INTERCONNECTION OF 802.11B WIRELESS PHYSIOLOGIC MONITORS WITH A 802.11A/B/G WIRELESS VOIP NETWORK AT SANTA CABRINI HOSPITAL'S EMERGENCY CARE UNIT

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ABSTRACT
Santa Cabrini Hospital (SCH) initiated the integration of VoIP wireless communication and patient monitoring systems in their Emergency rooms (ER). The new Bell-Nortel wireless network uses an IEEE 802.11a/b/g protocol while the GE mobile DASH 3000 monitoring system of the ER was initially an IEEE 802.11 one upgraded to IEEE 802.11b. A joint study conducted with the engineering teams of Bell, Nortel and GE Healthcare demonstrated the feasibility of this multivendor hardware (Symbol vs Nortel) and software (GE vs Bell) integration. During the first four months following the integration, issues regarding the secure cohabitation of both systems and electromagnetic interferences (EMI) with the medical equipment used in the ER were assessed. The functionality and clinical benefits of this integration have been demonstrated and the installation of wireless IP telephones in the other critical care departments of the hospital is being scheduled.

Keywords: *Wireless monitoring system, Wireless VoIP, Emergency room, EMI*

INTRODUCTION

Mobile telephones are intentional radio transmitters and receivers. Electromagnetic interference (EMI) occurs when the mobile telephone causes an electronic device to act as a radio receiver unintentionally. Mobile telephones alter their power according to signal strength and distance from nearest base station. Field strengths, and hence, EMI, are strongest at the beginning of an incoming or outgoing call[1]. There are already suggestions that complete bans have been ignored, especially by healthcare staff[2]. It would then be prudent to check the safety of any new wireless local area network (WLAN) transmitters based on new specifications that appear on the market[3]. Uncontrolled usage of mobile telephones will cause undue noise, disturbance, and distraction to both clinicians and patients.

Mobile communications (mobile phones, walkie-talkies, ambulance radios) have been reported to interfere with medical equipment with some of them leading to fatalities[4]. While introducing a WLAN in a hospital, attention must be paid on radiofrequency devices[3].

In 2002, Santa Cabrini hospital introduced a GE DASH 3000 wireless monitoring network in the emergency room (ER). These monitors operated with Symbol Spectrum24 antennas (Symbol, Motorola, USA) using an IEEE 802.11 protocol. In 2006, the new ER opened with a Wireless VoIP system running under Nortel 802.11a/b/g. Both wireless systems, initially running side-by-side, were integrated under the same Nortel 802.11a/b/g network and compatibility studies were conducted to ensure patient safety and to address EMI concerns.

MATERIALS AND METHODS

Santa Cabrini implemented a state-of-the-art 802.11a/b/g system throughout the new ER wing. As part of the service upgrade, we wanted to ensure that our Vital Sign monitors (upgraded GE Dash 3000 units) were able to use the Nortel wireless network. The objective was for the data gathered by the monitors to be sent, wirelessly using the 802.11b standard, to a centralized server for the monitoring stations.

Design

The Nortel network consists of 32 Nortel 2330 Access Points (APs), receiving power over Ethernet from Nortel BS-470 PWR Ethernet switches. The switches themselves were connected via Gigabit Ethernet fibre links to the core of the network; a pair of Nortel Passport 8609 routing switches. The traffic intended for the Vital Signs monitors, was not routed, and was kept at layer 2 in order to minimize delay, and simplify the interconnection. The traffic was treated by a Nortel WSS-2380 wireless domain controller, where it was extracted from the overall wireless traffic, and delivered to the GE application server. The SSID used was GEMS, and it was broadcast. For security reasons, IP addresses and port numbers are hidden in Fig. 1.

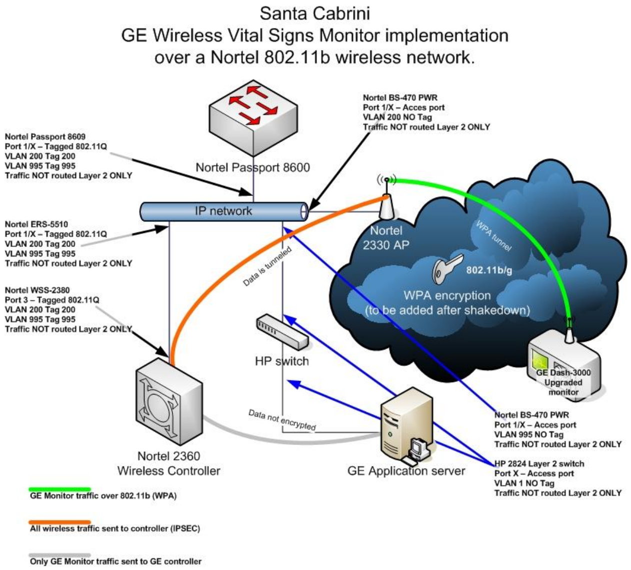

Figure 1: GE - Nortel WLAN architecture. Data Link layer-wireless and wired sides

Data Link layer - Wireless side

The GE Dash 3000 Vital Sign monitors included a Symbol wireless card which was limited to the 802.11 pre-standard, and therefore not compatible with the Nortel network.

Our team decided to have them upgraded as a cost effective way to achieve interconnectivity. The upgrade replaced the Symbol card with a newer Symbol model which supports the 802.11b standards. The monitors are capable of WEP (Wired Equivalent Protection) and WPA (Wi-Fi Protected Access) encryption. While the system was being tested, the transmissions were left unencrypted in order to facilitate testing. Once testing was completed, WPA (being the stronger of the 2 encryptions schemes) was activated on the wireless portion of the network. Once the data reached the 2330 AP, it along with all other wireless traffic (VoWIP, other data), was sent via a tunnel to the WSS-2380 controller.

Data Link layer - Wired side

The 2380 extracts the monitor data from the data stream, and places it in a VLAN (subnet) dedicated to the GE equipment. At the moment the data is placed on the wire, its COS (Class of Service) is changed to the value seven (7) from the default value of zero (0). This ensures that the network will handle this data with the highest priority and urgency. The data is then transported via Gigabit Ethernet, to a Nortel BS-470 switch, directly attached to the HP 2824 switch where the GE Application Server is connected.

Network layer - IP

The GE monitors use GE provided global IP addresses, outside of the hospitals 10.139 range. Because of this, this subnet is not routed by the network, but rather, it is bridged from source to destination.

Testing and Integration

Prior testing

The system was originally tested in Montreal at GE's offices with a Nortel WSS-2360 Wireless Controller, and GE Dash 5000 monitors, in November 2006. The Nortel controller was running software version 4.3. The tests were conclusive, and there was connectivity.

Compatibility and interference concerns

To confirm the actual compatibility of both systems, follow-up platforms were developed to collect the observations of a nurse, an information technologist (IT) and a biomedical technician, one month before and two months following the integration. Eight wireless phones were used by the staff on a normal clinical basis.

RESULTS

Santa Cabrini integration

When it came time to activate the system at Santa Cabrini, a number of issues surfaced, notably the monitors could not detect the wireless beacon. Finally an upgrade of the WSS-2380 software solved the issue. Santa Cabrini was running version 4.11 (which is not the version tested with); and the controllers were upgraded to version 5.0.11 (the latest version). Table 1 includes the relevant elements from the configuration of the WSS-2380. After the upgrade of Nortel firmware to the 5.0.11 version, all 802.11b DASH monitors communicated fluently with each other. However, one monitor that had a different EKG module configuration didn't fully accept the GE NetUpdate 2.0 upgrade. The configuration was subsequently completed manually and the monitor became functional. At the end of the three-month period of an 'IT-nursing-biomedical' observation process, no apparent problem was registered. The clinical personnel did not observe any difference between the previous configuration of the DASH 3000/4000 and the upgraded one.

Table 1: Relevant configuration of WSS-2380

Configuration nvgen'd at 2007-8-03 13:38:22
Image 5.0.11.4.0
Model 2380
set system countrycode CAset timezone est -5 0
set service-profile GEmonitors ssid-name GEMS
set service-profile GEmonitors ssid-type clear
set service-profile GEmonitors auth-fallthru last-resort
set service-profile GEmonitors auth-dot1x disable
set service-profile GEmonitors attr vlan-name GBM
set radio-profile clear service-profile GEmonitors
set radio-profile clear auto-tune power-config enable
set dap XX serial-id xxxxxxxxxx model 2330 radiotype 11b
set dap XX radio 1 channel 11 tx-power 14 radio-profile clear mode enable
set dap XX radio 2 tx-power 14 radio-profile dataRP
set vlan 995 name GBM
set vlan 995 port 3 tag 995
set mobility-domain mode seed domain-name santa-cabrini
set mobility-domain member 10.10.10.10
set security acl ip SVP permit cos 7 119 0.0.0.0 255.255.255.255 0.0.0.0 255.255.255.255
set security acl ip SVP permit 0.0.0.0 255.255.255.255
commit security acl SVP
set security acl map SVP vlan 101 out

Findings for the priorization of GE monitors data vs. wireless VoIP

1–Even if the Dash 3000/4000's wireless setup is enabled, as long as there is a "live" RJ45 Ethernet plugged into its port, the wireless signals are suppressed.

2 - The monitor will broadcast its data until it finds a responding server. This is important because the monitor is classful, and subnet masks cannot be configured.

3 – When a responding server is found (again via broadcast), the exchange starts to use unicast frames.

4 – The monitor uses User Datagram Protocol (UDP) port 3007 and 3009 (as source ports) for the data records.

5 – The monitor automatically sends the data with a DiffServ of 0x68: Differentiated Services Code Point (DSCP) 0x1A; Assured Forwarding 31.

6 – Each monitor will use approximately 60 to 70 Kbps of bandwidth; each frame is 500 to 700 bytes.

DISCUSSION

The best way to ensure proper and timely delivery of the monitor’s data, is to create a filter within the Nortel switch, that means to program the switch nearest the 2380 (wireless controller) to intercept data with a source IP coming from a monitor, that is an UDP frame, with a COS of 3.

The action to be performed when a frame matching this requirement is intercepted would be to re-tag its COS to 6, assert its DiffServ to 0x68 and change the DSCP to Assured Forwarding to Expedited Forwarding.

We suspected that the previous 4.11 firmware version treated the frequency band (2.4 GHz) differently, creating a subtle variation which does not affect most data devices, but which the monitors are sensitive to. By making GBM (see Table 1) the highest priority, we conceded that only DASH monitoring data could be trafficking on this network. High bandwidth networks such as the picture archiving and communication system (PACS) are wired using a cat 6+ twisted pairs.

This was the first wireless network integration between Nortel and Symbol in North America. Now that we have completed this study, the conditions under which both systems can operate safely on the same Wi-Fi network in an ER are well known and not specific to our hospital.

CONCLUSION

The upgrade of the DASH 3000 monitors was transparent to the clinical and biomedical personnel: there was no change to the user interface and the additional training was just a reminder to the nurses. The APs of the mobile IP telephony are now the same as the monitoring system in the emergency department. The next step will be to extend the wireless coverage to other critical care departments.

ACKNOWLEDGMENTS

This work was supported by Ministère de la santé du Québec (Grant MSSS 06-177A-04) and Fondation Santa Cabrini. Special Thanks to Mr. Gabriel Gagnon, chief of the ER and Mr. Angelo Bodo, chief of the IT department.

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