Abstract

Nowadays, one of the future wireless trends is 5G and beyond technology that can be a potential core network of the Internet of Things (IoT) concept as well as its applications, which bring many benefits for society. In addition, the explosive increase in the number of wireless devices and the high demands of communication performance have created a trend of new techniques in wireless networks. In order to catch up with those requirements, the wireless full-duplex technology and network coding technique are attracted by many researchers, because they can significantly improve the throughput of the system. In these research fields, there still exist a few problems that related to challenging for media access control (MAC) protocol, i.e., hidden terminal problem. The hidden terminal problem is a problem in which a node that cannot sense the ongoing transmission but is able to introduce enough interference to corrupt the reception if it transmits. This leads to difficulties in MAC sublayer. The carrier sense multiple access with collision detection (CSMA/CD), which is a MAC method used most notably in early Ethernet technology for local area networking (LAN), does not work effectively. Hence, the collision occurs and directly affects to the performance of the wireless network systems.

To overcome these problems, a lot of research that rated to half-duplex, full-duplex and mixture of half-duplex and full-duplex wireless networks, have already been studied in recent years. Firstly, the half-duplex is a wireless technology in which a wireless transceiver can either transmit or receive signals in a given bandwidth but not both at the same time. Meanwhile, the full-duplex technology can double spectrum efficiency by simultaneous transmission and reception on the same frequency and time resource. In addition, the full-duplex technique also helps to reduce end-to-end packet delay and improve network efficiency, the full-duplex technique is widely considered as one of the promising techniques in the fifth generation (5G) systems. However, the difference in half-duplex technology, the problem already exists on the full-duplex technology as the overwhelming nature called self-interference (SI), which is generated by a transmitter to its own collocated receiver. There are some solutions that related to SI cancellation were studied, such as passive SI suppression, analog cancellation, or digital cancellation. Moreover, there are still some technical obstacles to be overcome before the full-duplex technique is really put into the practice. The current studies mostly focus on theoretical analysis and the experiments based on the simple models. Besides, the mixture of half-duplex and full-duplex wireless networks that is the combination of the half-duplex and full-duplex nodes into the wireless network system, has considered resolving the existing problems as well as enhancing the performance of the wireless network systems.

In detail of the current solutions for solving the hidden terminal problem, there are much research that have presented. Mostly, they concentrated on the carrier sense multiple access with collision avoidance (CSMA/CA) wireless network under the request-to-send/clear-to-send (RTS/CTS) mechanism. In order to evaluate the performance in terms of saturation throughput of the wireless network systems, the two states of the channel, including collision and success have considered. Likewise, the discrete time Markov Chain (DTMC) model was applied to calculate the conditional collision probability that be used to formulate the transmission probability and saturation throughput of the wireless network systems. Additionally, the current solutions that related to full-duplex MAC protocol have been attracted by many researchers in this research field. They have proposed the new frame formats for MAC protocol that can be employed in both half-duplex and full-duplex wireless nodes. A few solutions have described, like shared random backoff, header snooping, virtual contention resolution.

Moreover, in order to improve the performance of wireless networks, network coding is of interest to researchers in recent years. Network coding is essentially a mathematical operation, which is exclusive-OR (XOR) applied to intermediate nodes between the source node and destination node. Instead of simply forwarding data, intermediate nodes may recombine several input packets into one or some output packets. Based on this operation, this can provide the possibility cut down the number of transmissions and maximize the network throughput of the system. A few research have been contributed the full-duplex technology using network coding, specifically physical layer network coding to enhance the performance of the wireless network systems as well as the reliability of the full-duplex technology.

However, today the hidden terminal problem has not completely solved and it still a challenging for MAC protocol. In addition, the performance of the combination of the mixture of half-duplex and full-duplex technology and network coding technique needs to be considered more explicitly. The aim of this proposition is to improve the end-to-end throughput of the wireless network systems. The most important things to achieve this target are related to the solutions for solving the hidden terminal problem and a new MAC protocol design in order to enhance the performance of the wireless network systems.

Therefore, base on the current methods, this research concentrates on analyzing and evaluation in the mixture of half-duplex and full-duplex wireless network considering hidden terminal problem. Likewise, this research revisits the solutions for solving this problem such as shared random backoff, header snooping, virtual contention resolution. The header snooping is the best one for three nodes of the mixture of half-duplex and full-duplex wireless networks and it has been analyzed more explicitly in this research. Additionally, the challenge of MAC protocol design has reconsidered and analyzed to completely resolve the existing problems as well.

The applied method still bases on the RTS/CTS mechanism. Besides, the Markov Chain approach with three states of the channel, like success, collision and freeze has proposed under the three nodes topology considering hidden terminal problem. Based on the system mode, this research extends the scheme of transmission by using the network coding technique. Hence, this research proposes a new MAC protocol called integrated full-duplex and multiple access (IFDMA) protocol for the combination of the half-duplex, full-duplex, header snooping, and network coding techniques. Especially, the transition models of relay-based XOR and source-based XOR operation have discussed.

In order to evaluate the effectiveness of the proposed IFDMA protocol, the numerical simulation has been determined under the grid topology and the random wireless networks. Besides, the model of the interference influence that is also considered, directly affects the performance of the wireless network system in the real environment. In addition, this research also considered the random wireless networks with the ratio index of the half-duplex and full-duplex wireless nodes that indicates the appearance probability of which topology in combination. Thus, this index alters the throughput of the system. Furthermore, the evaluation results, which were explicitly presented by comparison among various techniques, demonstrated that the wireless networks with the IFDMA protocol operation, give the highest saturation throughput. Likewise, the effectiveness of IFDMA protocol has shown by the recognition the effects of interference model and the combination of all techniques.

In conclusion, the proposed IFDMA protocol has achieved to provide the considerable improvements in the mixture of half-duplex and full-duplex wireless network considering hidden terminal problem. The expected outcome is to show the improvement in the performance in terms of saturation throughput and indicate the comprehensive of the proposed IFDMA protocol as well as the high ability of the full-duplex technique implementation in the real wireless environment. As a result, this research will be an open key to researchers who are interested in full-duplex technology.

Keywords: MAC protocol, half-duplex, full-duplex, network coding, hidden terminal problem, Markov chain.