International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Rf Interference Minimisation in Bio-Applications using Cr-Ad Hoc Network

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Abstract

The E-health applications use wireless technology to transmit and receive vital information. However, Firstly there are certain associated risks like, electromagnetic interference exposure to bio-medical devices by wireless devices could critically affect their performance and secondly since different types of e-health applications have different priorities. So access to the wireless channel by the corresponding devices needs to be prioritized. In this paper a novel cognitive-radio-based approach to address these challenges in wireless communications for e-health applications in a hospital environment, is introduced.

It protects the medical devices from harmful interference by adapting the cross-layer based cognitive radio multichannel medium access control (MAC) protocol with TDMA, which integrate the spectrum sensing at physical (PHY) layer and the packet scheduling at MAC layer, for the ad hoc wireless networks. Such kind of a protocol enables secondary users (SUs) to utilize multiple channels by switching channels dynamically, thus increasing network throughput. The proposed cognitive radio MAC (CR-MAC) protocol allows SUs to identify and use the unused frequency spectrum in a way that constrains the level of interference to the primary users (PUs).

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1. Introduction

Electronic health (e-health) basically combines information processing and communications technologies for provisioning healthcare services. Wireless communication is a key technology to improve mobility and service flexibility for different e-health applications such as remote patient monitoring, telemedicine, and mobile hospital information system applications [1]. However, many medical devices are sensitive to electromagnetic interference (EMI) [2] caused by wireless transmissions. The interference can result in malfunctioning of medical devices (e.g., automatic shutdown, automatic restart, waveform distortion, and howling), which can potentially be harmful to patients using healthcare services.

Therefore, wireless communications systems to be used for e-health applications, especially in healthcare centres such as hospitals or clinics, have to be carefully designed to avoid this EMI problem. Cognitive radio, which is implemented based on software-defined radio, has recently emerged as a promising technique to improve the efficiency of wireless communications by increasing the radio spectrum utilization and reducing unintended interference. A cognitive radio transceiver can observe and learn the status of the operating environment, make a decision, and adapt the wireless transmission parameters accordingly. The cognitive radio concept can be applied to the wireless communications for e-health applications by taking the stringent constraints on EMI to medical devices [3] and different quality of service (QoS) requirements of various e-health applications into account.

1.1 How does EMI affect bio-medical appliances?

Electromagnetic Interference occurs when electromagnetic waves emitted by one device interfere with the normal operation of another. Sensitive electronic components inside any equipment that relies on computer chips can be vulnerable to other electromagnetic energy. This causes RF interference. Devices that are used to measure patients' health indicators are particularly susceptible to interference for two reasons: they can measure very low-level signals, and the human body and the connecting wires act as an antennae. There are many sources of RF frequencies in hospitals. Fixed sources include FM and television transmitters and paging systems, and mobile sources include two-way radios (such as on utility trucks) and cellular phones. Wireless computer equipment and other medical devices can also be culprits. There exist several electronic medical equipment’s such as infusion pumps, ECG monitors, and EMG monitors, operating in ICUs for different patients. Therefore, to avoid RF interference to the medical devices in ICUs, the wireless transmission parameters must be carefully chosen.

1.2 Need of Cognitive Radio Network

Cognitive radio (CR) has emerged as the solution to the problem of spectrum scarcity and reducing RF interference for Wireless applications. It has been using the vacant spectrum of licensed band opportunistically.

Cognitive radio networks (CRNs) refer to networks where nodes are equipped with a spectrum agile radio which has the capabilities of sensing the available spectrum band, reconfiguring radio frequency, switching to the selected frequency band and use it efficiently without interference to PUs [4,5].

CR Ad hoc networks (CRANs) are emerging, infrastructure less multi-hop CRNs. The CR users (nodes) can communicate with each other through ad hoc connection.

Although the basic idea of CR is simple, the efficient design of CRNs imposes the new challenges that are not present in the traditional wireless networks [6,8]. Specifically, identifying the time-varying channel availability imposes a number of nontrivial design problems to the MAC layer. One of the most difficult, but important, design problems is how the SUs decide when and which channel they should tune to in order to transmit/receive the SUs' packets without interference to the PUs. As CRNs need to use several channels in parallel to fully utilize the spectrum opportunities, the MAC layer should accordingly be designed. Multichannel MAC protocols have clear advantages over single channel MAC protocols: They offer reduced interference among users, increased network throughput due to simultaneous transmissions on different channels, and a reduction of the number of CRs affected by the return of a licensed user. To amend the aforementioned problems of the existing schemes, in this paper, I propose a multichannel CR-MAC protocol which enables nodes to dynamically negotiate channels such that multiple communications can take place in the same region simultaneously, each in different channel.

The network we consider is an ad hoc network that does not rely on Infrastructure, so there is no central authority to perform channel management. The main idea is to divide time in to fixed-time frame intervals, and have a small window at the start of each interval to indicate traffic and negotiate channels and time slots for use during the interval. A similar approach is used in IEEE 802.11 power saving mechanism (PSM).

2. CR-MAC DESIGN:

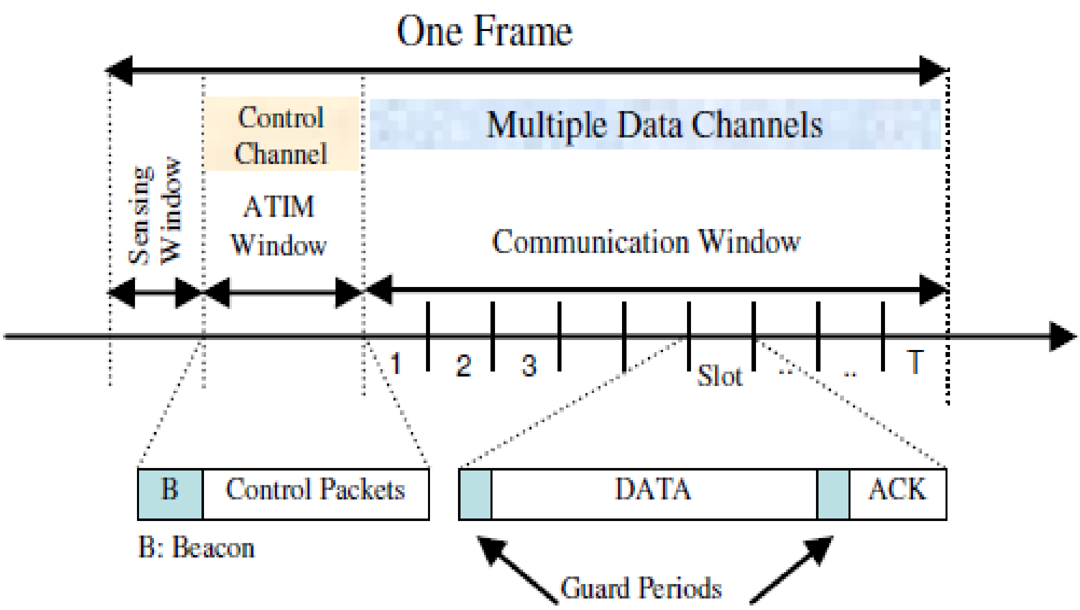
A TDMA scheme is used in the communication window of the proposed CR-MAC. The CR-MAC scheme has some similarities with TMMAC. On assuming that the time domain is divided into fixed length frames and each frame consists of a sensing window,

an ad hoc traffic indication messages (ATIM) window, and a communication widow. The ATIM window is contention-based and uses the same mechanism as in the IEEE 802.11 DCF [9]. The ATIM window is divided into the beacon and the control window. During the ATIM Window, control channel is used for beaconing and to exchange control message. All of the CR users are synchronized by periodic beacon transmissions. In this MAC scheme, channel sensing is performed in the starting of each frame to avoid possible collisions with PUs. If any chosen channel is found to be busy, that channel will not be used in the ATIM window.

As mentioned earlier, the communication window is time-slotted and uses TDMA scheme. The duration of each timeslot is the time required to transmit or receive a single data packet and it depends on the data rate of PHY layer and the size of data unit. In order to minimize possible collision with transmission from PUs, the slot size is restricted for a single data packet.

3. Conclusion

I have proposed a cognitive radio system for e-health applications. This system considers the issues of EMI to medical devices and QoS differentiation, which are crucial in healthcare environment. The *cognitive* capability of the system arises due to its EMI awareness to control the wireless access parameters.



Structure of CR-MAC protocol

The performance (i.e., delay and loss probability) of the cognitive radio system can be improved by incorporating multiple data channels. The CR-MAC protocol, which is a multichannel MAC protocol using a single half duplex transceiver for cognitive radio ad hoc networks. CR-MAC requires time synchronization in the network in order to avoid the multichannel hidden terminal problem and divides time into fixed frame intervals. Nodes that have packets to transmit negotiate which channels and time slots to use for data communication with their destinations during the ATIM window. This two-dimensional negotiation enables CR-MAC to exploit the advantage of both multiple channels and TDMA in an efficient way. Further, CR-MAC is able to support broadcast in an effective way.

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