Leaf Healthcare

Technical Overview of the Leaf Patient Monitoring System

A high level technical review of a new wireless monitoring system

Abstract

This paper presents a brief overview of the technical attributes of the Leaf Patient Monitoring System. The Leaf Patient Monitor is a system that enables hospitals, long term care facilities (LTC), and nursing homes to wirelessly monitor the real-time orientation and activity of patients susceptible to pressure injuries; and to provide alerts when patient orientation or activity deviates from individualized turn management protocols set by the healthcare provider.

Basic System Architecture

The Leaf Patient Monitor is a distributed, wireless system comprised of four main components:

1) Leaf Patient Sensors
2) Mesh Network of Leaf Relay Antennas
3) Leaf Back-end Mesh Network Server Software and SQL Database
4) Leaf Turn Management Software

The sensor takes measurements of the patient's orientation and communicates this data wirelessly to the mesh network of Leaf Relay Antennas that had previously been setup in the facility.

A disposable and wireless Leaf Patient Sensor is affixed adhesively to the patient's upper torso. The sensor takes measurements of the patient's orientation and communicates this data wirelessly to the mesh network of Leaf Relay Antennas that had previously been setup in the facility. The mesh network relays data from the Patient Sensors to a server computer having an RF to USB transceiver. The Leaf Mesh Network Server Software, running on the server computer, collects the patient data from the transceiver and stores the data into an SQL database for subsequent analysis. The Leaf Turn Management Software displays each patient's turn history, current status and also alerts staff if any patient requires a caregiver assisted turn.

Leaf Patient Sensor

The Leaf Patient Sensor is a single-use, disposable, wireless device that is adhesively affixed to a patient's skin. The sensor itself is comprised of several key components: a 3-axis accelerometer to measure patient orientation and activity; a capacitive contact sensor that enables the device to sense when it is attached to skin and sense when it is removed from skin; a microcontroller for automated data collection; an RF radio for transmitting and receiving messages; and a common CR2032 coin-cell battery for providing electrical power.

Each Patient Sensor has a unique 64-bit serial number that is assigned to the device during the manufacturing process. When the sensor is turned on and joins the wireless mesh network, it is assigned a much shorter network address by the Mesh Network Server Software, by which it is subsequently addressed. Since the sensor knows no patient identifying data (such as patient name or patient electronic medical record number), the data transmitted by the sensor is anonymous and obviates any concern about data security on the wireless network.

Mesh Network of Relay Antennas

The Leaf Patient Monitoring System uses a propriety wireless local area network (WLAN) to relay messages between the Patient Sensors and the computer running the Mesh Network Server Software. The WLAN is comprised of many Relay Antennas that are plugged into available power outlets within the facility where patients are being monitored. Each Relay Antenna communicates with multiple nearby Relay Antennas to form a mesh, or web-like, connection of antennas. Messages sent to or from Patient Sensors over the mesh network are relayed from the source to the destination by sequentially hopping from one Relay Antenna to the next. A single mesh network can be composed of hundreds of Relay Antennas. Further, multiple mesh networks can be configured within a single facility. The web-like architecture of the mesh network ensures there are redundant pathways between the sensor and server.

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The network over which the Patient Sensors and Relay Antennas communicate is conformant with the physical layer specifications prescribed by the 802.15.4 wireless standard.[1] The 802.15.4 wireless standard defines a low-power wireless network architecture especially well-suited for battery powered devices and is the network on which the more commonly referenced Zig-Bee communication protocol is based.

Back-end Mesh Network Server Software and SQL Database

Messages sent by the Leaf Patient Sensors are relayed by the Leaf Mesh Network to a server computer running the Leaf Mesh Network Server Software. The primary purpose of the Mesh Network Server Software is to collect patient orientation data and save the data into an SQL database.

The Mesh Network Server Software is a Microsoft Windows compatible application that has been tested to work on computers and servers running Windows Server 2008 R2, Windows 7 and Windows 8 operating systems. The server software runs equally well on dedicated server computer hardware or on hardware more typical of desktop systems or even laptop computers. Multiple instances of the Mesh Network Software can be run on multiple computers, ensuring data relayed from Patient Sensors have multiple, redundant means of being collected and entered into the SQL database. The SQL database may reside on the same computer on which the Mesh Network Server Software is running, or may be located on a different server on the LAN or internet.

Data exchanged between the Mesh Network Server Software and the SQL database contain no patient identifying data such as patient name or patient electronic medical record number which obviates any concern about data security on any network links between the Mesh Network Server and SQL Database.

Leaf Turn Management Software

A user interface to the system is provided by the Leaf Turn Management Software. The Turn Management Software accesses the SQL database, analyzes the data, and displays in near real-time the relevant information. Caregivers using the system can customize a turn protocol for each patient being monitored. The software alerts caregivers when a patient has been in an orientation for a duration longer than was specified by the individualized turn protocol.

Typical installations of the Leaf Patient Monitoring System use Citrix Xenapp to serve the Turn Management Software to virtually all common desktop or mobile computing devices, including Microsoft Windows and Apple desktop systems, iPads, and Android tablets. A "thin client" such as a web browser is all that is necessary on the caregiver's device. A dedicated server computer having Citrix Xenapp installed can be configured and provided by Leaf Healthcare, Inc. or the Turn Management Software can be installed on an existing Citrix system already in use at the caregiver's facility.

The high degree of configurability of the Leaf Patient Monitoring System gives the IT and nursing staff of the facility in which it is used the flexibility to decide how best to implement the system. A status board and/or computing device may be positioned at the central nursing station to give caregivers access to the Leaf User Interface. Additionally, a display device providing caregiver access to the Leaf User Interface can be positioned

in each patient's room. The use of mobile computing devices such as laptops or tablet computers can enable dedicated turning teams to easily check which patients are due or soon due for an assisted turn.

Summary and Additional Information Source

The Leaf Patient Monitoring System architecture is flexible, allowing the healthcare facility to configure the system to best accommodate existing nursing workflow and IT infrastructure. A more detailed and comprehensive technical description white paper on the Leaf Patient Monitoring System is available by contacting Leaf Healthcare at info@leafhealthcare.com

High level schematic representation of the Leaf Monitoring Network
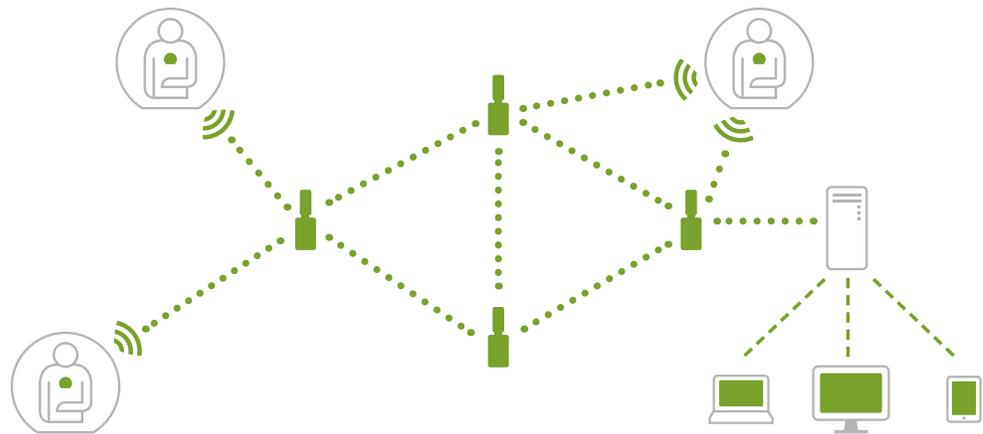
Continuous Monitoring

Patient position and activity data is automatically routed to the nearest Leaf Antenna. As a patient moves about the ward or hospital, their data is seamlessly transmitted through the Leaf Mesh Network in order to provide uninterrupted patient monitoring throughout the care environment.

Secure and Redundant

A series of relay antennas forms the basis of the system's wireless mesh network. This mesh network provides highly redundant data transmission that is fault-tolerant. Data is encrypted and securely transmitted using a proprietary wireless protocol.

Flexible Viewing Options

Patient data can easily be viewed at a central monitoring station or on mobile platforms (i.e. tablets, smartphones). System administrators can view data for specific patients, individual wards, or even the entire hospital from virtually any web-enabled computing device.

References

1. IEEE Std 802.15.4-2003, Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (LR-WPANs)