Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**OFDM based Ranging Enhancement for the TG3 and TG4**
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Re:	This document is an input contribution for the TG3 and TG4 MAC drafting teams.
Abstract	This document describes proposed enhancements to the TG1 MAC's ranging mechanism for the TG3 and TG4 MAC. The goal of the enhancements is to use the advantages of the OFDM based PHY to facilitate simpler and safer synchronization of the user with the base station.
Purpose	Update the TG3 and TG4 MAC draft with the proposed Ranging mechanism.
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OFDM/OFDMA based Ranging Enhancement for TG3 & TG4

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Introduction

This document describes proposed enhancements to the TG1 MAC's ranging mechanism for the TG3 and TG4 MAC.

The goal of the enhancements is to use the advantages of the OFDM/OFDMA based PHY to facilitate simpler and safer synchronization of the user with the base station.

The physical part of the proposed enhancements are described in the PHY proposals [1] submitted several times to the TG3 & TG4 groups.

The proposed mechanism is fully integrated in the approved (since April 2001) DVB-RCT standard (that is based on an OFDMA return channel) as a mature and well-defined improvement technique of the classical Ranging algorithms.

The contribution describes full description of the Ranging enhancements, proposed changes to the TG1 MAC to accommodate the proposed mechanism.

Background

The OFDMA (OFDM) upstream physical layer access method is based on the use of a combination of time and frequency division access technique.

The proposed synchronization technique is based on several sub carriers that are spread on the entire bandwidth and are collected in CDMA form. This allows several users to perform synchronization simultaneously, those special carriers within a OFDMA (OFDM) time symbol are allocated for synchronization purpose and shall be referred as R*anging slots*.

The basic allocation unit (e.g. *slot*) is a combination of a time symbol and a sub-channel. The current OFDMA (OFDM) based PHY proposals define several working modes, those modes define two upstream access schemes:

1. Each OFDMA (OFDM) symbol will carry either data or ranging slots

2. Each OFDMA (OFDM) symbol will carry both data and ranging slots

Figure 2 and Figure 1 illustrates the concept of access scheme 1.

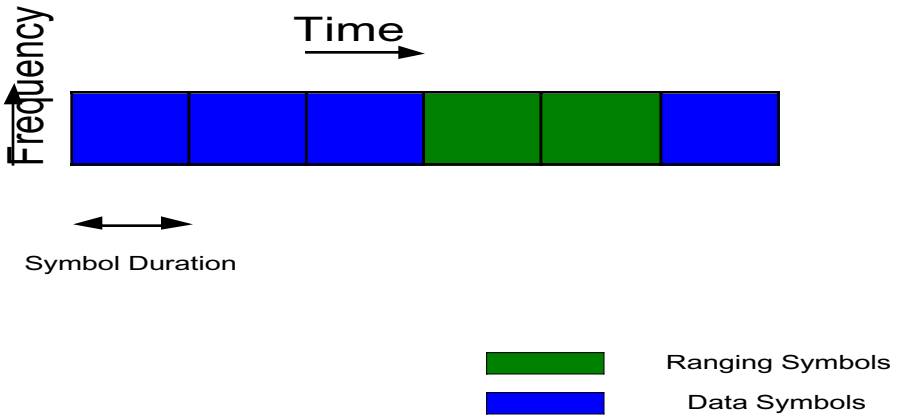

Figure 1. OFDMA Symbols carrying either Ranging or Data slots — General Concept

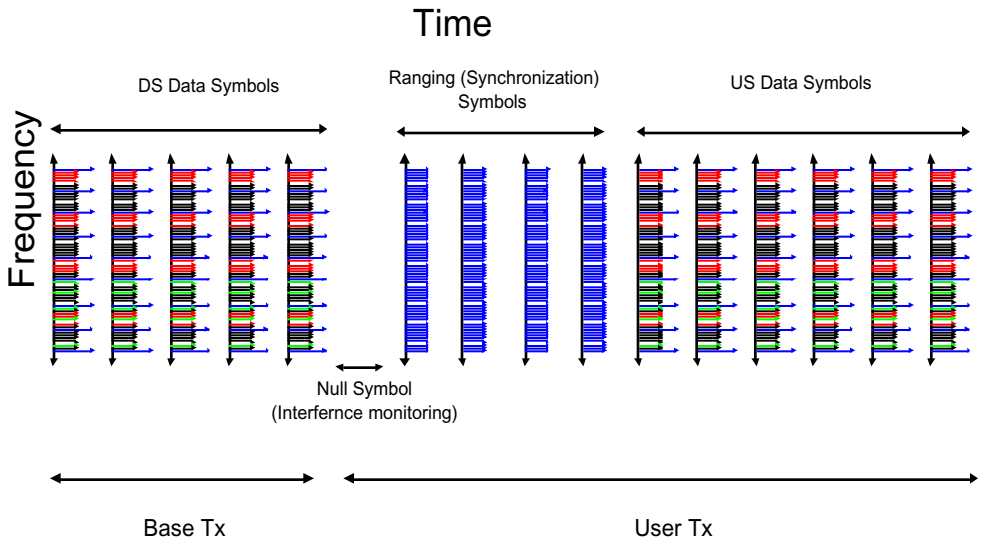

Figure 2. OFDMA Symbols carrying either Ranging or Data slots — In TDD mode

Figure 4 and 0 illustrates the concept of access scheme 2.

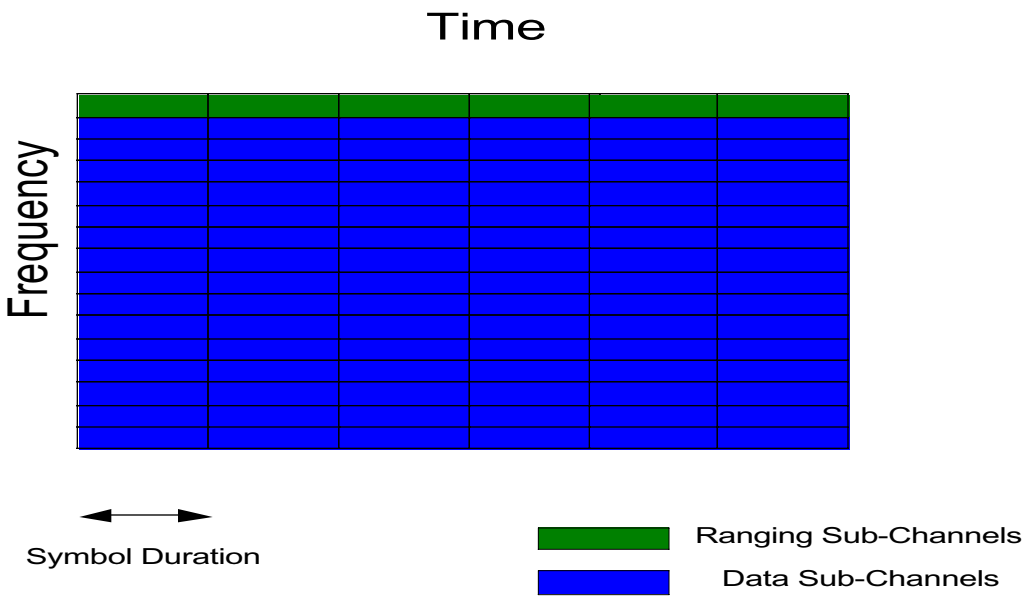

Figure 3. OFDMA Symbols carrying both Ranging and Data slots — General Concept

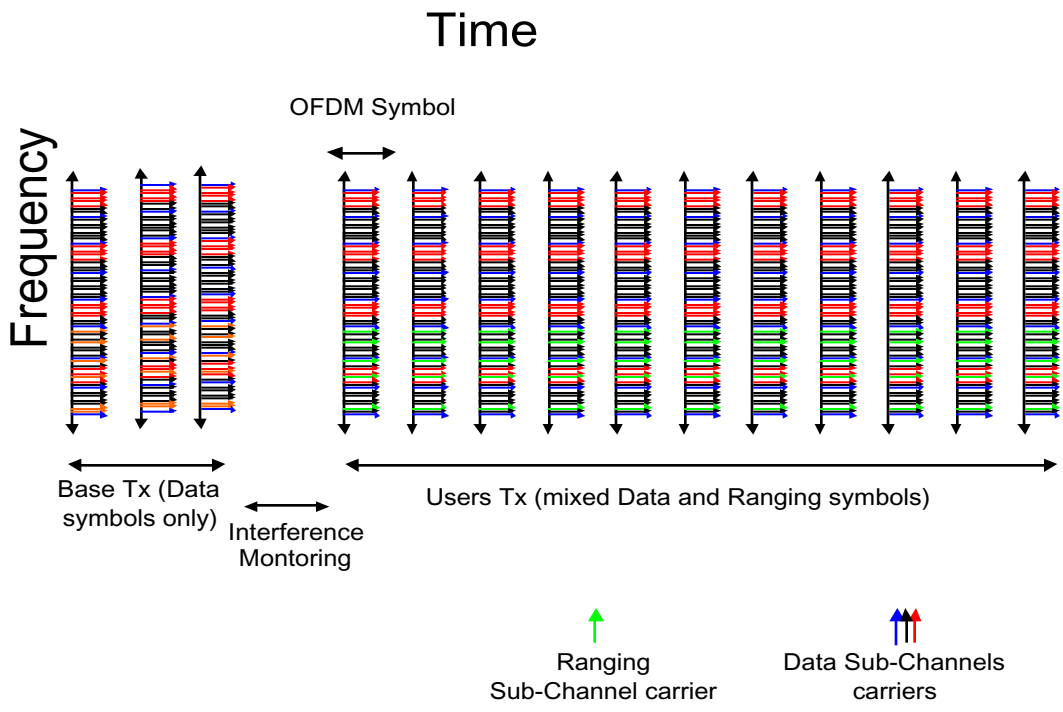

Figure 4. OFDMA Symbols carrying both Ranging and Data slots — In TDD mode

Each user that wants to perform ranging will choose randomly a PN sequence from a pre-defined set of PN sequences (16 different sequences) and will modulate (with a pre-defined robust modulation scheme, i.e. BPSK) it on a pre-defined set of carriers. The randomly chosen PN is referred as *Ranging Code.*

Proposed Ranging Mechanism Overview

The ranging is the process of acquiring the correct timing offset and power corrections such that the SS's transmissions are aligned to a symbol that marks the beginning of a burst(s) boundary with the required power.

The proposed ranging technique is mostly similar to the one presented in [2]:

The SS, after acquiring downstream synchronization and upstream transmission parameters, shall choose randomly a Ranging Slot (with use of a binary truncated exponent algorithm to avoid of possible re-collisions) as the time to perform the ranging, then it chooses randomly a Ranging Code (from the Initial Ranging domain) and sends it to the BS (as a CDMA code).

The BS upon successfully receiving a Ranging Code sends a Ranging Response message that addressed the sending SS by supplying the Ranging Code and Ranging Slot in the message.

The Ranging Response message contains all the needed adjustment (e.g. time, power and possibly frequency corrections) and a status notification.

Upon receiving Ranging Response message with continue status, the SS shall continue the ranging process as done on the first entry.

The main points of difference with the classical ranging process are:

- In modes with number of carriers ≥ 1K, a specific set of carriers shall be used for ranging, hence deduce that each OFDM symbol will always contain a pre-defined and fixed ranging slot.
- In modes with number of carriers < 1K, a full symbol(s) shall be used for ranging, this means that the base station shall define an Initial Maintenance region in the same way it defined in [2].
- The entry to the system is anonymous and remains so for the whole ranging process, the SS is identified by the indication of the sent ranging slot and sent ranging code.
- In modes with number of carriers ≥ 1K, the BS does not need to allocate a specific ranging region, this allow the SS to choose when to initiate the system entry.
- Several SS can send ranging code simultaneously without colliding (due to the CDMA technique).

The following message flow charts (Figure 5 and Figure 6) describes the ranging adjustments process in the two access modes.

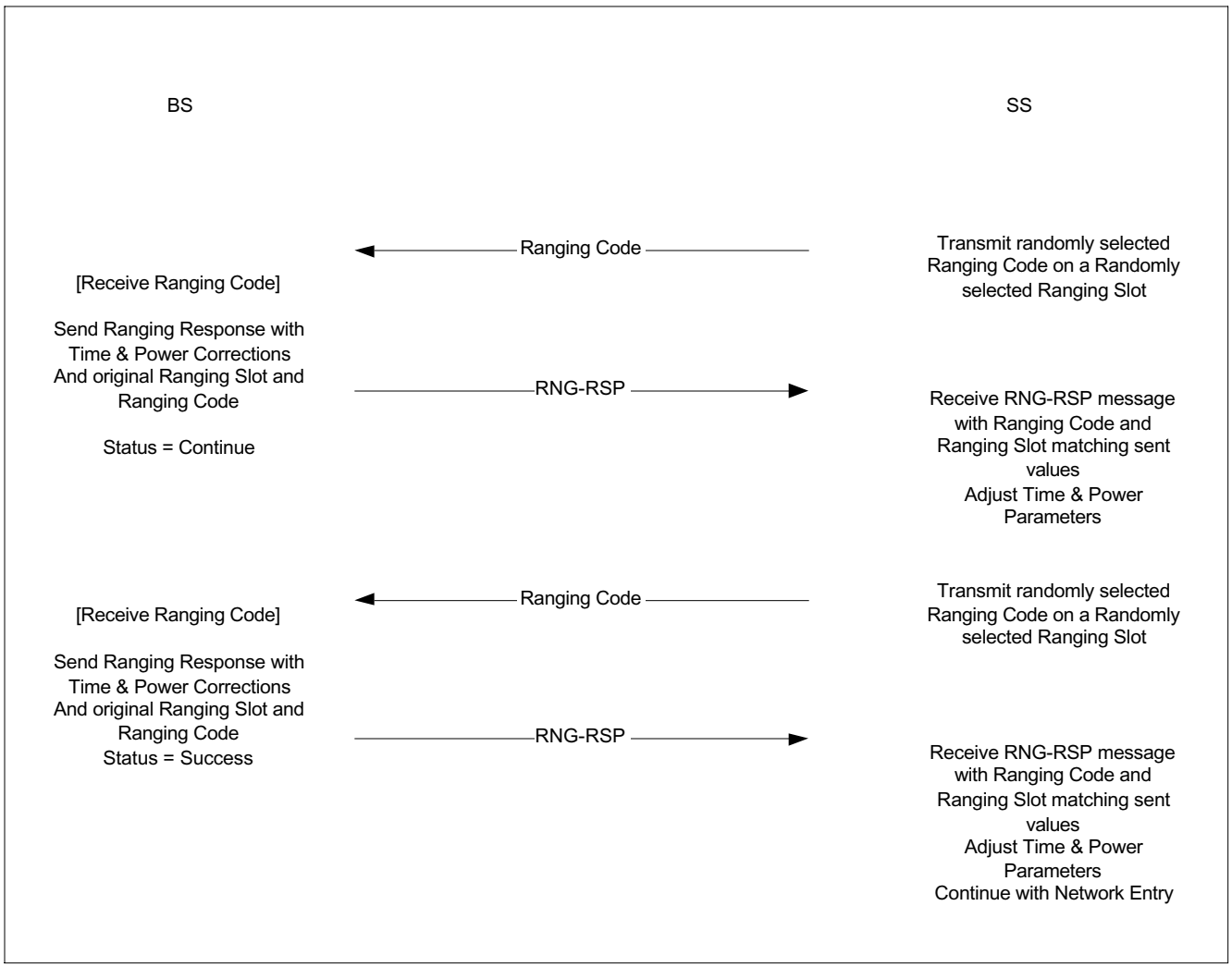

Figure 5. Ranging and Automatic Adjustments procedure for Access Scheme 2

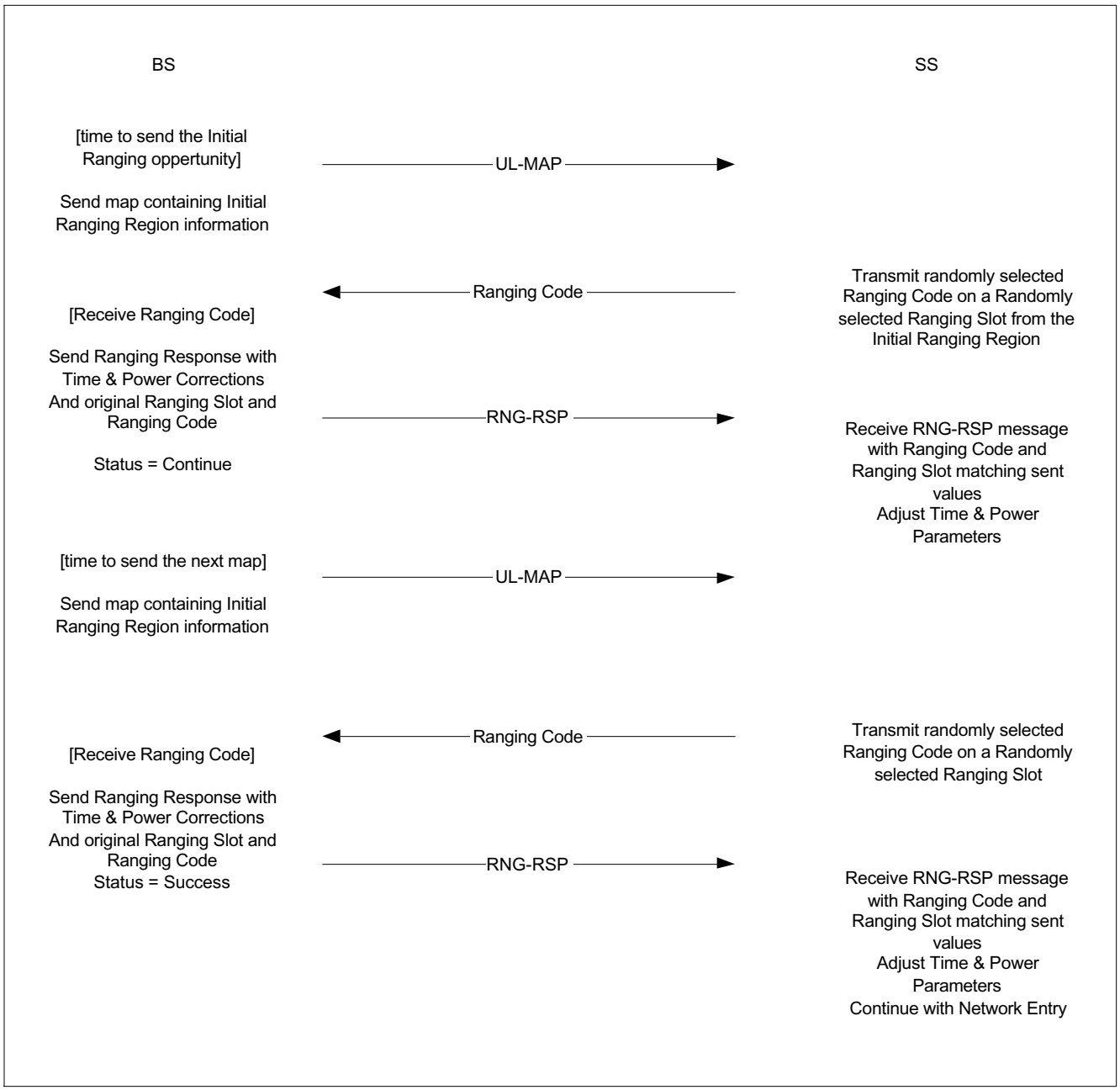

Figure 6. Ranging and Automatic Adjustments procedure for Access Scheme 1

Proposed Modifications to the 802.16.1 MAC

The following section defines the modifications need to done to the 802.16.1 MAC in order to accommodate the proposed CDMA ranging technique assuming that the PHY layer supports the required features (e.g. ranging slots, ranging codes etc.)

Ranging region indication

For the modes with number of carriers < 1K, the ranging slots shall use full OFDM symbols, therefore the initial ranging interval shall be allocated in the same way it is done in [2].

For the modes with number of carriers ≥ 1K, the ranging slots shall use one (or more) sub-channels of an OFDMA symbol and will exists for each OFDMA symbol, therefore no indication about initial maintenance region is required.

Update to 6.2.2.2.6 Section

The following addition should be done to the RNG-RSP Message description in section 6.2.2.2.6 line 61 page 69:

Ranging Slot: A required parameter if the SS used CDMA ranging code for initial ranging, in this case the RNG-RSP message will be sent using broadcast CID, and the combination of Ranging Slot and Ranging Code shall be used to address the sending SS.

The Ranging Slot value shall indicate a combination of OFDMA time symbol and Sub-Channel number

Ranging Code: A required parameter if the SS used CDMA ranging code for initial ranging, in this case the RNG-RSP message will be sent using broadcast CID, and the combination of Ranging Slot and Ranging Code shall be used to address the sending SS.

Change to the RNG-RSP Message

The following TLV values should be added to the RNG-RSP message encoding table, section 11.1.4 page 318:

Table 1: RNG-RSP TLV Addition

Name	**Type** (1 byte)	Length (1 byte)	Value (Variable Length)

Ranging Slot	13	TBD	Used to indicate the OFDMA (OFDM) time symbol and Sub-Channel reference that was used to transmit the ranging code. This TLV is used in conjunction with the Ranging Code value to identify the sending SS.
Ranging Code	14	1	Used to indicate the ranging code that was sent by the SS (unsigned 8-bit). This TLV is used in conjunction with the Ranging Slot value to identify the sending SS.

References

[1] Y.Segal, Z.Hadad, I.Kitroser. Initial OFDMA Proposal for the 802.16.3 PHY Layer. January 2001.

[2] IEEE 802.16.1/D2. Draft Standard for Air Interface for Fixed Broadband Wireless Access Systems. January 2001.

[3] IEEE 802.16.3-00/02r4. Functional Requirements for the 802.16.3 Interoperability Standard. September 2000.

[4] IEEE 802.16.4c-01/02. Modifications to the TG1 MAC for use in TG4 Systems. January 2001

[5] DVB-RCT v.116 standard approved draft, April 2001.