Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Ranging Code Power Enhancement for 802.16e OFDMA PHY**
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Source(s)	Kevin Baum Vijay Nangia Motorola 1301 E. Algonquin Rd., IL02-2928 Schaumburg, IL 60196, USA mailto:Kevin.Baum@motorola.com
Re:	IEEE 802.16e ballot #14b
Abstract	The contribution proposes an enhancement to the ranging code selection process that can compensate for limitations in the transmit power capability of portable battery operated subscriber stations.
Purpose	Adoption of proposed changes into P802.16e
Notice	
Release	
Patent Policy and Procedures	

Ranging Code Power Enhancement for 802.16e OFDMA PHY

Kevin Baum
Vijay Nangia

Motorola Labs

1. Overview

The contribution proposes an enhancement to the ranging code selection process that can compensate for limitations in the transmit power capability of portable, battery operated subscriber stations. In the current draft of WirelessMAN-OFDMA PHY (REVd/D5), separate sets of the ranging codes are defined for initial ranging, periodic ranging, and bandwidth request. All of these ranging codes are derived from a Pseudo-Random Binary Sequence (PRBS) generator and have a length of 144 bits. When a ranging code of a particular type (i.e., initial ranging, periodic ranging, bandwidth request) needs to be transmitted, one is selected randomly from the set of ranging codes assigned to that particular function.

The PAPR of the PBRS based ranging codes, when modulated onto the OFDMA subchannels of the ranging channel, is typically in the range of 7 dB to 12 dB. This can be seen from which shows the CDF of the PAPR of the 256 ranging codes for the case of UL_IDcell = 0, where the lowest numbered subchannel in the ranging channel is zero.

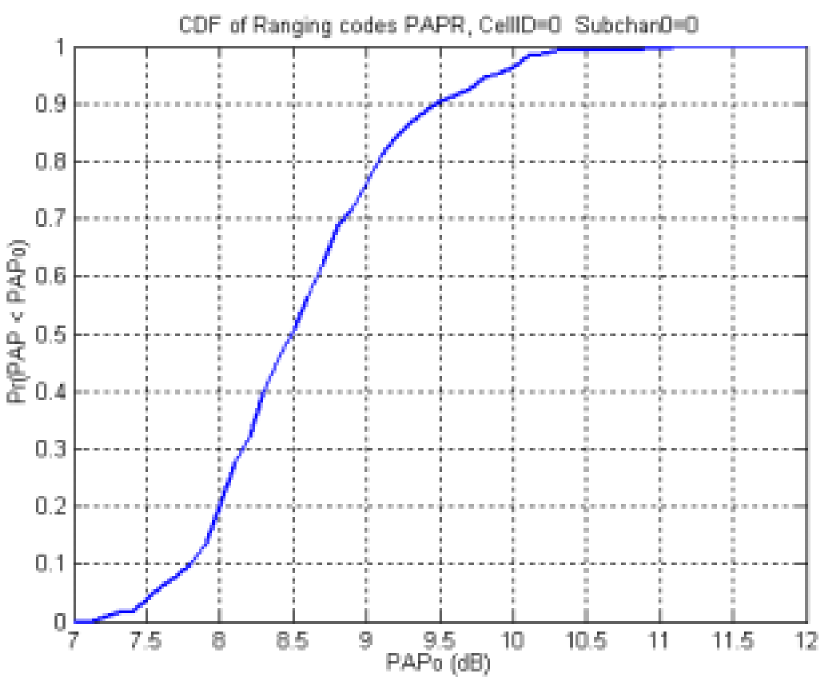

Figure 1. CDF of ranging codes PAPR for UL_CellID=0.

Considering that portable, battery powered devices will have a very limited transmit power capability compared to fixed access devices, a near-far problem can arise on the ranging channel. Specifically, a portable SS near the cell edge may be unlucky enough to pick one of the high PAPR ranging codes, and not have enough transmit power available to meet the desired received signal level at the BS. In that situation, a near-far problem can occur if other SSs using the same ranging channel are transmitting at a power level that satisfies the desired received signal level at the BS (these SSs may be other portable units located closer to the BS or fixed access units). Even in the absence of contention, when an SS cannot meet the desired signal level at the BS, its SNR will be degraded accordingly due to the power amplifier output limitations.

In order to enhance the performance of the ranging channel for the case where a SS cannot initially meet the desired received signal level at the BS due to a high PAPR ranging code, we propose a simple modification to the current random ranging code selection process. The outline of the proposal is as follows:

- A SS that wants to transmit a ranging code determines the desired transmit power for the transmission. This is based on procedures already defined in the REVd/D5 specification (e.g., Section 6.3.9.5.1 for initial ranging with no prior calibration, Section 8.4.10.3 for transmissions after power-control calibration, and parameter "Ranging data ratio" in Table 355 UCD burst profile encodings – WirelessMAN-OFDMA).
- The SS determines whether it has sufficient power amplifier (PA) output capability to achieve the desired transmit power, assuming that a worst-case PAPR ranging code (approximately 12 dB) might be chosen.
- A ranging code *r1* is randomly selected. If the SS determined it has sufficient power for a worst-case PAPR ranging code in the previous step, then the ranging code *r1* is used for the ranging transmission. Otherwise, the SS will attempt to select a ranging code with a low enough PAPR that the transmit power can be increased to meet or at least come close to the desired transmit power. The specific procedure for selecting the ranging code is described below:
  - The SS will set a worst case acceptable PAPR value, denoted $PAPR_{acc}$, equal to max[PAPR needed to meet the desired transmit power level, α dB]. The threshold α needs to be made large enough to prevent the ranging code selection from becoming too deterministic for an SS in that wants an extremely low PAPR ranging code. On the other hand, α needs to small enough to ensure significant PAPR gains can be achieved by SSs in worst-case conditions. Based on the CDF of the PAPRs in Figure 1, we will choose $\alpha = 8$ dB.
  - The SS will evaluate the PAPR of the ranging code *r1*. If the PAPR of *r1* is less than $PAPR_{acc}$, then that code is used as the ranging code. Otherwise, the SS may randomly select another code and compare its PAPR to $PAPR_{acc}$. The SS may continue to randomly select additional ranging codes until the currently selected code has a PAPR less than $PAPR_{acc}$. Then the SS will use the last selected code as its ranging code. Alternatively, the SS may stop searching before the stopping criterion of PAPR < $PAPR_{acc}$ has been met. In this case, the SS will select the lowest PAPR code that it has found so far as the ranging code.

The above procedure can be used for initial ranging, periodic ranging, or bandwidth requests. Since the ranging waveform PAPR values are typically between 7-12 dB, so there is a potential gain of several dB with the proposed technique.

Simulation Results

In order to verify that the proposed method maintains a collision probability similar to the existing method, a series of simulations were run. One ranging channel consisting of six subchannels is assumed. The lowest numbered subchannel in the ranging channel = 0 and the UL_IDcell = 0. N_{users} are assumed to be transmitting CDMA ranging codes on the ranging channel during the same ranging symbol. N_a is the number of available codes (for initial ranging, or periodic ranging, or bandwidth requests) from which a user has to select the ranging code. A uniform distribution of "desired" PAPR values (i.e., PAPR needed to meet the desired transmit power level) between 6 and 16 dB is assumed.

The randomness of the code selection process can be evaluated by computing the collision rate of the ranging codes. The collision rate is defined as,

$$\text{Collision rate} = \frac{\text{number of users colliding}}{\text{total number of users transmitting ranging codes}}$$

and shows the ranging code collision rate for different number of ranging users (N_{users}) and are for N_a =64 or N_a =128 ranging codes respectively. The collision rate for the current method described in REVd/D5 and the proposed method is shown.

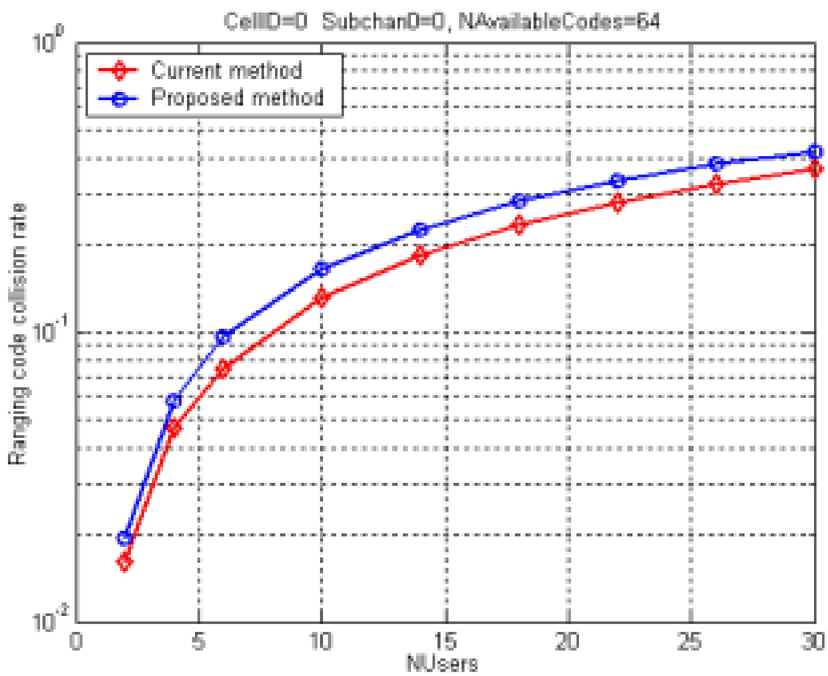

Figure 2. Ranging code collision rate for N_a=64 codes.

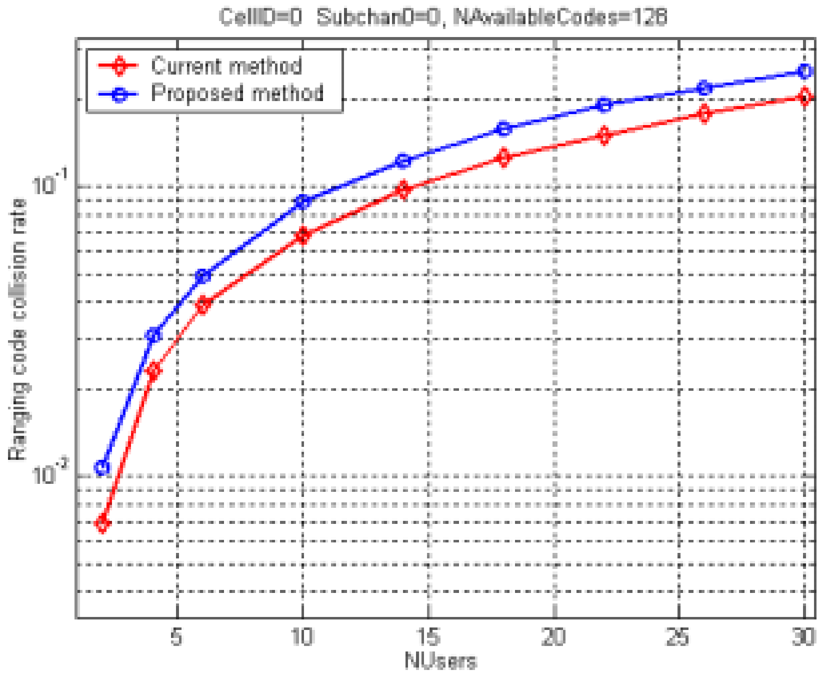

Figure 3. Ranging code collision rate for N_a=128 codes.

It can be seen from and , that the collision rate of the proposed method is comparable to that of the current method even for the relatively high number of 30 users transmitting ranging codes.

Also, to evaluate the gains provided by the proposed method, the number of users achieving PAPR < $PAPR_{acc}$ with and without the proposed method was evaluated. When a user achieves PAPR < $PAPR_{acc}$, it is labeled as "satisfied". For N_a =64 or N_a =128 ranging codes, it can be shown that the proposed method satisfies 31% more users than the current method described in REVd/D5.

In summary, the proposed method provides a transmit power enhancement to the SSs that have difficulty in meeting the desired received signal level at the BS while maintaining good randomness in the code selection process.

2. Proposed Text Changes

[Insert a new section 8.4.7.3 as follows]

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8.4.7.3 OFDMA Ranging Power Enhancement

The PAPR of the PBRS based ranging codes, when modulated onto the OFDMA subchannels of the ranging channel, is typically in the range of 7 dB to 12 dB. In order to enhance the performance of the ranging channel for the case where a SS has difficulty meeting the desired received signal level at the BS due to power amplifier output limitations (such as a portable battery operated SS), a SS may use the following ranging code selection procedure. The procedure is used individually for the *N* initial ranging codes, *M* periodic ranging codes, or *L* bandwidth request codes defined in 8.4.7.3.

- A SS that wants to transmit a ranging code determines the desired transmit power for the transmission. This is based on procedures already defined other sections of the specification (e.g., Section 6.3.9.5.1 for initial ranging with no prior calibration, Section 8.4.10.3 for transmissions after power-control calibration, and parameter "Ranging data ratio" in Table 355 UCD burst profile encodings – WirelessMAN-OFDMA).
- The SS determines whether it has sufficient power amplifier (PA) output capability to achieve the desired transmit power, assuming that a worst-case PAPR ranging code (12 dB) might be chosen.
- A ranging code *r1* is randomly selected from the appropriate set of available codes (set of *N* or *M* or *L* codes for initial ranging, or periodic ranging, or bandwidth requests, respectively). If the SS determined it has sufficient power for a worst-case PAPR ranging code in the previous step, then the ranging code *r1* is used for the ranging transmission. Otherwise, the SS will attempt to select a ranging code with a low enough PAPR that the transmit power can be increased to meet or at least come close to the desired transmit power. The specific procedure for selecting the ranging code is described below:
    - The SS will set a worst case acceptable PAPR value, denoted $PAPR_{acc}$, equal to max[PAPR needed to meet the desired transmit power level, α dB]. The threshold α needs to be made large enough to prevent the ranging code selection from becoming too deterministic for an SS in that wants an extremely low PAPR ranging code. On the other hand, α needs to small enough to ensure significant PAPR gains can be achieved by SSs in worst-case conditions. The value of α shall be set to α = 8 dB.
    - The SS will evaluate the PAPR of the ranging code *r1*. If the PAPR of *r1* is less than $PAPR_{acc}$, then that code is used as the ranging code. Otherwise, the SS may randomly select another code from the appropriate set and compare its PAPR to $PAPR_{acc}$. The SS may continue to randomly select additional ranging codes until the currently selected code has a PAPR less than $PAPR_{acc}$. Then the SS will use the last selected code as its ranging code. Alternatively, the SS may stop searching before the stopping criterion of PAPR < $PAPR_{acc}$ has been met. In this case, the SS will select the lowest PAPR code that it has found so far as the ranging code.

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