Evaluating Virtualization of a Control System for use in a Production Environment

As control systems age considerations must be made on the lifecycle of the control system and how the system will be maintained in the future. One of the considerations is the hardware platforms available that will run the system. As this hardware ages, how should the system be replaced? Should the existing hardware on a production Distributed Control System (DCS) system be replaced with standard PCs and server hardware, or should the installation be moved to a virtual system?

FUJIFILM Diosynth Biotechnologies, USA (FDBU) ABB distributed control system was configured and installed in 1996 to control batch operations and control clean utility distribution. Since this time, the DCS system has been expanded as the facility has expanded to coverer a larger range of products and services (see list below).

1. Additional controllers added for new equipment.
2. A refold suite and new production reactors were added.
3. New clean in place (CIP) systems were added.
4. A new single use cell culture line was added.
5. A new water for injection, WFI, subloop was added
6. New purification and cell culture production suites were added.

During this time, there have been 5 changes in company ownership which have made continuity and priority of system upgrade plans fluctuate with capital availability.

Timeline:

- 1996 - Installed **ABB** Advant MOD HP-UX (UNIX) Distributed Control System.
- 2001 - Microsoft Windows XP Released
- 2005 - Upgrade from UNIX platform to Microsoft Windows Platform - **ABB** stops selling UNIX operator workstations.
- 2006 - Start **ABB** Upgrade to Windows XP
- 2010 - Sales of Microsoft Windows XP ended – October/2010
- 2014 - Extended Support for Microsoft Windows XP ends - No more security updates

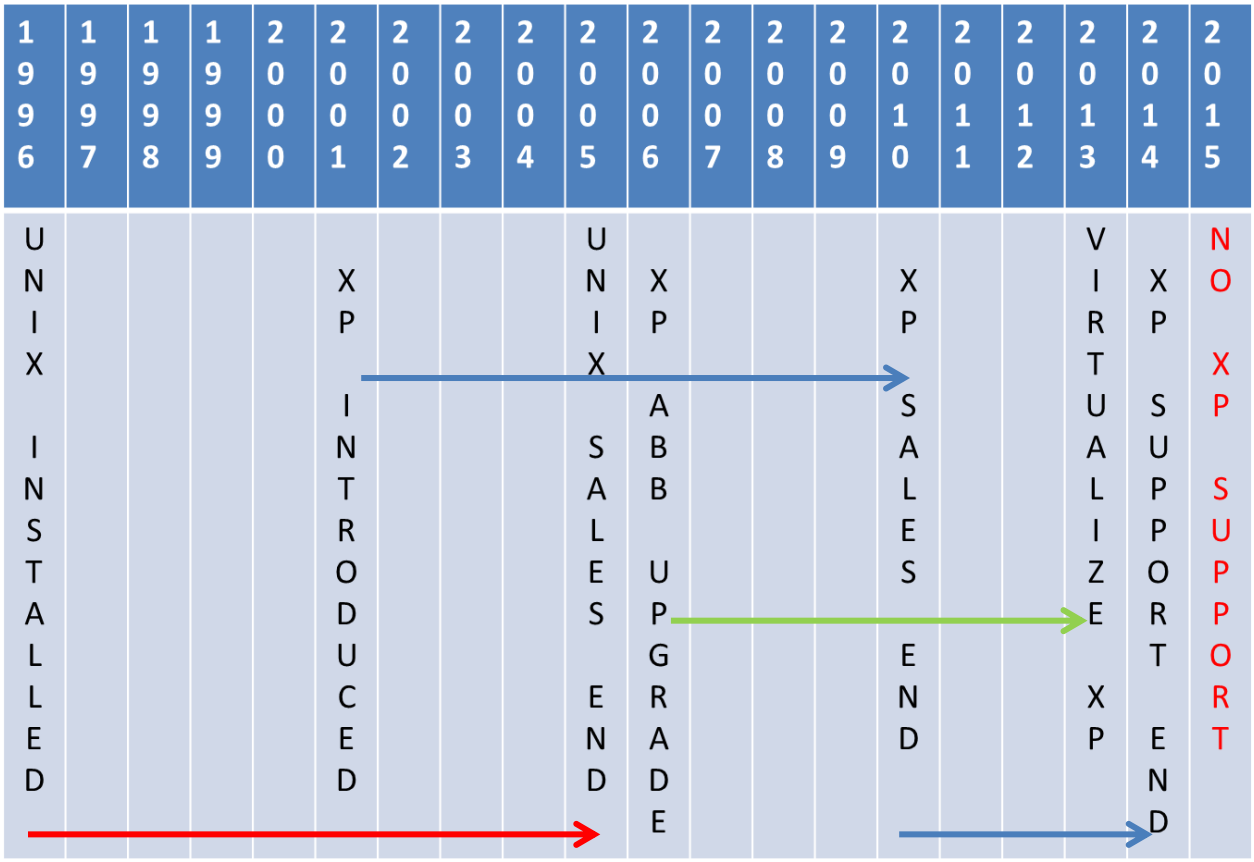
Currently the production DCS system is used for automated batch operations, such as CIP and Steam in place (SIP) in Fermentation, Cell Culture, Buffer Preparation, Media Preparation and Purification Areas. To help assure repeatability and consistency of operations for Fermentation and Cell Culture, the DCS is used for automated production batch operations. The system is also used for Clean Utilities Distribution and Monitoring to help assure continued operation and quality of clean utilities. The system can be used to page out critical and non-critical alarms on systems such as Environmental Chambers and production systems that are not continuously monitored by production or utility operators.

Some hardware running the Microsoft Windows operating system on the plant DCS system is 8 years old and is no longer supported by the manufacturer. When hardware failures occur, some of the server components can no longer be replaced as they have been obsoleted. The vendor operating software is currently running on a Windows 2003 Server and with

Windows XP operator stations. Most of the batch portion of the distributed control system is running the ABB Advant MOD control system software platform, which runs on the HP-UX 10.20 UNIX operating system. Unfortunately, HP-UX 10.20 does not have an option for virtualization. Proprietary communication cards utilized with the Advant MOD DCS systems are additional hurdles that prevent virtualization from being a viable alternative for upgrading systems on the HP-UX platform. These cards used for the Advant MOD systems, referred to as RTAB's, connect the MOD DCN communication ring with communicating workstations and MOD controllers such as the ABB AC460 controller. These have been typically installed in the server or workstation in an ISA or EISA I/O slot.

The proprietary HP-UX systems must be converted to run on the ABB 800xa Production Manager to continue to run on the Windows operating systems for long term viability of the system. Running the Advant MOD DCS system forces reliance upon the used/refurbished hardware market to support hardware that is no longer available in the new or remanufactured market from HP, the sole source provider of the hardware required to run HP-UX. Dwindling support of the Advant MOD system can also be felt as those trained on the 30 year old technology system, retire or change jobs adding fuel for the need to upgrade these systems. As fewer and fewer of the obsolete manufacturing DCS systems remain in the manufacturing industry, companies reduce staff or redirect staff to work on the more modern versions of the systems and only a select few retain the knowledge which can solve problems on these older systems.

A clear upgrade path must be considered to keep control systems in a state where plant personnel, control system manufacturers and control system integrators can help maintain and troubleshoot these complex control systems.



In 1996 the control system was installed as part of the then new Biotech manufacturing facility. In 2005, hardware sales ended that supported the HP-UX 10.20 system. In 2006, the upgrade to Windows XP began and nine years after that, the extended support for Windows XP by Microsoft will end in 2015. The end of extended support to an operating system means that any new security vulnerabilities found by the community at large will not addressed by Microsoft, and no patches will be provided to resolve the issues. The users will need to address these problems on their own. The above illustration is an example of the unavoidable lifecycle of some computer operating systems, until you consider virtualization of your systems.

We need to ask a few questions: Does hardware dependence ever end? How can we avoid the need for continual software upgrades to be able to support hardware which will eventually fail? Why/how should this be avoided?

Purchasing a new set of hardware, costing on the order of tens of thousands of dollars now at its end of life, will allow extension of the control system life another 5-7 years. Expecting

that in the near future hardware and software produced will no longer run the obsolete operating system, but where do we go from there?

Upgrading to the Windows 2008 Server operating system and the Windows 7 operating system require that the DCS operator graphics be redeveloped using PG2 graphics. Development and validation is expected to require an investment of hundreds of thousands of dollars.

Legacy systems:

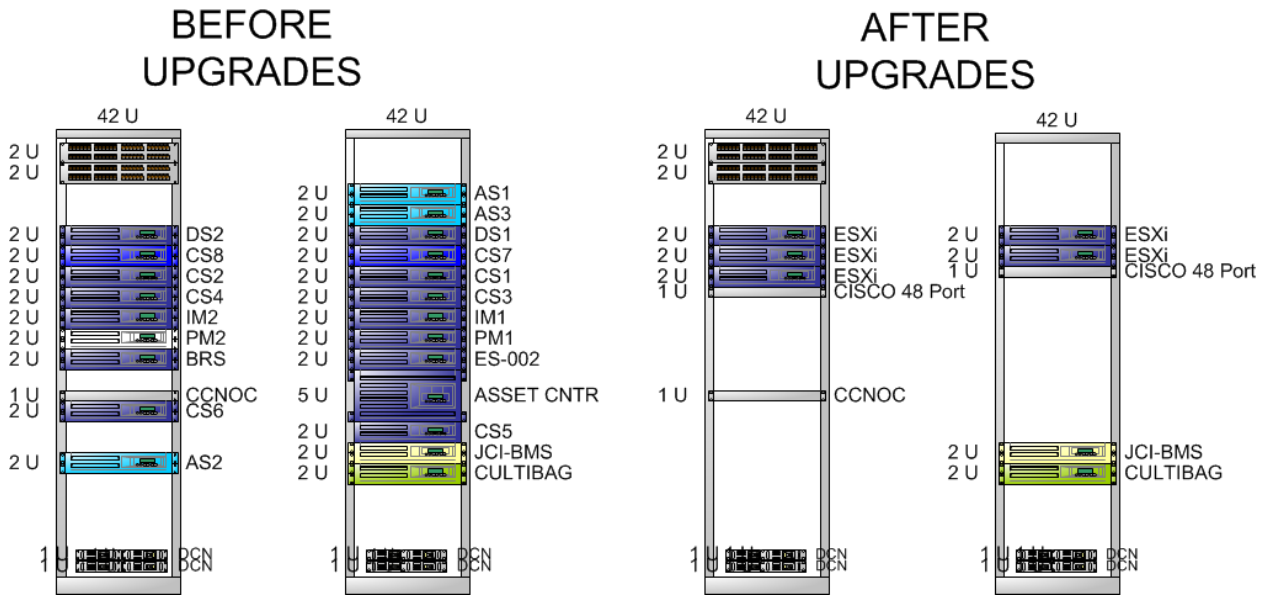
In 2005 HP discontinued sales of its HP-UX 10.20 B2600 workstations which were the last model supported by ABB to run the ABB Advant MOD DCS system. This began the inevitable task of upgrading the software platform to keep up with supported hardware. Three workstations out of about 20 HP-UX operator stations remain to finish the upgrade to a complete Windows interface and historian system. The ABB Batch 300 MOD software remains as a controlling part of the system. Two MOD UP-UX historians are also required to collect the production data logs of the system. This batch portion, although it seems small performs a major role in the system and is costly and time consuming to replace under the ABB 800xa Production manager which runs on a Windows operating platform. This replacement project is ongoing, but should be completed early next year. We are now looking at the imminent obsolescence of Windows XP and Windows 2003 Server hardware. New Dell workstations no longer natively support windows XP without virtualization.

The Virtual Solution:

First we have to consider if the control system vendor software and required hardware platform supports virtualization. The hardware should be considered first. Any proprietary hardware must be able to connect to native Ethernet interfaces or other virtually supported I/O ports such as com ports. ABB answered this question by providing a new externally Ethernet connected RTABs to resolve the proprietary interface problem. Secondly the software needs to be considered. Virtualization is a relatively new technology to be used in a production control system and not widely accepted. The answer from ABB therefore was not direct, and took a few weeks to determine because the vendor documentation at that time did not fully cover all topics completely. A meeting was held with knowledgeable ABB personnel that helped drive the decision to allow the system to be installed on a virtual system. .

There are many advantages of virtualization. Most system backups are easier. Restoration of a server can take minutes in some cases instead of hours or reloading the software on a new piece of hardware. Test systems are easier to build. Virtual servers are hardware independent and portable. The Power consumption of a virtual system is lower because the number of physical machines has decreased. The virtual system can have a smaller footprint when multiple servers are involved. The following figure helps illustrate how a number of hardware servers can be consolidated into a smaller number of servers containing a number of virtual machines. Outdated operating systems such as Windows XP and Windows 2003 server become hardware independent. Training systems can be easily built if the processor

and memory of the hardware platform permits. Many of the control system manufacturers have used this technology to conduct training because of the portability of the virtual systems. Within minutes they are able to switch from one version of their training system to another just by stopping and starting a new virtual machine. This allows a manufacturer to teach a class to one customer running one version of software and the next day they could be teaching another customer on the same hardware with a different version of software or even different control system software product.

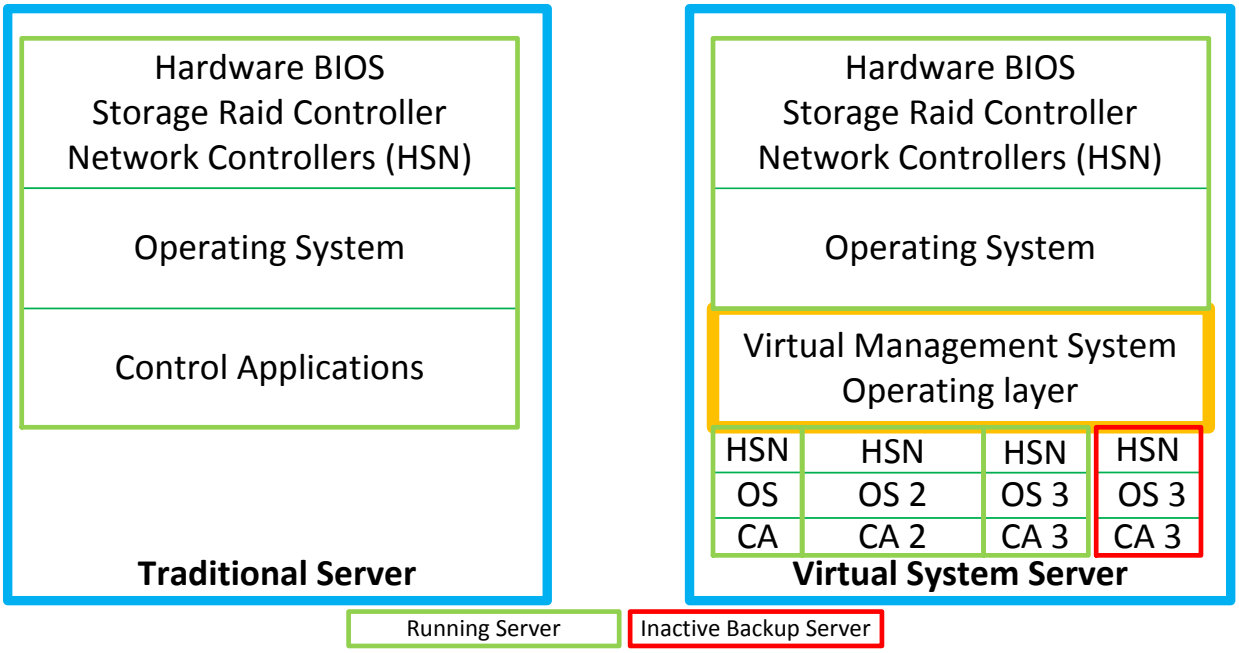


Some additional advantages of virtual systems include easier administering as remote desktop. Restart of the system is faster avoiding the hardware tests and bios checks of a traditional hardware server. Higher uptime diversity is also a plus for the virtual systems when choosing a system with multiple blade servers such that if a hardware server fails, the virtual machines can restart on a backup server that has a copy of the machine installed. Systems can be quickly rebuilt in disaster situations where a roaming profile or system registry is corrupted. Virus protection software can be installed on virtual management system operating layer to help protect operating systems running on the virtual machine (VM) layer which may no longer be updatable.

The virtual system can run multiple different operating systems on the machine layer, old and new. Upgrading a system can be done totally offline by making a copy of the existing virtual systems and upgrading the software machine by machine. On the day of the upgrade cutover the old VMs data can be backed up and be shut down and the new VM brought online and data backups restored quickly to bring the system back up into operation with very little down time.

Some disadvantages of virtualization include the Hardware/Software License Costs being more expensive in cases where you have a large system and need redundancy. There are unknown compatibility issues and fewer implementations of these systems in the control system environment and additional training is needed for support personnel. The installed

system is more complex because of the additional virtual management system, operating layer which manages the virtual machines. If designed improperly, the virtual system can put too many eggs in one basket. If the hardware running multiple virtual machines would fail, the whole system could be lost. Careful consideration must be made when designing the hardware platform to assure it is fault tolerant for a production system.



In this case moving to a virtual environment allows one to escape from the hardware dependencies of Windows XP and 2003 server, but is flexible enough to allow the old and new Windows operating systems to run. A moderate amount of initial investment is required, but in the long term, this will be the lower cost alternative postponing upgrades that are required to run on new server and workstation technology, as long as the new operating systems can continue to be virtualized on the chosen platform.

About the Author

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FUJIFILM Diosynth Biotechnologies is an industry-leading biologics Contract Manufacturing Organization with locations in Research Triangle Park, North Carolina, USA, and Billingham, UK. Recognized leaders in microbial-derived biologics, the two sites offer over 25 years' combined experience in the development and manufacture of recombinant proteins, vaccines and monoclonal antibodies, expressed in a wide array of microbial, mammalian and insect cell culture systems.

Michael Baldauff joined what is now FUJIFILM Diosyth Biotechnologies 13 years ago which was then part of Covance. Michael has 23 years of Automation and Controls experience and is a member of the International Society of Automation (ISA) and ISPE and currently serves as Vice President of ISA District II and holds a CAP certification. The ISA is a nonprofit organization

that helps its members and other automation professionals solve difficult technical problems while enhancing leadership and personal capabilities. He has a Bachelor's Degree in Electrical Engineering from the University of Minnesota Institute of Technology.

For more about ISA or FDBU you can visit www.isa.org or www.fujifilmdiosynth.com.

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