METHOD AND SYSTEM FOR REMOTE MONITORING MULTIPLE MEDICAL PARAMETERS

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Abstract

An integrated medical monitoring system comprising at least one patient monitor, at least one central monitor, and at least one remote access device which are tied together through an integrated communications link is disclosed. The communications between various components of the system are bi-directional, thereby affording the opportunity to establish monitoring parameters from remote locations, provide interactive alarms and monitoring capabilities, and provide data exchange between components of the system.

Remote monitoring activity based on Doppler shifts in radio signals shows promise in medical and security applications, however the problems of motion artifacts and presence of multiple subjects limit the usefulness of this technique. By applying MIMO signal processing, it is possible to overcome limitations of current systems and isolate signals from multiple sources.

1. INTRODUCTION

The performance of enterprise wireless LANs over the past few years, and especially since the introduction of 802.11n, has evolved to the point where industry analysts now expect Wi-Fi to replace wired Ethernet as the network connection of choice[1]. In this I will discuss the capabilities required to transform an 802.11n network into an Multi-purpose Medical Mobility (MMM) network. These capabilities fall into several different categories: reliability, security, versatility, scalability, upgradeability, manageability, interoperability [5].

Some systems depend on a hardwired system which requires that patients be disconnected from a monitor, connected to a mobile monitor in transit, and then reconnected to the system at new location. Furthermore, an additional monitor and often different sensor devices must be attached to the patient when the patient is in transit. These systems, therefore, are inefficient for use in clinical settings where patients are frequently transferred between various facilities [6].

Furthermore, when an emergency situation occurs, prior art systems generally require a relatively long time period to determine that an emergency has occurred and to broadcast the signal to a remote caregiver. This delay is extremely important in critical care monitoring, where a matter of seconds can make a significant difference in the outcome of a patient experiencing a life-threatening condition [7].

Other problems associated with prior art medical alert systems include difficulties associated with controlling the broadcast of a message and difficulties associated with determining whether an emergency message has been received.

2. MAIN TEXT

The latest development in WLANs for medical applications is the 802.11n standard. Finalized include new options for even better performance, 802.11n uses Multiple Input, Multiple Output (MIMO) and other techniques to significantly increase the achieved bit rate over distance (rate-range) performance of a Wi-Fi connection [8-9].

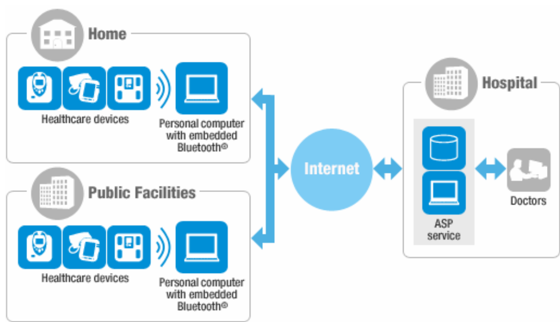

Fig. 1. Telemedicine System Service

The most significant performance improvements are due to a doubling of the channel bandwidth, from 20 to 40 Mbps, and dividing the video stream into two or more spatial streams, capable of finding separate paths from transmitter to receiver.

For healthcare organization, 802.11n increases the bandwidth available to medical applications by a factor of 5x to 7x over earlier Wi-Fi, performance surpassing a wired 100 Mbps Ethernet connection. Higher network capacity means the WLAN is more than ever suited to multi-use, multi-media traffic: new applications such as video streaming, and high-speed transmission of large files such X-ray images become much easier implement [10].

Remote sensing of heart and respiration activity by measuring Doppler shift in radio signals is a promising technique for unobtrusive health monitoring and life sensing, with proof of concept demonstrated for various applications [2-4]. When more than one target is in view, multiple transmitters and receivers providing multiple signal copies could be used to distinguish between the different sources of Doppler motion, isolate the desired signal, and determine a number of targets [11].

3. ILLUSTRATIONS

The system MIMO consisting of n_{tx} receive antennas, forming two proper linear antenna arrays. The arrays are spatially separated, for example, occupying two opposite walls in a room while facing each other (Fig. 2).

The MIMO receiver has knowledge of the pilot signals, and it applies channel estimation to learn the channel response between each transmit and receive antenna. Consequently, an estimate of the channel

$$h_{ij} = h_{ij} + n_{ij} \,,$$

where n_{ij} is the additive white Gaussian noise corresponding to the thermal noise. The noise has a zero-mean complex Gaussian distribution with the variance N_e given as

$$N_e \,|_{dBm} = 10\log_{10}(KTB) - G_e + 30[dBm]$$

where K is Boltzmann's constant, T is the environment temperature, B is the signal bandwidth and G_e is a gain introduced by the estimation procedure.

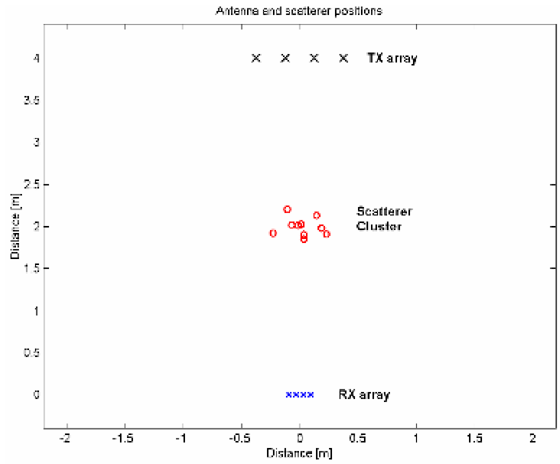

Fig. 2. A typical arrangement of Tx and Rx antennas, and cluster of chatterers that models a human body

Simulations were done for MIMO system with 4 transmit and 4 receive antennas, with the carrier frequency of 2.4 GHz, and 2λ and λ/2 separation between transmit and receive antenna elements. The two arrays are 4 meters apart. The scatter cluster of 10 chatterers is randomly positioned, with the diameter D=0.5m. Based on the above assumptions, the channel response between the *ith* receive and *jth* transmit antenna ($i=1, \dots, n_{rx}$ and $j=1,\dots,n_{tx}$) is

$$h_{ij} = \sqrt{P_j}\,\frac{\lambda}{4\pi}\left(\frac{1}{d_{ji}}e^{i\left(\frac{2\pi}{\lambda}d_{ji}\right)} + \sum_{k=1}^{N_s}\frac{\sqrt{S_s}}{\sqrt{4\pi d_{jk}}}e^{i\left(\frac{2\pi}{\lambda}d_{jk}+\varphi_{jk}\right)}\frac{1}{d_{ki}}e^{i\left(\frac{2\pi}{\lambda}d_{ki}\right)}\right)$$

where d_{jk} the distance between transmit antenna j and scatter k, d_{ki} is the distance between scatter k and receive antenna i, d_{ji} is the distance between transmit antenna j and receive i, and finally, φ_{jk} is a random phase shift.

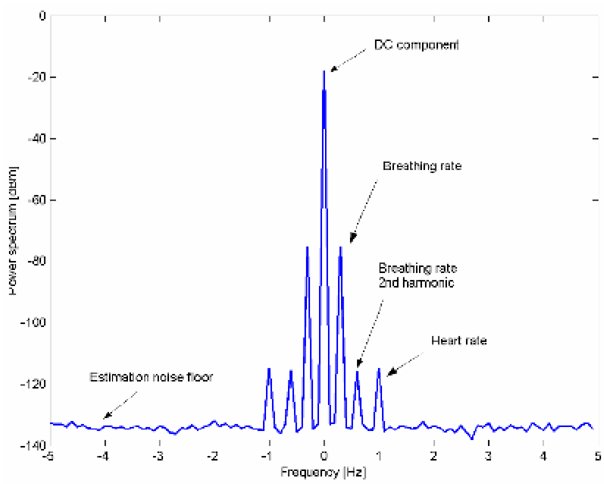

Fig. 3. The power spectrum of the channel state estimate sequence

Figure 3 shows the power spectrum of the channel state estimate sequence averaged over all transmitter-receiver pairs. The accumulative Tx power from all Tx antennas is 20 dB. The MIMO channel state sampling frequency is 10 Hz and the total of 100 samples/Rx-Tx pair is collected.

4. CONCLUSION

This paper demonstrated that Multi-purpose Medical Mobility networks can provide comprehensive network-edge connectivity with full communication reliability and end-to-end Quality of Service.

The application of MIMO systems to detection of cardiopulmonary signals resulting from Doppler shifts in radio signals. In future work the effect of different number of antennas and antenna arrangements on system performance will be investigated.

Mobility network can now reliably and securely meet the connectivity needs of all data, voice, and video applications in

Healthcare organization of virtually any size.

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