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# Asymmetric Time Division Multiple Access Method for Tactical Radio Communication

[ Joong-Hyuk Cha, Seung-Han Kim, Jin-Yong Im and Dong-Seong Kim* ]

***Abstract*—This paper proposes the effective asymmetric multiple access method to improve performance of tactical radio communication for land wheeled weapon systems on the domestic tactical communication operational environment. The proposed approach adapts modified TDMA scheme in place of CSMA/CA as media access protocol on the basis of the analysis of the operational environment of tactical radio communication. For proving effectiveness of the proposed approach, the simulation model is used to overcome constraints of real experiments. The simulation results show that the response time and the throughput of tactical radio communication are improved in terms of by adapting proposed TDMA as media access protocol than CSMA/CA.**

***Keywords*—Tactical radio communication, Multiple access method, Domestic operational environment**

## I. Introduction

The purpose of tactical radio communications is offered tactical data networks for real-time transmission of tactical information[1][2]. It should be tactical data exchange between weapon systems and command control systems and available in real-time battlefield situation sharing and control weapons systems and the conduct of warfare[3][4]. Data network in the ground maneuver weapon systems use a wireless communication environment in consideration of the maneuver operation, accessorily a wired communication considering the limited use of such static position. The tactical wireless communication network is made up the network to the transceiver which provided by the traditional voice communications medium without development of the wireless communication equipment.

Conventional tactical data networks are designed using CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance)[5]. CSMA/CA is to reduce the collision probability to give priority to the command post and 6 unit node using Prioritized-NAD scheme[6]. But prioritization gives rise to problems that channel access opportunity to each unit node does not equal. Lower priority node have queueing time up to five times than higher priority node. In addition, uplink message have more latency than downlink message while command post send message to unit nodes.

For solving unevenness of that problems, tactical data networks are designed using TDMA-based control[7]. But the TDMA can’t solve the problem that uplink message has more latency than downlink message.

As a scheme for this, this paper proposes an asymmetric TDMA-based control and analyzes the performance of that. Tactical wireless communication required analysis of requirement and performance because these networks performed mission based on data networks. For that, proposed tactical radio communication simulation model is implemented for analysis of response time and throughput.

## II. Asymmetric TDMA Scheme

### A. *Asymmetric TDMA structure*

In this section, in order to improve latency of uplink message from command post to unit node and unequal access opportunities between unit nodes, asymmetrical TDMA is proposed.

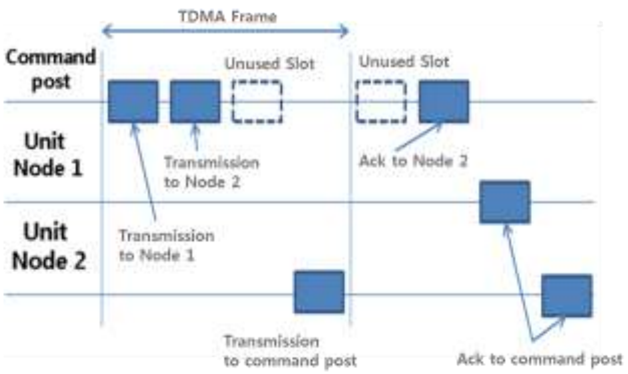


Figure 1. Tactical wireless communication flow applied the asymmetrical TDMA.

Tactical wireless communication applied to TDMA is connected in the same manner as Figure 1. Command post is configured to allocate a time period corresponding to the unit of the node to be transmitted. The rest unit of the nodes send the message when there is a message to send in the time slot. And the command post to send a response to the received message sends a response message to each unit nodes in the assigned time slot. The unit nodes transfer response message regarding to receive message from command post to the command post in the assigned time slot.

In applying the TDMA on the ground maneuver systems, they are necessary to take into account the operational environment of the wireless communication. Therefore, the

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size of each time slot as the characteristics of the tactical transceiver should be made more than a few hundred millisecond.

Downlink message has a structure which sending message and receiving numerous response message. However, because of the small size compared to the response message, downlink message is dropped down the network efficiency. Because of this, it is necessary to consider a separate response message transmission scheme.

If the size of time slot is determined to consider only high frequency uplink message and small size message like a response message, when a relatively large downlink message transfer requires a number of TDMA frames. Thereafter, the transmission time of a downlink message are required for the number of frames.

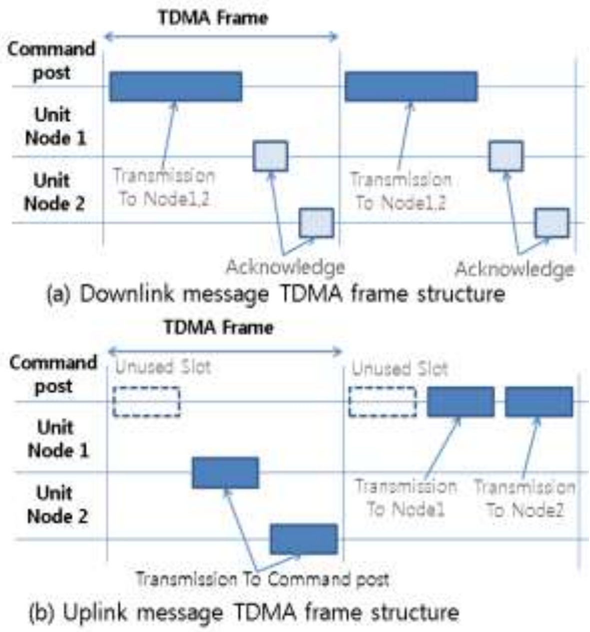


Figure 2. Configuration of proposed asymmetric TDMA frame.

In Figure. 2, the frame structure of asymmetrical TDMA are presented. Downlink message frames are designed for transmitting without fragment of message in Figure. 2 (a) Furthermore, relatively short time duration is assigned for avoiding increase frame size by numerous acknowledge.

Uplink message of the TDMA frame in Figure. 2 (b) has a structure for allocating a time period of equal size to the command post and a node unit. Figure. 2 (b) shows that TDMA frame of uplink message is transmitted on time slot to each node. The transmission from command post to unit node, also limited to acknowledge. Time slot is assigned to the command post is set to an unused slot, and transmitting acknowledge is between each node unit assigned to the time slots.

Like Figure. 3, Uplink and downlink messages of proposed TDMA frame are constructed by 7 time slots are considered fixed command post and 6 node unit.

In order to have a frame structure of a TDMA, the frame at the beginning of a frame in a node unit is to be able to distinguish between the downlink and uplink frame. For this, in Figure 3 like uplink message TU0 time slot is used as Listen & CD Check. Unit nodes first monitor the status of the network and check the CD. At this time, unit nodes receive the message as the downlink frame in using the network, and unit nodes send the message as the uplink frame in unused the network.

TDMA downlink frame is transmitted a message to allocate TD0 time slot to command post. And it was assigned TD 1-6 time slot to transmit acknowledge in unit node.

TDMA Uplink frame is assigned TU0 time slot to detect carrier by utilizing the CSMA. If it is determined to uplink frame, time slot allocated TU1-6 for transmitting message is at unit node.

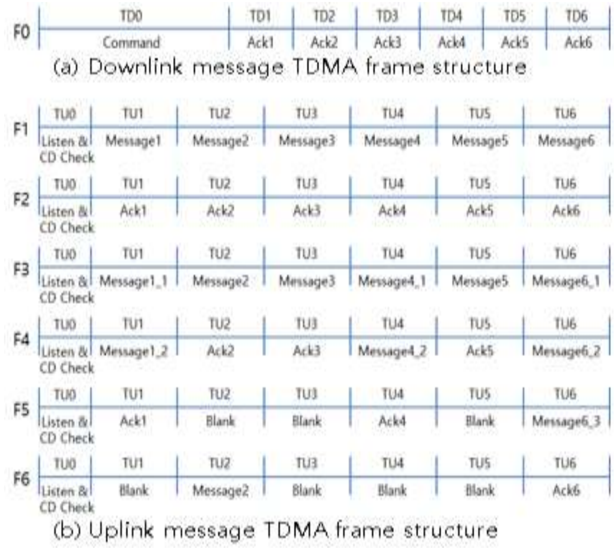


Figure 3. Message configuration of proposed TDMA.

## B. *Asymmetric TDMA frame*

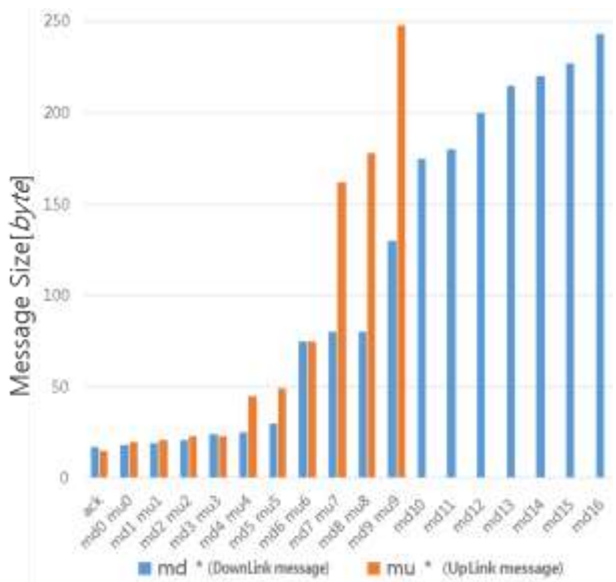


Figure 4. Downlink and uplink message size.

A Message used in the tactical wireless communication is divided into downlink and uplink message, and its size is the same as Figure 4. The maximum size of the message shows a less than 255byte. Downlink message consists of md0-16 and response message sent from the node units.

Uplink message is used in order to transmit the tactical information to the command post from the node unit. The whole message consists of mu0-9 and response message received from command post. In the uplink message, response message about command message and high frequency message has a size less than 50byte. Relatively large messages to send the tactical information in the unit node has a size of between 50 and 250 byte.

In table 1, time slot size of uplink and downlink message are presented. The TDMA frame size of uplink and downlink message is assigned as 10000ms, starts the beginning of the frame in every 10s.

Table I. TIME SLOT SIZE OF UPLINK AND DOWNLINK MESSAGE.

| | | | | |
|---|---|---|---|---|
| Downlink Message Frame | Time slot | TD0 | TD1-6 | Total |
| | Use | Tactical Information | ACK | |
| | Allocation (*msec*) | 3400 | 6600 | 10000 |
| Uplink Message Frame | Time slot | TD0 | TD1-6 | Total |
| | Use | Listen & CD Check | Tactical Information or ACK | |
| | Allocation (*msec*) | 1000 | 9000 | 10000 |

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# III. Simulation Results

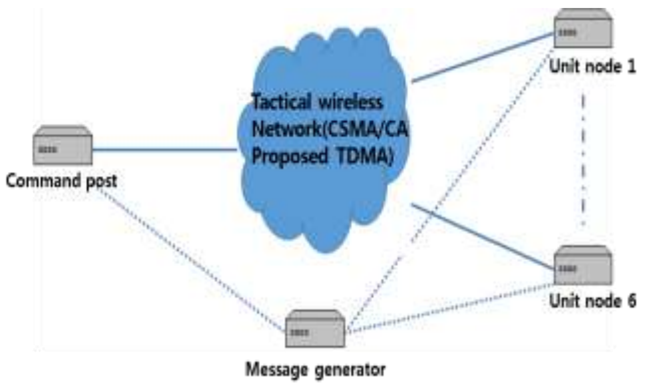


Figure 5. Tactical wireless communication simulation model.

Configuration of the system for performance analysis of the tactical wireless communication is shown in Figure 5. The tactical wireless network determines whether or not collision between transmission messages as CD checking, and the success of the transmission. Message generator makes unit nodes start to send uplink message. The BER between transmission is regarded as 0, The simulation model assumed that the retransmission is not performed.

## A. *Proposed TDMA throughput response time analysis*

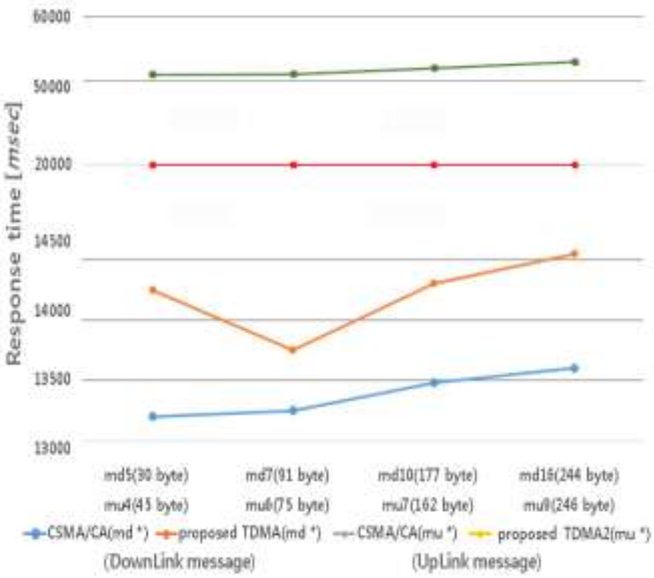


Figure 6. Response time to CSMA/CA and asymmetric TDMA.

In Figure 6, in transmission rate 4800bps of Tactical radio, asymmetry TDMA is slower than conventional CSMA/CA on downlink message response time, but considered the equivalent performance. In uplink message response, tactical wireless communication applied asymmetry TDMA is verified to be improved performance than the conventional CSMA/CA to all messages.

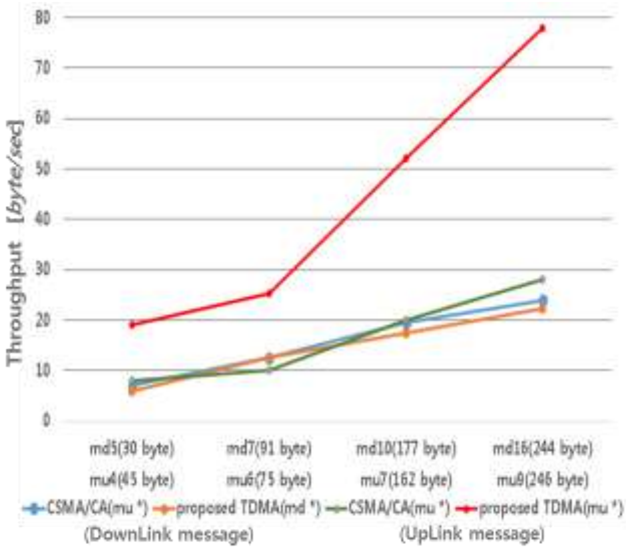


Figure 7. Throughput to CSMA/CA and asymmetric TDMA.

Figure 7 shows the throughput of downlink message regarding equivalent performance. But, throughput of asymmetry TDMA on uplink message transmission is higher than the conventional CSMA/CA. At md16 and mu9, the throughput is improved to 50 byte/sec.

## IV. Conclusion

*This paper proposed asymmetry TDMA for the ground tactical maneuver weapons as a way to improve the performance of wireless communication. The problems of conventional tactical radio communication is solved by designing asymmetrically the uplink frame and downlink frame with TDMA-based.*

*Future work will progress in the related to the frame synchronization error because the synchronization of proposed TDMA frame may affect the performance.*

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