WIRELESS DOWNLOAD FROM MAC 5500 ECG CARTS AND THE MEDICAL FIELDS USE OF EXISTING IT HARDWARE.

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INTRODUCTION

At Capital Health a MUSE® EKG Management System has been in use for over a decade. The first installations predated my involvement with this institution, and was Windows 3.1 based. We have recently upgraded to latest MUSE, version 7. With this system ECGs done on mobile carts are electronically downloaded into the computer based ECG management system, MUSE.

At one of our sites it was determined that wireless download of ECGs would be of benefit due to the number of Carts in use and work flow issues.

The vendor in question, GE offers a wireless upgrade option. We initially received a quote from the vendor that was at least $50,000 for the hardware and software to upgrade 10 ECG carts to wireless transmission. This cost was prohibitive. Because the GE wireless solution is implemented with off the shelve hardware and this hardware has no impact on patient diagnostics it was decided we would attempt to implement a solution ourselves.

We where able to upgrade 10 ECG carts for less then $5,000. Even counting in the significant amount of time spent on the project it was still done for less cost then that quoted by GE.

This paper does not discuss the technical details but rather how knowledge required to do this project was gathered.

MUSE HISTORY

The history of the MUSE system is a classic example of an evolving system who's functionality has moved from specialized hardware to the generic IT hardware. As each generation of PC hardware became more powerful additional functions where moved the to PC platform and the specialized hardware was no longer required.

The MUSE system is also an example of the pitfalls that occur when vendors fail to break from existing architecture in a timely fashion.

An Example of evolving technology.

An example of this evolution within MUSE is the printing of stored ECGs. When the MUSE system was first introduced laser printers where very expensive and reproduction of full page graphical images was very slow. So at this time a custom built thermal printer was connected to the mini computer they where using. This thermal printer borrowed much of it's technology the ECG carts.

By the time MUSE was ported to Windows 3.1 Laser printers had become faster and cheaper, so they had become an option for printing the ECG's. However the 486 computers available at the time did not have the processing power required to quickly plot format the ECGs with all the required grid lines. So with this generation of hardware a Co-Processor card was added to the PC. This card did the required plot formatting and feed the data directly to the PCL LaserJet printer.

This is speculation on my part but at this point the software code that generates the ECG plots was created. Because this software ran in specialized hardware it ran independently of the Windows printer architecture. This code and hardware feed a raw PCL print job to the laser printer.

With the advent of Pentium class computers the PC platform could now do the required plot formatting in a reasonable time. Once again I am speculating, but the same code used in the specialized hardware was used to generate plot formatting on the PC hardware. At some point Postscript printer support was added. In both

cases the print jobs whether PCL or Postscript print jobs are feed directly to the printers.

This approach, still present in MUSE 7, did give consistent results. Bypassing the functionality built into the windows print drivers now leads to other problems.

- Only PCL or Postscript printers can be used.
- MUSE can't produce a decent PDF, because it won't interact with windows GDI print drivers which most PDF distillers are. The PDFs which MUSE does produce are straight bit maps which scale poorly, and are very large. This fact is being exploited by the main MUSE competitor (one does exist [5]).
- MUSE printer jobs have no control over the advanced features of the print driver. Such as;
    - Controlling what paper tray to use.
    - Controlling resolution used by the printer to render the print job.
    - Print area on the page.
    - In all cases MUSE prints using the default settings of the printer which must be matched to the needs of the MUSE print jobs. This becomes a problem when printers are used for multiple purposes.

As printers become more advanced we are finding more PCL and Postcript printers that are having issues with this 10 year old approach. For example Lexmark printers work best when set up as PCL printers. And HP work best when set as Postscript printers. Which is ironic considering HP is the author of PCL (Page Control Language).

Failing to break with out dated technology.

These printer problems are all examples of what happens when a vendor fails to break with an out dated architecture.

Breaking with an out dated architecture is expensive as it requires a re-engineering of a product. Adding a bridging technology is often done as quicker and lower cost solution.

However each bridging technology comes with it's own set of problems which tend to be cumulative, and eventual cause the whole house of cards to become unreliable and hard to maintain.

Understanding the history of a product often helps identify a bridging technology. This is exactly what happened with MUSE ECG carts and wireless downloads.

MUSE CART DOWNLOADS

History of Cart Downloads

Since the first MUSE system, Marquette (The manufacture at that time) added a method for downloading ECGs from their carts. With the MAC 12, 15, 6, 8 and PC the method used was a custom SDLC modem for phone download and for direct download, a high speed interface (I believe RS485 [6]) was implemented on custom hardware in the PC.

When existing PC modems became fast enough and PCs could run their RS232 serial ports at full speed Marquette dropped the custom modem and serial interface.

Network Cart Downloads

With the MAC 5500 direct network downloads feature was added. One of the products being used for this is **Serial/IP COM Port Redirector** [7] from **Tactical Software**. The vendor provided documentation did nothing to explain what was being done here and how this was all suppose to work. I think this partially explains why no one could get it to work properly.

Knowing the history of the MUSE product, see previous paragraph, and some internet research [8], what the vendor was attempting to accomplish became apparent. Once the intended operation was understood getting it to work was much easier.

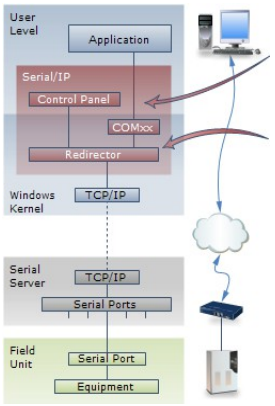
This leads me too three points I wish to make.

- ***You need to understand how it's suppose to work before you can troubleshoot it. This more true with IT then every before.***
- ***Understanding the product line history can really help you understand how it's suppose to work.***
- ***The Google and Wikipedia are your friend when dealing with IT problems.***

Few vendors completely change how they do something, rather they build on what was done before. Understanding what was done before helps a person learn what is being done now.

In the all of history, no new technology has been as self documenting as the IT field. Any new information technology will be quickly documented in some form on the internet. In most cases the documentation will exist long before you will see the technology in the field. In fact it needs to be there so it is available to the engineers and technologist that design the new equipment using the technology.

The hardest part of looking to the internet for information is determining the proper terminology. For example once it was determined that the **Serial IP** software was used with **Serial Servers** several good articles[8] on serial servers could be found. I was even able examine the MAC 5500 ECG Cart identify the Serial Server module that was being used, locate a 3rd party supplier, order replacement modules and the development kit. As an interesting side note, the modules cost approximately $50. As part of replacement assembly from the vendor the cost was over $1500.



I won't relate all that was learned about Serial Servers, it was explained better in the articles anyway. I have included a small diagram from Tactical Software's web site [7]. Suffice to say it is a bridging technology.

Wireless Cart Downloads

When the vendor made available wireless technology for the MAC 5500 ECG carts it was no surprise to learn they where building on the previously used technology and using a wireless serial server.

Having success in getting the network downloads working, having used serial servers, and having researched the available options for wireless serial servers I concluded we could do this ourselves for much less money.

The serial servers used are from Quatech [9]. They are about the same size as small wireless router and have the same type of web based interface. They have the added advantage of being able to run directly from the power supplied by the ECG cart (12V-9V) the GE supplied Wireless device required a separate voltage converter module.

The IT department at capital health [1][2][3] where instrumental in getting these units to connect to our wireless network. Quatech[9] was also able to provide guidance with configuration of the wireless modules.

The module are mounted directly on the ECG cart and are powered by the cart, just as the Vendor supplied solution. The connecting cables where constructed in house [4] as the cables that where available from the vendor cost almost as much as the wireless modules.

On the server end the tactical software installed by the vendor was used.

Because we did all configuration we where able to break from the vendor preference of using static IPs and instead used DHCP for the modules. We have found this to work much more reliably on the large network at Capital Health's.

When a ECG cart has a static IP the server is constantly attempting to connect to a device that is only intermittently present on the network. And is likely to appear at different port on the network each time. This is problematic in larger networks as the time it takes to locate the sole device amongst the tens of thousand's of devices can be quite long.

The worse case scenario we found was when a single network port was used to download one cart after an other, each with a different IP and MAC address. The network hardware doesn't like this and often a cart would take 5 minutes or more to initialize a connection.

By using DHCP the cart initiates the connection to server which is always at the same location in the network. In this way wireless connections are reliably established within 45 seconds every time. This leads to an other point I would like to make.

- ***By implementing our own solution we where able to configure it optimally for our situation.***

Gaining the required knowledge

The knowledge required to implement this solution was gained over several years. Most of it was documented for the benefit of myself and others that support the MUSE system at Capital Health. At this point documentation for the MUSE system at Capital Health is over 88 pages. The full configuration of our wireless modules is also included in this documentation.

During this project this documentation was referenced numerous times. While very time consuming to produce documentation it saves a greater amount of time in the coming years when the lessons learned don't have to be relearned.

Creating documentation also has an other effect. In order to explain a complex system in writing, one must first break it down into it's component parts and it must be clear in your own mind how each part works.

You may have heard it said *"The act of explaining a problem often leads you to the solution"*. Well that axiom can be extended to; "*Documenting a system often helps a person fully understand it."* This leads to my final point.

- ***Creating documentation for complex systems is always worth the effort.***

The information required to learn about IT systems is readily available on the Internet for free. If you show a basic understanding and a willingness to learn your hospital IT staff will most likely fill in the remaining details.

Learning IT systems can be a daunting task. It is time consuming, often there doesn't appear any real return on the time spent. But if you document what you learn and are willing build on what you have learned there can be significant payback.

ACKNOWLEDGEMENTS

The following individuals assisted with this project and where invaluable in it completion. Also listed are the primary sources of information.

[1] Lynn Pace – IT Project Manager - Her support got this project of the ground and keeping it going.

[2] Andrew Kozma – Sr. Security Administrator – Andrew got our wireless modules on the network

[3] Daniel Clement – Network Analyst - Kept the wireless modules on the network and provided other options to try when I couldn't more then one to connect.

[4] Ron Cheverie - Biomedical Technologist – Ron assisted in the installation of the modules and made all the required cables, keeping the project under budget. Ron also trouble shot and resolved the interference problems resulting from the wireless modules.

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