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Design of an Enterprise-wide Physiological and Clinical Data Solution

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Abstract— The deployment of new wireless and networked technology and advanced clinical applications has significantly increased the quality and the quantity of patient diagnostic and monitoring information throughout the patient care environment. Coupled with increasing workloads and reduced staffing, the difficulties in effectively prioritizing and handling this information have resulted in a rise in equipment-related errors, patient dissatisfaction, a potential for patient injury, and an increasing overall concern for patient safety. Concerns about this trend have prompted the Joint Commission to established seven patient safety initiatives geared to the patient environment of care, establishing methodologies and protocols to reduce the probability of errors, and to provide an enhanced level of communications. Planned deployment of advanced medical devices and supporting technologies coupled with our existing wired / wireless network infrastructure, need to consider the potential integrating clinical device, onto a unified network infrastructure providing advanced capabilities to share and effectively manage this key patient clinical information. Implementation of a Biomedical Device Information Network represents a significant advance in the management of clinical patient information, and enables device data, specifically critical patient alarms to be shared, coordinated, prioritized and sent directly to specific assigned care providers. The care giver utilizing a common hands-free wireless device can receive a prioritized audible (or a simulated voice) alarm message and utilize this same device for directed staff-to-staff or staff-to-patient communication. The Biomedical Information Network implementation identifies or associates patients with devices and consequently critical alarms, filters low priority or nuisance alarms, and eliminates the need for multiple costly communication devices. This implementation establishes an enhanced environment of care, providing increased patient safety, and a clear proactive response to the national patient safety initiatives.

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I. Introduction

Each generation of new clinical equipment has had increased capability in terms of interconnectivity and the output of clinical alarms and operational information. As an example, a physiological monitoring system of a decade ago provided for 6-12 discrete high-low and arrhythmia alarms. Present physiological monitoring provides 25-30 discrete alarms. Expanding this increase in alarms over the trend of increased patient monitoring and an increasing equipment inventory, we are moving quickly in the direction of information overload. The ability of handling this increasing number of critical alarms by a reducing staff results in an increased potential of missing critical information and the introduction of errors. This trend is so significant and has raised significant concerns that regulatory agencies such as the Joint Commission have had standards developed to address a number of patient safety issues, including the responsibility of organization leadership to create and implement a culture of safety. The National Patient Safety goals were established to provide guidelines in establishing an enhanced level of patient safety.

II: IMPLEMENTATION OF A SOULTION

Statement of the Problem:
Current deployments of clinical devices in the patient environment, require dedicated infrastructure per system as illustrated in figure # 1. These systems commonly deploy

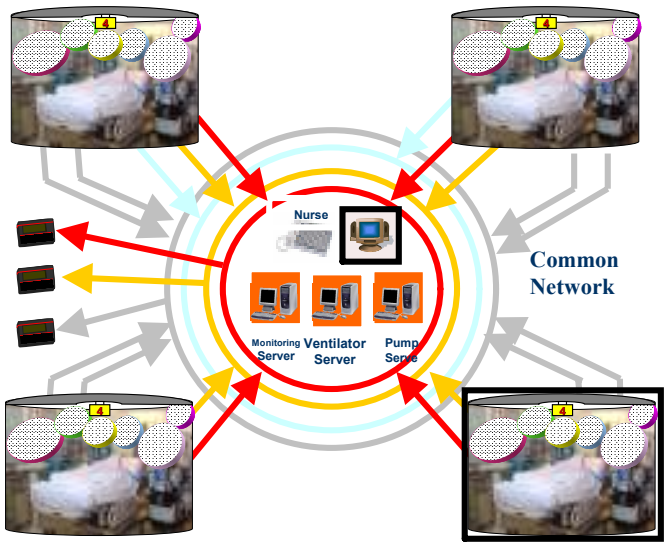


Figure #1: Typical Biomedical Device Infrastructure

paging systems that are device specific in an effort to address the need of directing critical alarm information to specific care givers, or rely on the conventional distribution

of alarms and clinical information to centralized locations, such as nursing stations. Alarm interpretation, analysis, prioritization, and management are handled by the care provider. Alarms from multiple clinical devices continue to be isolated, disjointed and uncoordinated. The implementation results in each patient care provider having several costly and redundant communications devices, yet still requires staff to identify, process and prioritize critical alarms manually between systems.

Institutional Solution

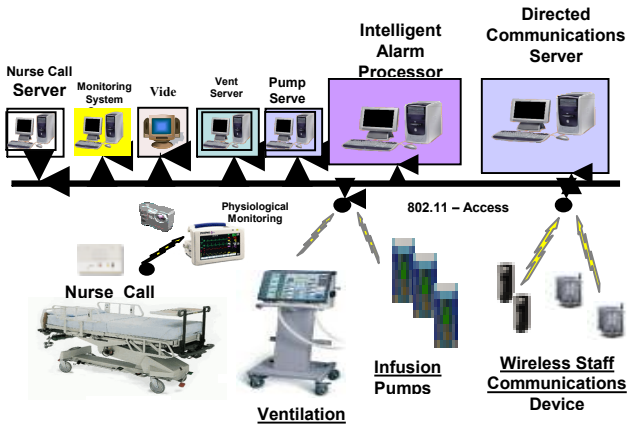
Any institutional solution would require several key components to be considered and integrated. These components include a robust TCP-IP network, wireless access, clinical devices capable of distributing clinical parameters, and alarms directly onto the network, a central processor to collect, collate and process the clinical information and directed communications device.

Network and Wireless Infrastructure

As indicated fundamental to any integration of medical equipment, an institutional TCP/IP network, providing both wired and wireless connectivity needs to exist within the patent care environment. This network architecture provides the basis for both present solutions and the connectivity for future biomedical devices and supporting technologies such as RF-ID.

Development of a Biomedical Device Information Network:

An overview of the proposed network implementation is shown in Figure # 2, illustrating all diagnosis, monitoring, and treatment devices utilized in patient care connected either wired or wirelessly to the center's Ethernet network via a room level hub or router. Each device is assigned an IP address on the network, downloading critical alarms and operational parameters onto the network, resulting in the shared availability of data eliminating the need for redundant



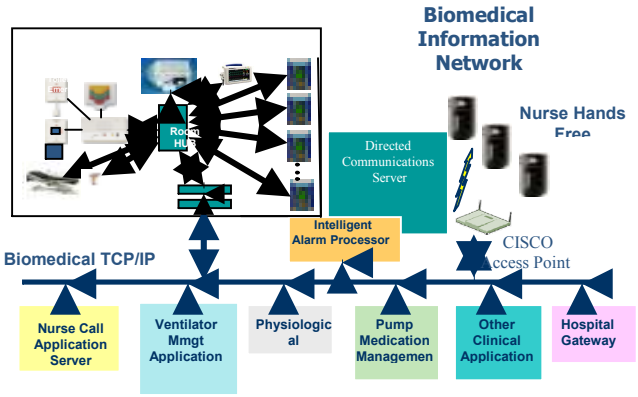


Figure # 2: Network Overview

and costly system-dedicated wiring. System operation is based on a simple association methodology where devices are associated to patients and patients associated to specific care providers, which then enables alarms to be directly routed to the appropriate staff. The use of a common hands-free device, such as the voice over IP Vocera telephone, provides hands-free alarm annunciation, along with staff-to-staff and patient-to-staff communications.

Each clinical system (physiological monitoring, ventilator, infusion pump) continues to operate normally, processing information and providing this information to their dedicated central monitoring stations, as currently deployed. Nurse call alarms ring at the unit nursing station, physiological monitoring alarms are displayed on the central monitors, etc. With the network architecture and implementation, all device alarms and data are additionally shared on an institutional network, with a central alarm processor or server used to acquire and collate patient-specific alarms from multiple devices. This processor additionally filters nuisance alarms, prioritizes clinical alarms, and routes critical high importance alarms to specific care providers based on the association of devices to patients, and patients to care providers.

Association Methodology

The overall system operation is achieved through a software-driven association process, as illustrated in figure #3. This association methodology, establishes the dynamic relationship between staff, patients and the clinical equipment used to diagnose, monitor, treat, or perform life support on the patient. As illustrated, a unique bar code or RF-ID tag can be used to identify patients, staff, and clinical equipment and to establish their association.

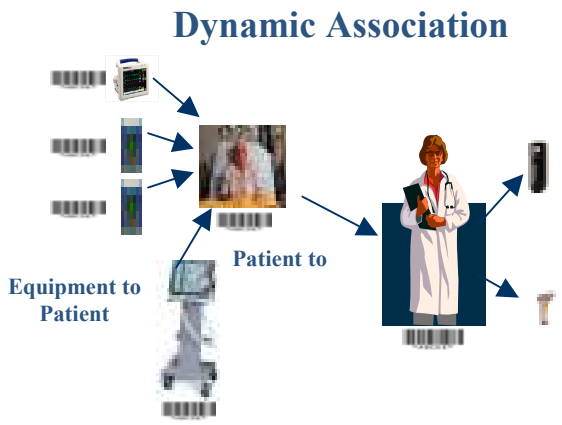


Figure #3 Association Methodology

Operationally, at the bedside or point of care the staff member simply identifies themselves, the patient, and associated equipment being used in the care of that patient. This association is dynamically stored and is used by the alarm processor to collate, analyze, and prioritize alarms with a specific patient. Critical alarm information is then directed to the associated care provider as required based on alarm or information criticality. This association eliminates the redundant staff to patient relationships currently entered and required in the nurse call, monitoring, and ventilator systems. The association establishes and supports a one-to-many relationship between a single staff member, multiple patients, and many devices, as illustrated in figure #4.

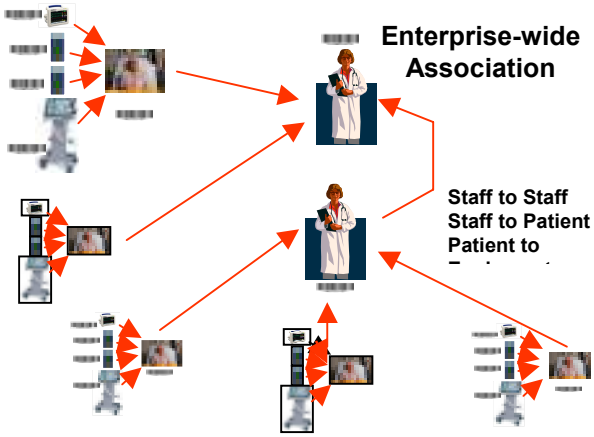


Figure #4 Association Relationships

Alarm Processing and Management

Alarm processing and management is achieved through software application developed by Emergin. This application performs the following functions:

- Establishes an association between patients, devices, and assigned care providers, utilizing a standardized bar code or RF-ID methodology.
- Acquires all alarm data from all associated devices on the network
- Collates devices alarms based on the patient to device association, provides filtering, and prioritization of clinical alarms
- Sends alarm data to a communications server (Vocera). The selection of staff device is not limited to the Vocera pendant and can include any combination of wireless phones, PDAs, or other wireless devices.

Directed Communications (Vocera)

Processed critical clinical alarms are automatically directed to patient associated care providers via the Vocera hands free pendant, eliminating the need for high cost IR tracking, or dedicated paging systems. The Vocera product is an 802.11 wireless telephone which when interfaced with the PBX, to support incoming and outgoing telephone functions. The Vocera pendant is a hands-free device, typically hanging around one's neck, capable of voice command and recognition. Prioritized alarms are annunciated via a tone or a descriptive simulated voice. Detailed alarm information and description is available both via a visual test message or a simulated voice.

Feasibility Network Concept Demonstration

In order to demonstrate the cost effective implementation of the proposed network Biomedical Engineering has developed a functional multi-patient (room) prototype configuration. The feasibility demonstration utilizes a mixture of the actual medical devices deployed within our institution, performs the dynamic association based on either bar code or RF-ID methodology. All devices integrate on a common network and share critical alarm data with the alarm processing server application, developed by Emergin. This application acquires all alarm data, collates specific patient alarms based on the established association, filters and prioritizes alarms, and transmits alarm messages to the Vocera directed communication server and associated devices. All alarm information is acquired and transmitted in real time.

Conclusion

The information network concept and design represents a significant advance within the environment of care providing a significant enhancement to the level of patient safety through the coordinated management of alarms. The system capitalizes on our existing network and wireless infrastructure and medical equipment inventory. The proposed configuration integrates a centralized alarm processor coupled with the Vocera communications server and pendants. The deployment of the Vocera 802.11 wireless communications devices replaces our existing high cost system dedicated pagers. Timely and comprehensive critical alarm information is now available directly to the care provider and enables an immediate critical response or

decision, without questions about the seriousness of the alarm or requiring the staff to go to central locations to investigate the alarm condition. The feasibility prototype system demonstrates proof of concept and provides a baseline for further development and advancement.