

Virtualization as an Obsolescence Mitigation Strategy

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Exelon Generation®

Background – Exelon’s PPC Long-Term Asset Management Strategy

Original PPC Replacement Plan Approved in 2002 to replace obsolete, legacy PPCs with a fleet-standard solution (Scientech R*Time)

PPC Long Term Asset Management (LTAM) Strategy implemented in 2011 to address Continuous PPC Life Cycle Management

- Continues replacement plan and includes periodic refreshes as part of strategic life cycle management initiative
- Refresh hardware, O/S, and applications every 7 years
- Full system and I&O replacement every 21 years

Replacement Projects Completed:

- Ginna (2001)
- LaSalle (2003/2004)
- Oyster Creek (2004)
- Dresden (2005/2006)
- Clinton (2008)
- Quad Cities (2009/2010)
- Nine Mile Point 1 (2011/2012)
- Byron (2011/2012)
- Braidwood (2011/2012)
- TMI (2016)

Replacement Projects Underway/Planned:

- Limerick (2014 - 2017)
- Nine Mile Point 2 (2015 – 2018)
- Peach Bottom (2017 – 2019)
- Fitzpatrick (????)

Refresh Projects:

- LaSalle (2016)
- Oyster Creek (2016)
- Dresden (in-progress)

The Oyster Creek Challenge

- Per the LTAM strategy, Oyster Creek PPC refresh was planned for 2013
 - Due to a unique set of economic conditions and changing environmental regulations facing the plant, ending operations in 2019 was determined to be the best option for the company, employees and shareholders
 - Given these economic realities, the team was challenged to research and recommend lower-cost options to the planned full refresh (upgrade Hardware, Applications and OS)
 - The Oyster Creek PPC is needed past 2019: Due to emergency plan commitments the system will need to be maintained until 2023 at a minimum, and possibly up to 10 or more years after shutdown based on OE from several decommissioning nuclear plants.
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Goals

- Maintain a stable, operating PPC until end of plant operating life
- Have a reliable platform for continued monitoring during decommissioning period
- Minimize cost
- Minimize Engineering impact
- Minimize Risk

The Solution

Platform Virtualization

- Upgrade to current computer hardware
- Retain R*TIME Version
- Retain Operating System Version
- No Application Code Changes
- No Significant New Functionality

Pros:

- Much lower cost (less than half the cost of traditional refresh)
- Minimal Testing, Engineering and Validation
- Ability to easily re-host hardware for extended operation
- Maintain high availability to meet regulatory requirements
- Simplified Disaster Recovery

Cons:

- Inability to add functionality (new applications, interfaces, etc...)
- Limited/reduced support model (Scientech, Microsoft)
- “First-of-a-kind” risks and unknowns...

Virtualization Concerns/Unknowns

- First of a kind: No other known instances of a Production Nuclear Plant PPC running in a virtual environment
- I/O performance, DAS in particular
- Testing Strategy
- Scope and Roles/Responsibilities definition between Exelon and Scientech

Risk Mitigation

Proof-of-Concept testing performed in Cromwell, CT

Virtualizing a replica Oyster Creek system would be ideal, but impractical (No DAS, limited HMI and Plant System Interfaces available). So, since TMI's system just happened to be on the floor after FAT...

- Virtualized TMI System

- Post FAT configuration setup to run in a VM

- Complete TMI DAS Connected – Significantly more I/O than Oyster Creek
- TMI HMI connected and available
- TMI Archive Configuration Fully Configure
- Some Serial Link Connectivity
- All TMI Applications Running

- Testing the Environment

- Scientech Did Basic Operability Check
- System Made Available to Oyster Creek and Staff for Testing
- Oyster Creek Executed Desired Performance Testing
- Main Focus: I/O, SOE's and Archive

Results of Testing

- No Noticeable Performance Loss
- Data Acquisition Performed as Expected
- Archive Worked Properly
- Normal System Function (Failover, Active/Standby Communication, Messaging, etc.) all operating normally.

Oyster Creek Implementation

Hardware for PPC server:

Exelon Corporate Standard Server Offering

- 1U Rack Mount Servers
- Dual RAID Setup with Hot Spare
 - In order to separate Hypervisor Disk I/O and PPC Disk I/O
- Multiple Gigabit NICs for redundancy and management
 - Replicated Existing Network Connections
 - Added VMware Network Redundancy

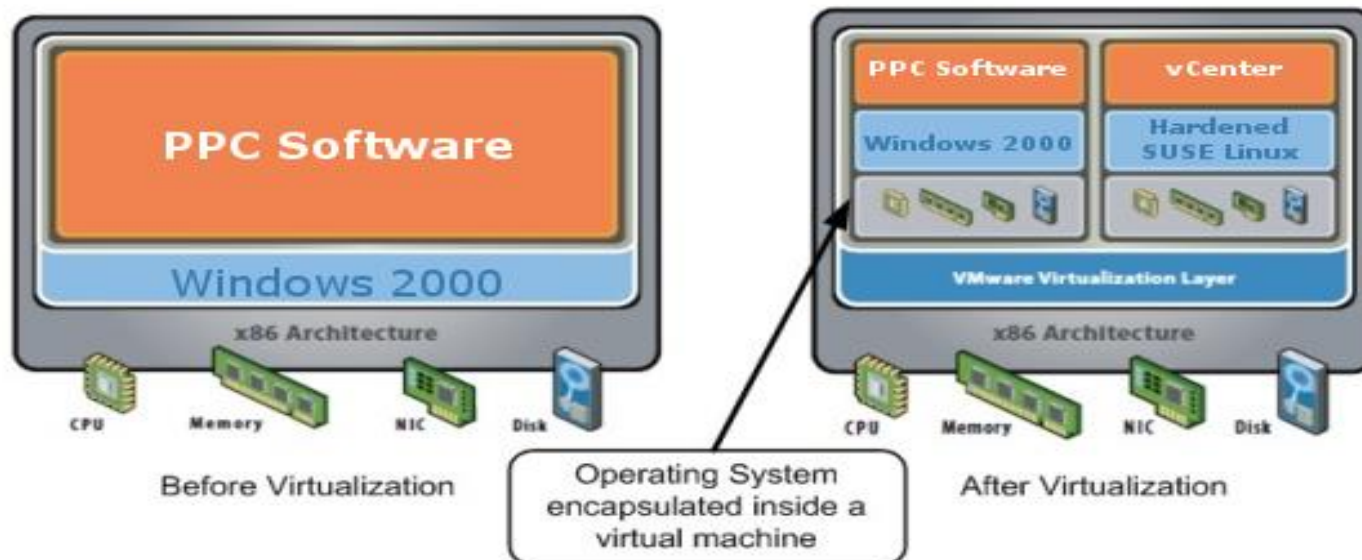


Oyster Creek Implementation

Software on each physical PPC server:

VMware ESXi version 6.0.0 (HP Edition)

- VMware vCenter Server Appliance (vCSA) ver 6.0.0 – Virtual Guest Machine
 - The vCenter Server Appliance is a preconfigured hardened SUSE Linux virtual machine, which is optimized for running vCenter Server and the associated services on Linux.
- PPC Server – Virtual Guest Machine
 - The Windows 2000 operating system
 - R*Time 11.9 (No Code Changes!)



Oyster Creek Implementation

DAS Hardware:

- Maintained current RTP2000 and 2000M design

Software on Workstations:

- No Changes to existing Workstations
- No end user training / No new features
- Added two Windows 7 Management Workstations

Oyster Creek Implementation

Leveraging Virtualization:

- Legacy OS Support
- Legacy R*Time Support via Legacy OS
- Modern Hardware Support
- Portability
- Server Consolidation (DEV/TEST Only for OYC)

Oyster Creek Implementation

Testing of Virtualized Platform (PRE-FAT):

First Time Testing Windows 2000 / R*Time 11.9 with Production Copies

- Created backups of Running System
 - Could not use VMware Utility to convert running R*Time Archives
 - Practice Restores and develop production cutover plans
 - Removed Unknowns

Testing of Virtualized Platform (FAT):

- 4 Week run through of selected FAT tests from 2004 PPC Refresh and 2009 I/O refresh at OYC including DAS testing for scanned and SOE data
- Only Virtualization specific Issue was reported Memory Utilization

Oyster Creek Implementation

- Virtual PPCA was installed on 8/15/16 in parallel with the Physical PPCB . It ran as the primary PPC server until 10/27/16* .
- Virtual PPCB was installed on 10/27/16 with all interfaces fully SAT tested and accepted by Operations. It is still currently running as the primary PPC server without issue.
- To date the a virtualized PPC servers have been running as the primary PPC servers for approximately 5 months without any significant issues related to the virtualization platform. During this time the plant has fully exercised all of the functions including LPRM calibration (TIP RTP Interface) and several full SCRAMs (Control Rod Scram Time SOE data) and code updates.
- PSS was also virtualized at the same time as PPC-A.

*Temporarily switched Physical PPC-B to Active to facilitate code update

Next Steps

The successful implementation of a Virtual PPC at Oyster Creek served as a pilot for alternative obsolescence management strategies in the Exelon Nuclear fleet

- 2018 updates to the PPC LTAM Strategy will include platform virtualization as the refresh approach for plants within 5 years of final shutdown
- Considering virtualization as the standard approach for future PPC replacements and refreshes
 - Peach Bottom PPC Replacement is being bid with an option for virtualization
 - Would provide more options for mid-cycle refreshes

Advantages

In addition to the financial benefits demonstrated by the Oyster Creek Refresh, there are a number of other reasons to adopt a “virtual first” strategy:

Development and Testing

- System Portability
- Easily reproduce OS level and above on any hardware that supports the virtualization platform
- Multi Instances can be created for testing and development in tandem

Disaster Recovery

- Simple backup methodology
- Virtual “Hardware” is just a configuration file

Separates Windows Operating System Environment (OSE) and HW

- Allows for simpler server hardware refresh
- Can isolate problems in HW vs SW

Questions?



Thank you!

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