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A Wireless Communication System using Multicasting with an Acknowledgement Mark

Changseok Lee[1], Myungjae shin[2], Gumjae Park[2]
[1](Hanbat National University, corresponding author)
cslee@hanbat.ac.kr)
[2](TechAnd Inc.)
mjshin@techandslow.com, gjpark@techandslow.com)

Abstract: Multicasting is an effective technique to save network bandwidth for low data rate wireless system, but there is no proper mechanism to detect the communication errors. In order to detect an error occurred at receiving part, a new ACK mechanism for multicasting is proposed in this paper. Instead of an ACK packet that takes long period of time, short ACK mark is used in this work. For the system proposed in this paper, 45 devices can send their ACK mark simultaneously in an ACK time slot as a reply for a multicasting message from the hub.

Keywords: *ACK, acknowledge, multicasting, wireless*

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I. INTRODUCTION

The wireless digital communications has been used in a wide range of services. In many applications, battery lifetime and range of communications are important, while a data rate of below kbps is sufficient for their messages. In Korea, the frequency band located at 424.7 MHz is a typical example of a low data rate communication. In this band, the bandwidth of the RF signal is limited to 8.5 kHz. A low data rate system using narrow bandwidth may have an advantage of long communication range. The limited bandwidth of the system limits the maximum data rate as low as about 4 kbps. In order to overcome the disadvantage of low data rate of the system, broadcasting and/or multicasting should be used in communication.

Wireless communications have broadcasting characteristics in nature. In wireless environment, when a sender transmits a packet to a particular user, the packet can also be overheard by the other users in the neighborhood, and it needs no extra bandwidth or power resource. As a result, it is sufficient to transmit a packet only once to reach all target users, and it can save a lot of power and bandwidth [1]. Multicasting is a technique to effectively save network bandwidth when a data item is simultaneously transmitted to different members of the same multicasting group. In a simple multicasting, neither ACK nor retransmission scheme is implemented. Lacks of packet retransmission may become a problem to recovery the data when interferences or congestion occurs in a wireless network [2].

The most straightforward way to achieve full reliability of wireless multicast is to make all clients transmit feedbacks (e.g., ACK) in sequence. Basically, ACK based multicasting process can be explained as follows: A node which receives a multicast packet replies an ACK to the sender via unicasting. If a sending node does not receive ACKs from all destination nodes within a certain time, the sending node resends the packet. Obviously the requirement of sending ACKs in response to the receipt of a packet for the receivers may cause time overhead, channel congestion and packet collisions. In order to reduce the channel congestion, some automatic repeat request (ARQ) mechanisms have been proposed, which are mostly based on the Leader Based Protocol (LBP) [3]. In LBP, only the leader client is responsible for replying with ACK while other non-leader clients, who receive an erroneous frame, issue Negative-ACK (NAK) as a jamming signal to cancel out the leader’s ACK. Thus, an Access Point (AP) can determine whether the preceding multicast frame is lost or not. However, in the case of error which is occurred by the nodes that cannot receive the signal, no NACK is issued.

In [4], Concurrent Feedback ARQ mechanism that enables multiple clients to transmit feedbacks simultaneously without collision has been proposed. Specially designed OFDM symbol in which a set of subcarriers in a feedback-symbol can be seen as a bitmap and the bitmap is used for representing NAKs of multiple packets received. For example, each subcarrier index in the feedback-symbol is mapped onto each packet index of the received signals. This mechanism is useful for the OFDM system, but it is not applicable to the narrowband system because of its wide bandwidth characteristics.

In order to detect a transmit error immediately, a new ACK mechanism is proposed in this paper. For a time slot based communication system consisting of a hub and a number of devices, one time slot is fully dedicated to ACKs from the devices, and the ACK slot is divided into a number of sub-slots that are assigned to the individual devices. Every device that receives the corresponding multicasting signal should transmit the ACK mark at the time assigned to the device in the ACK slot. The mark can be an unmodulated carrier, the hub just detect the existence of a signal for all assigned sub-slot in ACK slot. This ACK mechanism is so simple that even low data rate system can adopt it.

II. COMMUNICATION PROTOCOL AND PACKET DESIGN

In this paper, a lower power wireless communication system is considered. Figure 1 shows a system that consists of a hub and a number of devices for a frequency, and other hubs and corresponding devices using other frequencies may be existed in same area. It uses time slots for beacon, uplink, downlink, and ACK. The national regulation for the lower power radio equipment states that the maximum bandwidth of the signal should be 8.5 kHz, and it limits the maximum data rate of the system about 4 kbps. For immediate response of the system, the frame length should be less than 0.5 second. In order to use the AES (Advanced Encryption Standard)-128, packet should be multiple of 128 bits (16bytes). A hub broadcasts a beacon periodically to all connected devices. Devices are synchronized by the beacon comes from the corresponding hub.

When the hub has the message to be sent to devices, downlink slots are used. The number of slots used in sending message depends on the length of the message. According to the multicasting message, corresponding devices perform their mission and send an ACK mark at the time assigned to the device in the next frame. This downlink protocol is shown in figure 2 (a). When a device has the message to be sent to the hub, the device sends an REQ mark instead of an ACK mark at the time assigned to the device. Then in the down link slot, the hub sends the message that contains assignment of time slot that the device should use. The device sends the message in the assigned time slot, and then the hub send an acknowledge message instantly in unicasting manner in the same time slot. This uplink protocol is shown in figure 2 (b).

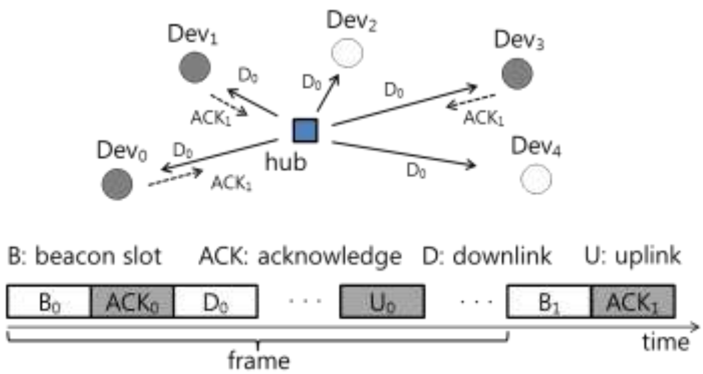

Figure 1. Proposed system model

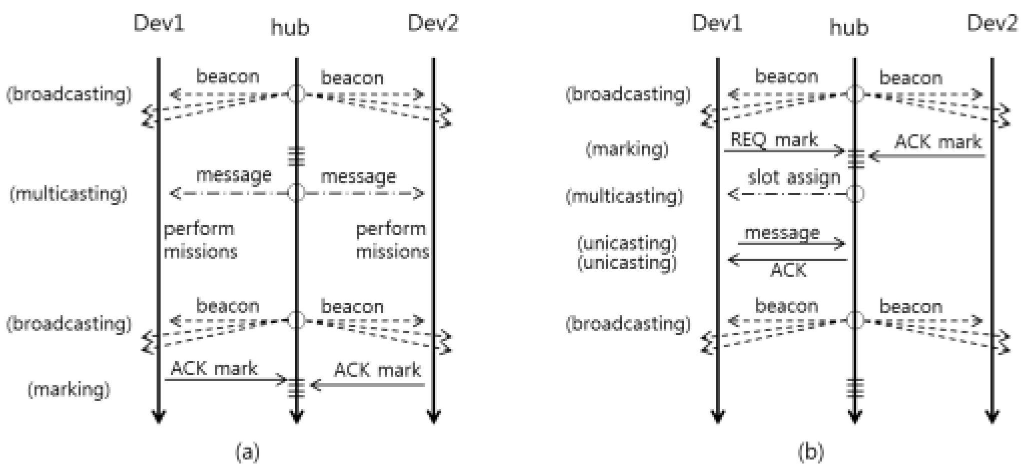

Figure 2. Communication protocol for downlink and uplink communication

(a) Downlink

(b) Uplink Communication

The longest time to be taken in the proposed protocol is the time occurred in the uplink message sending process. Sending a message and receiving an ACK should be performed just in one time slot. The packet structure is shown in figure 3. The message packet consists of 2 bytes of preamble field for clock timing adjustment, 2 bytes of sync field for indicating start of frame, 1 byte of length field, 1 byte of command field, 16 byes of encrypted data field, and 2 bytes of CRC field for error checking. It takes 48 msec. The ACK packet also has the same preamble and sync filed, and auxiliary data field is attached for status checking. It takes 12 msec, and adding an additional delay of 10 msec, total of 70 msec is needed for a time slot. In this paper, the slot time of 77.2 msec, and the fame period of 463.2 msec that is equal to time of 6 time slots are used

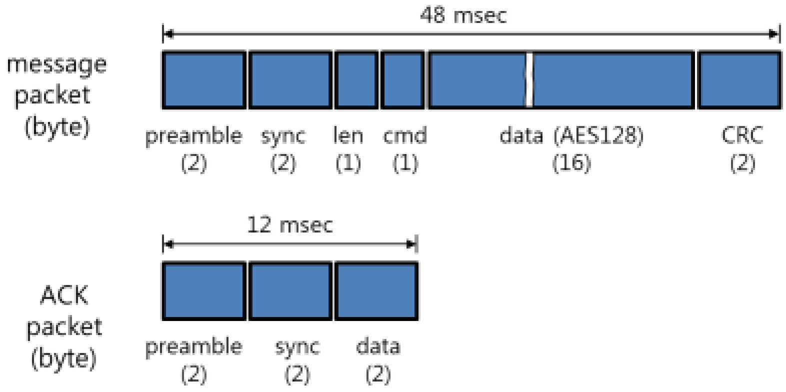

Figure 3. Packet structure and length

The system uses 6 time slots per a frame, and one time slot among them is used as a beacon slot, and the other one is used as an ACK slot. The ACK slot is divided into a number of sub-slots that are assigned to each device as shown in figure 4. A device that receives the corresponding multicasting signal should send an ACK mark in the assigned ACK sub-slot. A carrier signal itself can be used as an ACK mark and the RSSI(Received Signal Strength Indicator) signal can be used to detect the ACK mark. In this work, a number of coded pulse modulated carrier is used to improve the sensitivity.

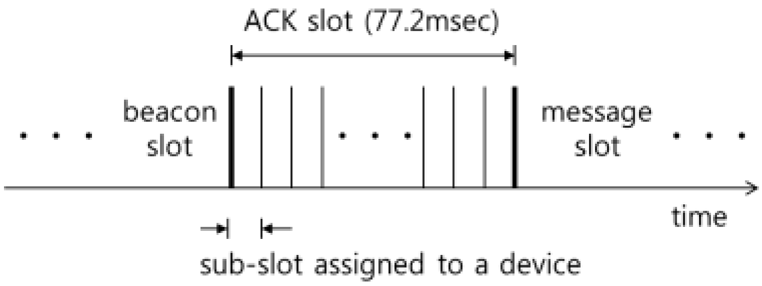

Figure 4. ACK slot divided into sub-slots assigned to each device

Figure 5 shows the spectrum of a pulse modulated signal. The 10-dB bandwidth of a 0.2 msec pulse width modulated carrier is 7.38 kHz that is lower than the bandwidth limit stated in the regulation. The 0.2 msec pulse width modulated carrier is one of the candidates for ACK mark that may send in the ACK sub-slot shown in figure 4.

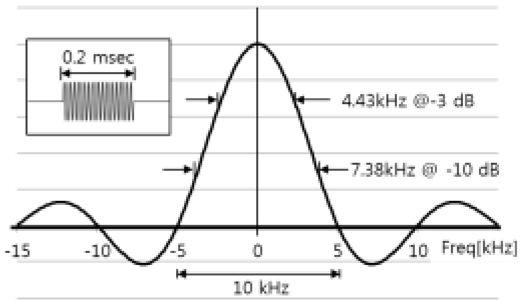

Figure 5. Spectrum of pulse width modulated carrier (pulse width = 0.2msec)

In order to improve the sensitivity, digital codes are applied to the 0.2 msec pulse, detect the signal using correlation. Figure 6 shows the determination process. As shown in figure 6 (a), mark has the pattern of "1100101". Due to the noise and interferences, RSSIs of the received signal are deteriorated as shown in figure 6 (b). By correlating the signal with original pattern, the correlation value of 23.4 is obtained as shown in figure 6(c). For the other pattern like "0101110", the correlation value is -6.

In this work, ACK mark consists of 8 pulses, and the width of each pulse is 0.2 msec. With the time slot of 77.2 msec, 45 sub-slot is used in the system.

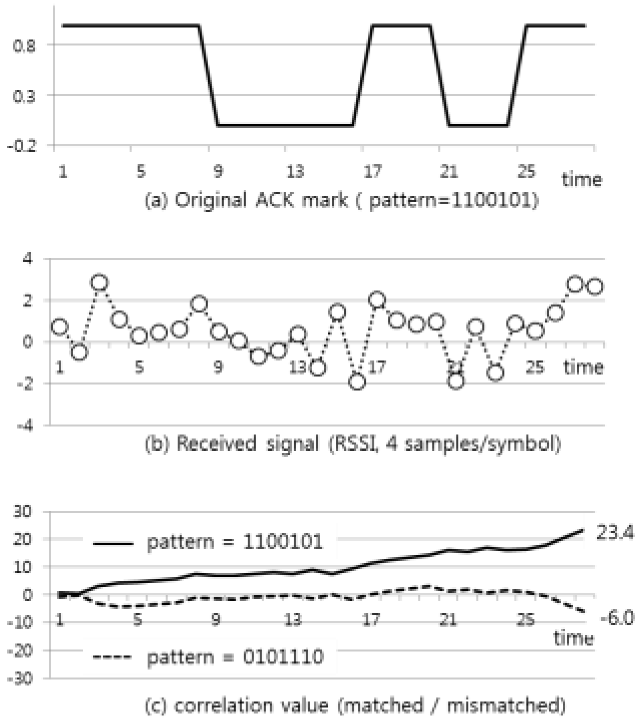

Figure 6. Coded mark and determination

III. IMPLEMENTATION AND EXPERIMENTS

Figure 7 shows the RF communication module and the hub developed in this work. Operating frequency range of the module is 424 ~ 448 MHz, and the maximum output power is 10 dBm. The hub relays RF module to an internet server through an Ethernet line.

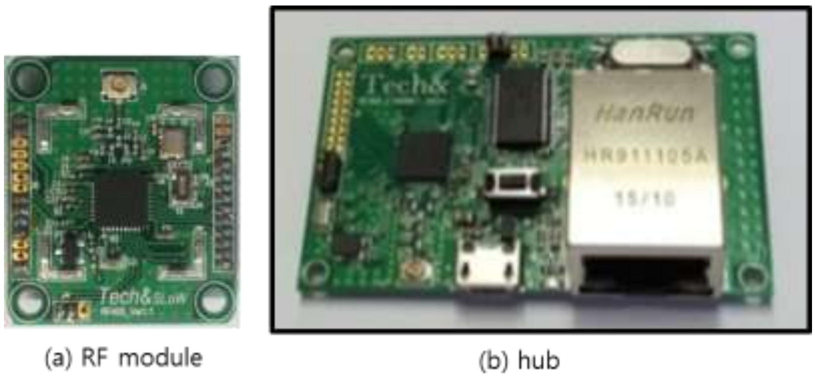

Figure 7. RF module and hub developed in this work

(a) 424.7 MHz RF module (26 x 30 x 5 mm^3)

(b) hub (33 x 58 x 15 mm^3)

Figure 8 shows the spectrum of the signal emitted by a RF module of this work. The 98% occupied bandwidth of the signal is 7.192 kHz that meets the bandwidth limit of the regulation.

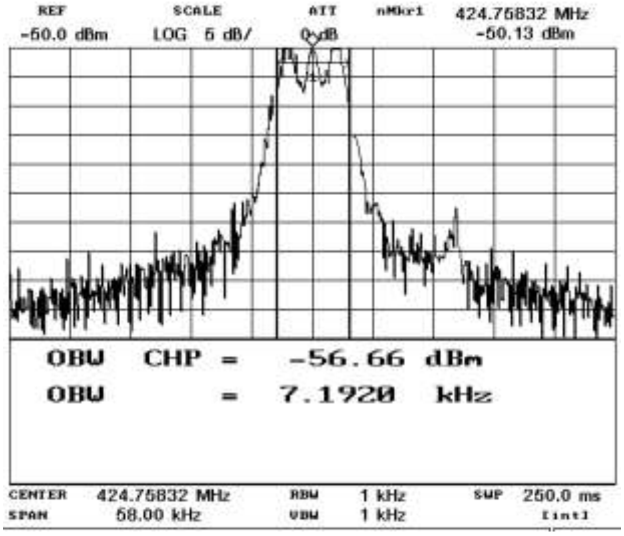

Figure 8. Spectrum of the transmitted signal

In order to test the multicasting mechanism using ACK marks, 8 RF modules and a hub are used as shown in figure 9. The hub sends multicasting message for 5 modules, then the corresponding module send ACK mark, while the other 3 modules ignore the message.

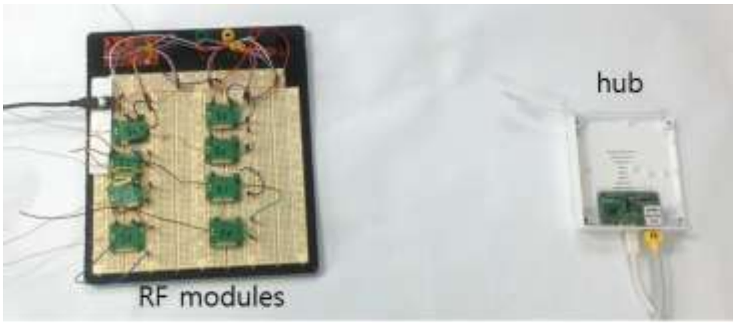

Figure 9. RF modules and a hub for testing

Figure 10 shows signal level variation that is received by an antenna connected to the spectrum analyzer with respect to time. Beacon signal and ACK marks can be seen in the figure. 5 ACK marks of different codes at different ACK sub-slot shown in the figure 10 are transmitted by different RF modules. Using the beacon from the hub, local times of all devices are synchronized with the hub., An 8-pulse ACK mark takes only 1.6 msec, while conventional ACK packet as shown in figure 3 takes 12 msec. By using the proposed mechanism, ACK time can be reduced to about 13% .

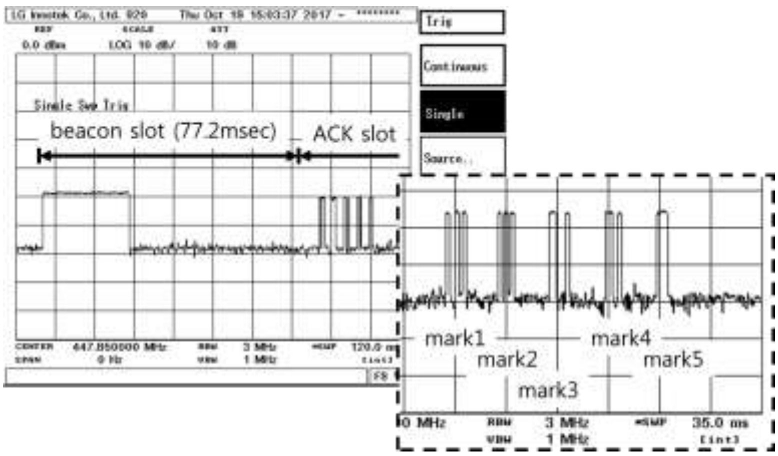

Figure 10. ACK marks

IV. CONCLUSION

In this paper, a multicasting mechanism that uses pulse modulated carrier as an ACK mark for reliable communication is proposed and evaluated. For a narrow band wireless system of which data rate of 4kbps and frame time of 0.5 second, 45 devices can send the ACK mark simultaneously in an ACK time slot. By using the proposed mechanism, multicasting can be used to improve the communication efficiency even in the services which require immediate acknowledgement for the sending messages.

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REFERENCES

[1] J Yu, Y Xu, W Xie, and Z Shen, Wireless multicast scheduling with packet loss and delay constraints, *Proc. International Conference on Wireless Communications & Signal Processing*, Nanjing, China , 2009, 1-4.

[2] T Sheu and S Lin, A Multicast Retransmission Scheme Using Negative ACK in Wireless Networks, *Proc. IEEE 27th International Conference on Advanced Information Networking and Applications*, Barcelona, Spain, 2013, 1144-1149.

[3] J Vella and S Zammit, A Survey of Multicasting over Wireless Access Networks, *IEEE Communications Surveys & Tutorials* ,15(2), 2013,718-753.

[4] Y Park , S Jeon, K Kim, K Kim, and Y Suh, Reliable and Adaptive Multicast Over IEEE 802.11n WLANs, *IEEE Communications Letters*, 20(7),2016, 1441-1444.

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