Doctoral Thesis

博士論文

Proposal Methods for Performance Analysis of WBANs Based on CSMA/CA

CSMA/CA に基づいたワイヤレスボディエリアネットワークの理論性能解析に関する研究

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Abstract

The world population has been increasing, leading to a number of problems to society and economics of many countries around the world. In which, a increase of life expectancy is likely to age population, that requires higher health care costs. Wireless Body Area Networks (WBANs) appear as a potential candidate to solve this matter because of providing a dynamic, efficient and high quality e-health care.

In 2012, IEEE set up the standard for WBANs, IEEE.802.15.6, that has been considered as a breakthrough in development process of e-health care and information communication technology in general. To develop better technologies, protocols and to realize WBANs in commercial area are continuous works of researchers and engineers. The trend of research on WBANs can be clarified as follows, doing survey and overviewing on WBANs, developing technic for WBANs as coding or modulation scheme, improving medium access control (MAC) protocol for WBANs, implementing and designing hardware for WBANs, modeling the propagation channel in which WBANs working on, finally analyzing performance of WBANs in order to optimize parameters to achieve higher performance. This thesis belongs to the final trend.

A dependable and efficient MAC protocol is really important with WBANs when they are applied for medicine or even though for non-medicine. Better MAC protocol can produce low energy consumption or at least can guarantee the timely delivery of emergency traffic. Therefore, beside of improving MAC protocol, correctly analyzing it is necessary. There have been many works on performance analysis of IEEE 802.15.6, especially based on carrier sense multiple access with collision avoidance (CSMA/CA) scheme. The performance analysis

on WBANs MAC layer can be clarified into two groups, using Markov chain model to simulate the state of sensor in WBANs and non-Markov chain model approach.

By employing discrete time Markov chain (DTMC) model, many previous works can illustrate the state of all sensor in WBANs or simulate how sensors working and affecting together in the system. As a result, previous works can calculate the access probability of all sensors and then calculate throughput and energy consumption or delay and consider these as final results. After reviewing carefully previous works, the authors of the thesis found out limitations as frequent assuming that channel is ideal and finishing such at analyzing, not optimizing or proposing any new technology, protocol or system. In order to overcome these limitations, the thesis developed discrete time Markov chain (MCMC) method to analyze performance of WBANs under non-ideal channel by taking into account bit error rate (BER) and packet error rate (PER). The MCMC method can be considered as development or adjustment of the DTMC method with key idea is to find the access probability approximately.

On the other hand, the DTMC method consists of method limitations as using assumption like saturation condition and non-saturation condition, and not taking into account remained packets. The saturation condition in this thesis can be explained as if a sensor in WBANs always has a packet to send or in its user priority (UP) queue there is always a packet waiting to be served, the sensor is saturated. In fact, saturation condition is likely to be relative with high traffic. The remained packets are the packets transmitted unsuccessfully due to collision or error. As a result, there are some previous works on MAC layer for WBANs not using the DTMC method. However, these works have limitations as consideration system having only a sensor node and a coordinator, or system with many sensors but only single UP, consequently, the effect each other of sensors in the same UP or different UPs is not taken into account. From these points, the thesis proposed dynamic statistical method for performance analysis

WBANs on MAC layer, taking into account remained packets and analyzing system performance changing following operation time and due to variable packet arrival rate, the number of sensors, payload size, retry limit and UP levels. The proposal method has been expected to be more flexible and precise.

Moreover, not finishing at analyzing performance, the thesis propose adaptive Bose-Chaudhuri-Hocquenghem (BCH) code rates for WBANs and the thesis also proved that this adaptive code can produce significantly higher throughput for WBANs.

In conclusion, the thesis produced three main results, proposing two methods, the MCMC and dynamic statistical method, for performance analysis of WBANs, and then proposing the adaptive BCH code rates for WBANs with higher throughput, which was already proved. The thesis still contains drawbacks or unsolved problems. Firstly, the proposal adaptive BCH code may cause system to become more complex and this is not solved yet in the thesis. Secondly, with the proposal dynamic statistical method in this thesis is only finished at algorithm. For the future work of this thesis, the authors hope to apply the MCMC method to other coding schemes with deep analysis of changing the complexity and energy consumption of system when adaptive coding scheme is employed. With the proposal dynamic statistical method, authors need to develop simulation program to produce the throughput or energy consumption of system and compare these with outstanding previous work results to prove the proposal method. Moreover, the second method should be extended to the real channel under noise and interference condition with deeper analysis of adaptive real change of channel because of noise and interference, employing cross layer with coding in order to optimize parameters of system and then proposing adaptive coding schemes with comparison of these.