International Journal of Network Infrastructure Security
Volume 1 Issue 1

Mitigation of Single Point Failure and Successful Data Recovery in Wireless Body Area Network

Mrs. Sanchari Saha[1]
[1]Assistant Professor,Department of CSE,
MVJCE, Bangalore

Dr. Dinesh K Anvekar[2]
[2]Director for Research & Product innovation,
VVIT, Bangalore

{saha.sanchari85@gmail.com,dinesh.anvekar@gmail.com}

Abstract

A wireless body area network can play a significant role in monitoring the physiological signs of human body and hence can be applied in various application areas such as battlefield, sports, hospital etc. As WBAN deals with vital signs of human body, network reliability is of utmost importance. The reliability of WBAN is the ability of the network to be connected even during node failures and malicious attacks. In this paper, we have proposed an efficient and highly reliable wireless body area network (WBAN) with a combination of cooperated network coding that can provide increased throughput and deal with single point of failure. Cooperated network coding in real time application areas of wireless body area network is an efficient way to deal with packet loss, single point of failure, data recovery and reduced latency due to retransmission of information. In this paper, we have proposed a many-to-many cooperated network coding to support multiple sources, multiple relays and multiple sinks or destinations in WBAN.

Keywords: *WBAN, cooperated network coding, single-point-of failure, data recovery*

INTRODUCTION

Due to the immense advancement in wireless technology, miniature sensor devices, low power consumption and increased battery life WBAN emerged as an idea during last century to revolutionize healthcare applications. The idea behind wireless body area network was to collect vital signs from human body by appending different types of sensors to the body even when the person is on the move. The main advantage of wireless body area network is to provide health monitoring without interfering with the patient’s day-to-day activities.

The appended sensors are responsible for collecting data from human body and send them via any wireless medium towards a gateway node which is responsible for forwarding the received data to a Personal Digital Assistant (PDA) or a mobile phone. The forwarded data is then finally sent to a medical server or doctor via any wireless network including cellular, Wi-Fi, Bluetooth etc.

In this paper, the focus is on battlefield application area. The use of WBANs in military application area or battlefield may enable chief commanders to monitor vital signs such as fatigue stage or low energy level, increased stress level, reduced alertness state of soldiers and can lead to proactive recovery process at an early stage. Additionally, WBAN may be capable of controlling actuators which based on correct measurements and settings, can automatically release medicine or other agents when needed. It can have data logging facility of a soldier’s normal environment, so that doctors can have a clear idea of the soldier’s status and the potential emergency issues.

As patient mobility increases the probability of packet loss, it is desired that the packet error rate should be kept less than 1%; it is highly required that WBAN should provide reliable communications which is insensitive to link or node failure. Additionally, the WBANs must transmit at low energy to protect the patients against harmful health effects.

COOPERATED COMMUNICATION

WBAN nodes are composed of battery driven sensors which are placed either inside or on the human body. As these sensors need frequent charging and electromagnetic radiation from these sensors can lead to adverse effect or discomfort to human body, along with other requirements, WBAN should also consider the need of low power and energy efficient communication. But as large path loss in WBANs is possible, if there is lack of sufficient transmit power, link quality will be degraded due to severe attenuation of wireless signals.

Cooperated communication in WBAN provides a unique solution to all these performance requirements. It uses the broadcast mode of wireless communication channels so that neighbouring nodes (named as relays) can hear the source signal intended for a specific destination, process the signal and transmit it to the intended destination. Signals that are received from relays and the source are combined at the intended destination which results in mitigation of packet loss due to link failure or single point of failure. The main idea behind this technique is to use available user terminals as relays that can cooperate to increase system performance.

In cooperated communications relay nodes are responsible to perform decoding on each received signal from each source node, then re-encoding those decoded signals and finally forwarding it to the destinations. Destination node then combines multiple signals arrived from different paths and decode the original source message. But with increased number of source nodes, this procedure may be jeopardized. If the number of source node increases, each relay node needs to forward multiple signals received from multiple sources that may lead to huge power consumption as well as delay in entire network communication.

As an example, if there are Ns source nodes and Nr relay nodes, for signal transmission Ns(Nr+1) time slots are needed; which means that, to forward Ns signals, a relay node requires minimum Ns time slots. Therefore, when Ns increases, the relay node needs to send more messages, which may lead to exhausting the capacity of the relay node.

COOPERATED COMMUNICATION WITH NETWORK CODING

Cooperated communication with network coding focuses on minimizing the count of signal transmissions of an individual relay. It also impacts on the overall network delay and gains reasonable output performance. In this paper, we propose a cooperated network coding scheme in combination with decode-and-forward relays. We call this approach as DReF_CNC (Decode_Re-Encode and Forward Cooperated Network Coding). In DReF_CNC approach, signals that are received at an individual relay are linearly combined resulting in only one signal, which is then transmitted to the destination. Therefore, only one time slot is needed by each relay to forward its signal.

As shown in the following Fig.1, we have considered a two-hop configuration of WBAN where Ns sources want to communicate with the destination D through Nr relays. Each source has information I to send and applies a channel code of rate R to generate a coded information of length n (= I=R).

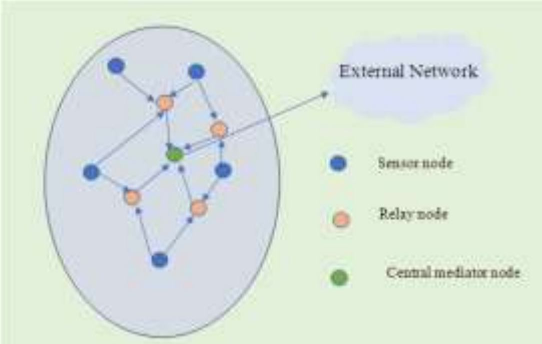

Fig. 1. *Cooperated network coding with Ns sources Nr relays and single destination*

The relays are assumed to communicate in half-duplex mode and hence any node will not be able to send and receive at the same time. Initially the source node broadcasts a packet to the destination node. A copy of the packet will also be sent in next time slot if the relay can decode it. Therefore, the sink or destination will decode the information from the two received packet copies.

DECODE, RE_ENCODE AND FORWARD WITH COOPERATED NETWORK CODING

In all types of decode and forward based cooperated communication schemes, relay nodes need to first decode the source message and then re-encode it and transmit it to the destination. But all these schemes are useful only with limited number of source nodes. With increase in number of source nodes, relay nodes need to do a lot of processing which consumes much transmission energy. As an example, a network with ten sources and one relay receives ten messages which it needs to decode and then forward to the destination in ten individual time slots. This is not convenient to deploy in WBAN with limited resources. Two possible solutions are available to overcome the above-mentioned issue. One solution is to reduce the decoding complexity at the relay where the relay needs to decode only few received signals instead of all. Even though it results in lower decoding complexity and the relay needs to use only few time slots for transmission, comparatively the overall network performance degrades as only few messages are processed and few remain unprocessed.

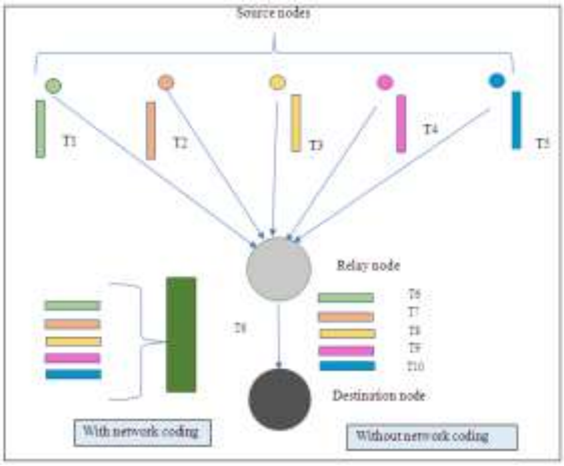

Fig. 2. *Time slots in a cooperated network with and without network coding*

The second solution is to use network coding where the relay still decodes all or a prefixed number of the received messages, and then together re-encodes them and forwards them to the destination. To reduce the complexity, a simple bitwise XOR operation is considered for network coding. Thus, in this solution, the relay needs to use only one time slot to forward the message to the destination. Fig. 2 shows a WBAN with five source nodes and one relay. When network coding is not deployed, the relay needs to use five time slots to forward the source messages to the destination. But, when network coding is used, the five decoded packets at the relay are combined linearly to produce a single coded packet and then forwarded to the destination which needs only one time slot.

NETWORK CODING AND DECODING PROCESS

In this process, we consider that each source node has I information symbols to send which are converted to n coded symbols after encoding. Let us consider that R_i has decoded set $Code_i$ of source nodes with cardinality N_i. So, N_i is the number of relays that have successfully decoded Si's message where S_i is the i^{th} sender node and R_i is the i^{th} relay node. We assume that $Code_i = \{A1, A2 \dots AN_i\}$ where $A_m \in \{S1, S2 \dots SN_s\}$. N_s represents source node and $Code_i$ is the decoding set for S_i, which is the set of all relay nodes that have successfully decoded S_i's message. Each network coded symbols at R_i can be calculated as follows. We can randomly choose a coded symbol from each source node in $Code_i$ and then XOR them. The j^{th} symbol of the network coded message at R_i can be calculated as follows:

$$r_{i,j} = \left(\sum_{k=1}^{Ni} a_{k,j}\right) \bmod 2 \quad ,$$

where j=1, 2 …. n (1)

While decoding at the destination, the first Ns time slots are allocated to the source node symbols. Signal received from the $source_i$ at the destination can be calculated as follows:

$$r_{iD} = ch_{iD}\, x_i + n_{iD} \tag{2}$$

Where, ch_{iD}, x_i and n_{iD} are the channel gain between the source i and the destination and the additive white Gaussian noise, respectively. The last Nr time slots are allocated to symbols from the relays. Therefore, the signal received from the jth relay at the destination can be calculated as follows:

$$r_{jD} = ch_{jD}\, \tilde{x}_j + n_{jD} \tag{3}$$

In this process, Message-Passing Algorithm (MPA) is used to decode the signal for the i^{th} source [1–5]. MPA supports iterative message transmission, where messages are transmitted from check node to variable nodes and then from variable node to check nodes in each iteration. This process repeats until a prefixed number of iterations are completed or all variable nodes are decoded.

COMPARATIVE ANALYSIS

Network coding allows messages from multiple sources to be combined in a mediator node. In this way performance gains like network flow, energy efficiency are possible to be obtained.

Network coding mainly aims at increasing the message transmission efficiency e.g., energy efficiency, bit error probability, frame error probability, throughput, network capacity for the wireless cooperative networks. Sample architecture for the two-source network is shown in Fig.4. In this architecture, the other source acts as a relay, performs network coding (bitwise OR operation) among another source's message and its own messages. Therefore each message is transmitted three times (one time directly and two times indirectly) instead of two (as Fig. 3), while the total resource usage is the same. Through this approach, coding gain is achieved by combining messages from different users. The improvement is more obvious for more number of message sources.

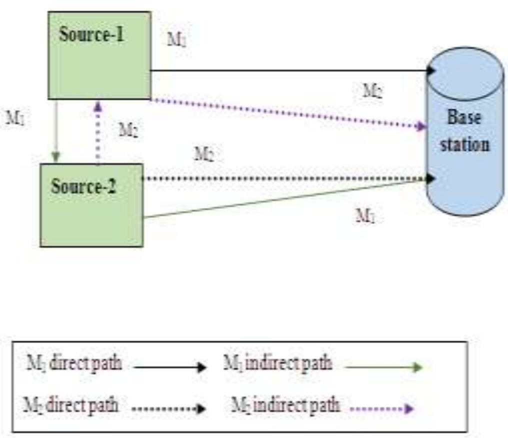

Fig. 3. *Cooperative communication without network coding*

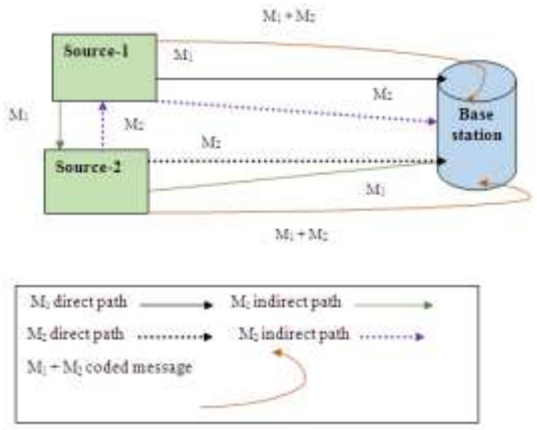

Fig. 4. *Cooperative communication with network coding*

CONCLUDING REMARKS

In this paper, we have proposed a cooperated scheme based on decode/re-encode/ forward step and network coding to enhance the energy efficiency and network lifetime in WBANs. In this scheme, each relay decodes the received source message, includes them in the coding process, re-encodes the message, performs permutation, then performs XOR and finally transmits to the destination. The scheme also reduces the count of time slots and can effectively handle single point of failure. In summary, cooperative communication with network coding can provide major advantages in terms of energy-efficiency, reliability and delay compared to direct transmission for WBANs.

REFERENCES

1. Samaneh Movassaghi_, Mahyar Shirvanimoghaddamy,MehranAbolhasan_, and David Smith, " An Energy Efficient Network Coding Approach for Wireless Body Area Networks", 38th IEEE conference on Local Computer Network, 2013

2. Gabriel E. Arrobo, and Richard D. Gitlin, "Improving the Reliability of Wireless Body Area Networks", 33rd Annual International Conference of the IEEE EMBS Boston, Massachusetts USA, August 30 - September 3, 2011
3. D. Smith and D. Miniutti, "Cooperative Body-Area-Communications: First and second-order statistics with decode-and-forward," in IEEE Wireless Communications and Networking Conference (WCNC), Paris/France, April 2012.
4. T.-W. Yune, D. Kim, and G.-H. Im, "Opportunistic network-coded cooperative transmission with demodulate-and-forward protocol in wireless channels," IEEE Transactions on Communications, vol. 59, no. 7, pp. 1791–1795, 2011.
5. 5.S. Movassaghi, M. Shirvanimoghaddam, and M. Abolhasan, "A cooperative network coding approach to reliable wireless body area networks with demodulate-and-forward," in 9th IEEE International Wireless Communications and Mobile Computing Conference (IWCMC), July. 2013, pp. 1 –6.

Ms. Sanchari Saha holds a Master's degree from CMRIT (VTU), Bangalore, and Bachelor of Engineering degree from NIT, Agartala. Currently, she is working as an Assistant Professor in MVJCE, Bangalore, and pursuing research work towards her PhD degree. She has published a text book titled "Object Oriented Modeling & Design pattern" and total 22 papers in reputed national & international journals and conferences. She has received gold medal from VTU for securing 1st rank during her Master's degree. She is a member of Indian Society for Technical Education.

Dr. Dinesh Anvekar is currently working as Director for Research & Product innovation, VVIT, Bangalore. He worked as Principal of Alpha College of Engineering. He also worked as HOD of Dept. of CSE at NMIT, Bangalore and Director Entrepreneurship and Professor of Computer Science at CMRIT. He obtained his Bachelor degree from University of Visvesvaraya college of Engineering. He received his Master's and PhD degrees from Indian Institute of Science. He received best Ph. D Thesis Award from Indian Institute of Science. He has completed two Nokia sponsored projects in Indian Institute of Science during 1997-1998. He has 15 US patents issued for work done in IBM Solutions Research Center during 1998-99, Bell Labs during 1993-94, and Lotus Interworks during 2000-04, and for Nokia Research Center, Finland. He has a INTR Authored book and over 55 technical papers. He is a Fellow of IETE and Senior Member of IEEE. He has supervised over 40 undergraduate and graduate engineering projects and research students in the Indian Institute of Science.