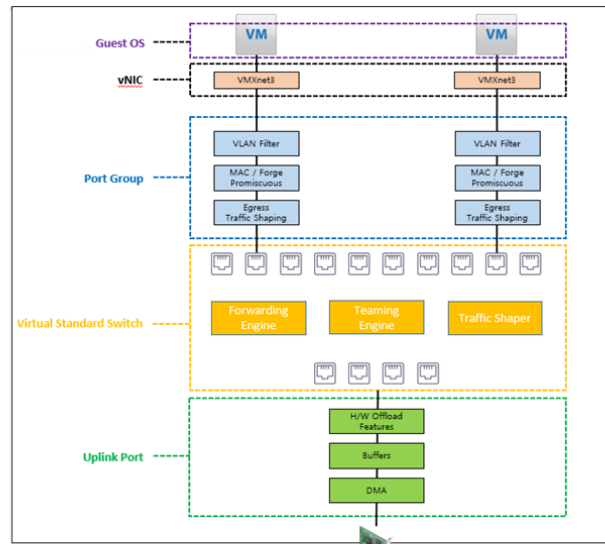


Fig. 3. Network Packet Capture Location – vNIC, Virtual Standard Switch, Uplink Port.

3. Conclusions

The MMIS digital twin aims to implement the physical structure of the Korean MMIS in a virtual environment as it is. However, due to the limitations of VMware, it is impossible to implement the hierarchical topology of the MMIS network as it is. This paper showed how to acquire packets without upgrading VMware's license. Also, by mapping the acquired network data to GUI that is physically identically implemented, it was shown how the user can check the information of the physically identical network configuration.

REFERENCES

- [1] Sungjin Lee, Won Woong Ko, "Basic Concepts of APR1400 MMIS Digital Twin using Virtualization Technology", Transactions of the Korean Nuclear Society Spring Meeting, 2020.
- [2] Sungjin Lee, "Development of digital twin of APR1400 MMIS based on Virtualization techniques", Conference on Information and Control System, 2021.
- [3] vSphere Networking Update 3, VMware, Inc.