| Project | **IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>** |
|---|---|
| Title | **Bandwidth Request Using CDMA Codes in OFDMA(OFDM) Base PHY** |
| Date Submitted | **2001-04-25** |
| Source(s) | Itzik Kitroser                    Voice:  +952 3 9528440<br>Yossi Segal                       Fax:    +952 3 9528805<br>Zion Hadad<br><br>Runcom Technologies LTD.          itzikk@runcom.co.il<br>2 Homa St. 75655                  yossis@runcom.co.il<br>Rishon Lezion Israel             zionh@runcom.co.il |
| Re: | This contribution is an input for the TG3 and TG4 MAC sub-group draft documents. |
| Abstract | This contribution describes an option for fast bandwidth reservation mechanism |
| Purpose | Input contribution for the TG3 and TG4 MAC draft. |
| Notice | This document has been prepared to assist IEEE 802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein. |
| Release | The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16. |
| Patent Policy and Procedures | The contributor is familiar with the IEEE 802.16 Patent Policy and Procedures (Version 1.0) <http://ieee802.org/16/ipr/patents/policy.html>, including the statement "IEEE standards may include the known use of patent(s), including patent applications, if there is technical justification in the opinion of the standards-developing committee and provided the IEEE receives assurance from the patent holder that it will license applicants under reasonable terms and conditions for the purpose of implementing the standard."<br><br>Early disclosure to the Working Group of patent information that might be relevant to the standard is essential to reduce the possibility for delays in the development process and increase the likelihood that the draft publication will be approved for publication. Please notify the Chair <mailto:r.b.marks@ieee.org > as early as possible, in written or electronic form, of any patents (granted or under application) that may cover technology that is under consideration by or has been approved by IEEE 802.16. The Chair will disclose this notification via the IEEE 802.16 web site <http://ieee802.org/16/ipr/patents/notices>. |

# Bandwidth Request Using CDMA Codes in OFDMA(OFDM) Base PHY for TG3 & TG4

*Itzik Kitroser*

*Yossi Segal*

*Zion Hadad*

*Runcom Technologies LTD.*

## Introduction

This contribution is a complementary contribution to [6] and describes an option for fast bandwidth reservation mechanism.

The functional requirements [3] and several contributions about the expected nature of the traffic of TG3 and TG4 context, describe an IP centric environment, with dynamic and bursty traffic that requires option of fast bandwidth reservation mechanisms.

The two main access techniques in centralized systems that are most commonly used are: Contention Access (also Random Access) and Polling.

The Polling methods are best for systems with short propagation delays, small number of subscribers and small overhead for polling messages but usually are less efficient with bursty traffic.

The Contention methods usually well fit for bursty scenarios, increase the statistical multiplexing gain, supply short delay for the bursty packets but reduces the channel efficiency with high risk of collisions and potentially high jitter.

The proposed mechanism take advantage of the OFDMA based PHY as proposed in [1] to provide a CDMA code based bandwidth reservation tool. This mechanism has all the advantages of Contention scheme for bursty traffic but with much higher success percentage (90% Vs 10% for 20 simultaneous requests with window size of 10 slots, see Simulation Results) and better channel utilization.

## Description of the proposed Bandwidth Request mechanism

As described in [6] and in [1], several PHY configurations are proposed, especially, the 1K and 2K modes defines the concept of sub-channels as a subset of the frequencies transmitted in one OFDM symbol, those two modes define a unique ranging slots that co-exists with data slots for each OFDM symbol.

The SS may use the ranging slots to send CDMA codes from a three domains of codes: Initial Ranging, Maintenance Ranging and bandwidth requests. The CDMA codes used for bandwidth request are defined as Request Codes.

The proposed mechanism defines usage of the Request Code by the SS to request fast bandwidth allocation on a bursty basis.

Figure 1 describe the messages sequence for CDMA bandwidth request:
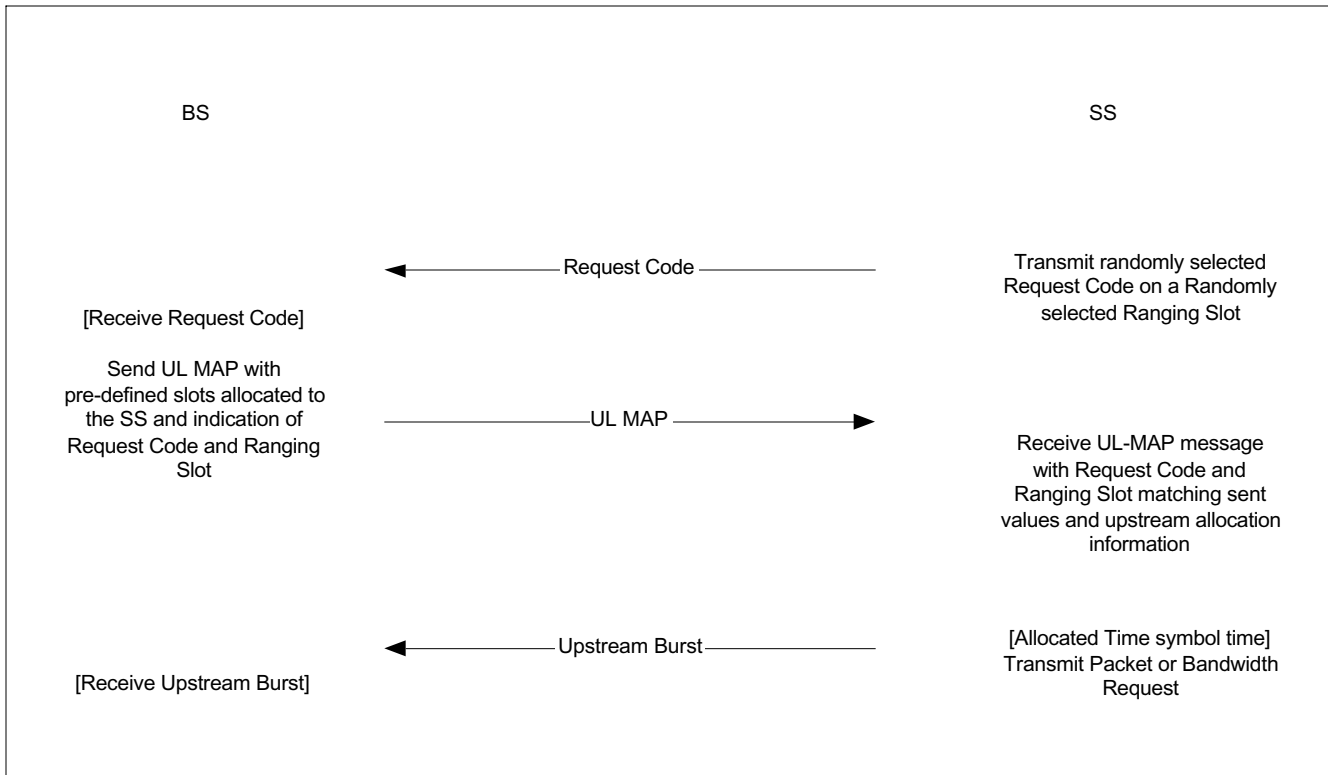
**Figure 1. Bandwidth Request in high FFT modes**

The SS, upon a need to request for transmission slots, shall access the air interface without the need to be polled and with reduced collision risk by transmitting a Request Code.

Several request codes sent by several SS can be transmitted simultaneously without collision (with limitation on the number of parallel codes).

The BS, when demodulating the ranging slots, and when receiving a request code, shall allocate a pre-defined (and configurable) number of bytes to the SS, the addressing of the allocation shall be done by attaching the indication of the Ranging Slot and Request Code.

The SS will use the unique allocation either to send packet or bandwidth request.

In the case of small FFT size (Access Scheme 1 in [6]), the UL MAP message shall have indication of the synchronization interval size and time (full OFDMA symbols carrying only CDMA codes with one or two sub-channels), the SS shall send the request codes in this interval.

Figure 2 describes the messages sequence for this case:
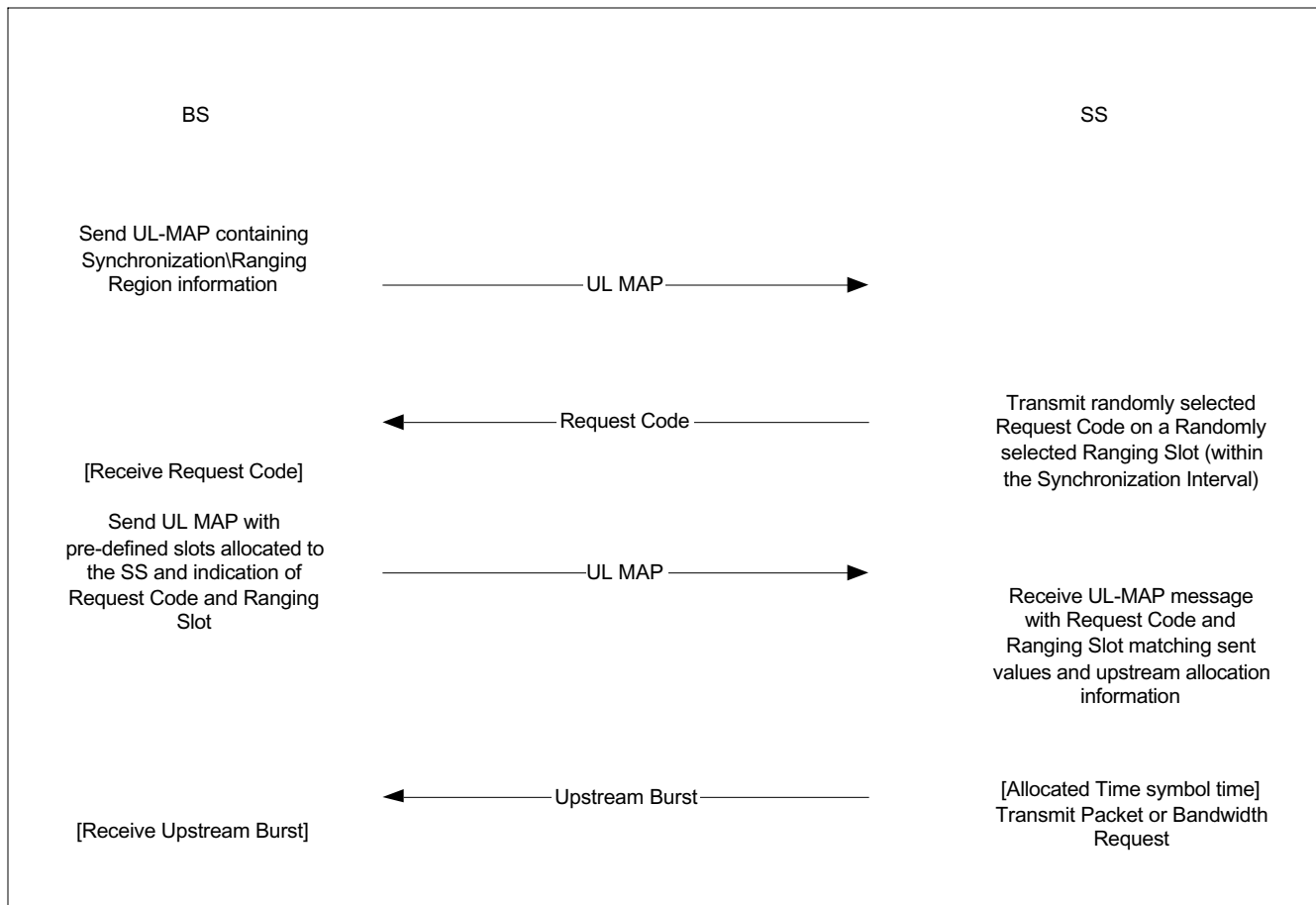
**Figure 2. Bandwidth Request in small FFT modes**

The advantage of the proposed mechanism is the fairly safe request indication by the SS and transmitting bandwidth request in a unique allocated slot, or the option for fast requests for small allocation that can be used to send bursty based packets (like TCP Acks) in a highly dense cells.

## Proposed Modifications to the 802.16.1 MAC

### *Request Code Grant Interval*

When using the Request Code, the BS allocates a pre-defined number of slots to the sending SS whose Request code and Ranging slots are provided in the upstream MAP IE.

The value of such allocation is defined by the BS and can be optimizes according to the traffic behavior.

The minimum value of the grant interval should be big enough to accommodate at least upstream bandwidth request message.

The Unsolicited Grant Size parameter (section 11.4.12.19 page 356) can be used for this purpose.

### *New UIUC Addition*

New UICU value should be added in order to identify allocation as reaction to Request Code.

The following UIUC value should be added to section 6.2.2.2.4 Table 5 page 67:

**Table 1: Request Code UIUC value**

| IE Name | UIUC | Connection ID | Mini-slot Offset |
|---|---|---|---|
| Request Code Allocation | 12 | Broadcast | TBD – According to OFDMA/OFDM allocation schemes |

In this proposal, we adopt the Upstream MAP IE structure presented in [4] to provide enhancements with full backward compatibility.

Figure 3 shows the proposed Upstream MAP IE for the proposed new UIUC (as defined in Table 1).
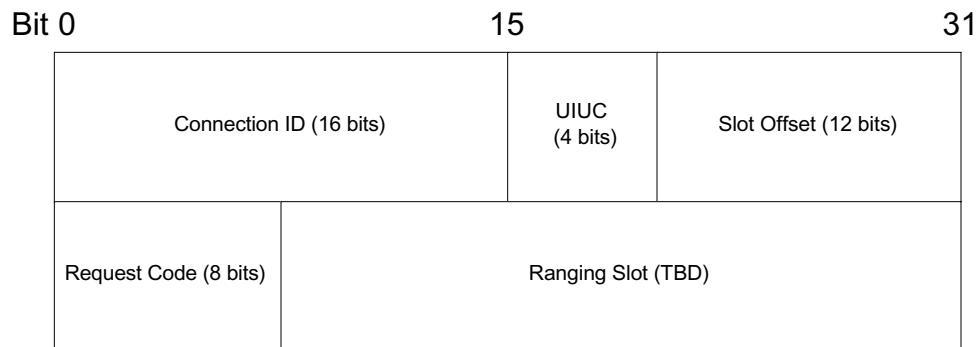


**Figure 3. Proposed Upstream MAP IE structure for Request Code UIUC**

**Ranging Slot**: A required parameter if the SS used CDMA Ranging Slot for bandwidth request, in this case the UL-MAP IE element will use broadcast CID, and the combination of Ranging Slot and Request Code shall be used to address the requesting SS.

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

**Request Code**: A required parameter if the SS used CDMA Request Code for bandwidth request, in this case the UL-MAP IE element will use broadcast CID, and the combination of Ranging Slot and Request Code shall be used to address the requesting SS.

## Simulation Results

The following section describes results of a simulation done to compare the proposed technique with classical contention based bandwidth request.

The simulation was done for period of 10 OFDMA symbols with one sub-channel allocated for Request Codes.

Each user randomly selects (with uniform distribution) time symbol and Request code, the number of available codes was 16, with cross correlation factor of 8 – meaning that if more then 8 users selected the same opportunity (bucket) then all of them are lost, also if two or more users selected the same code, they are considered as failed.

The conditions for the normal contention access assume that each request requires exactly one slot (if preamble should be required for each request, then the number of the transmission opportunities should have cut by half, and the results for the contention case would be worst).

The simulation deals with one attempt (with window size of 10 slots), retransmission will improve both of the scenarios, better for the CDMA case.
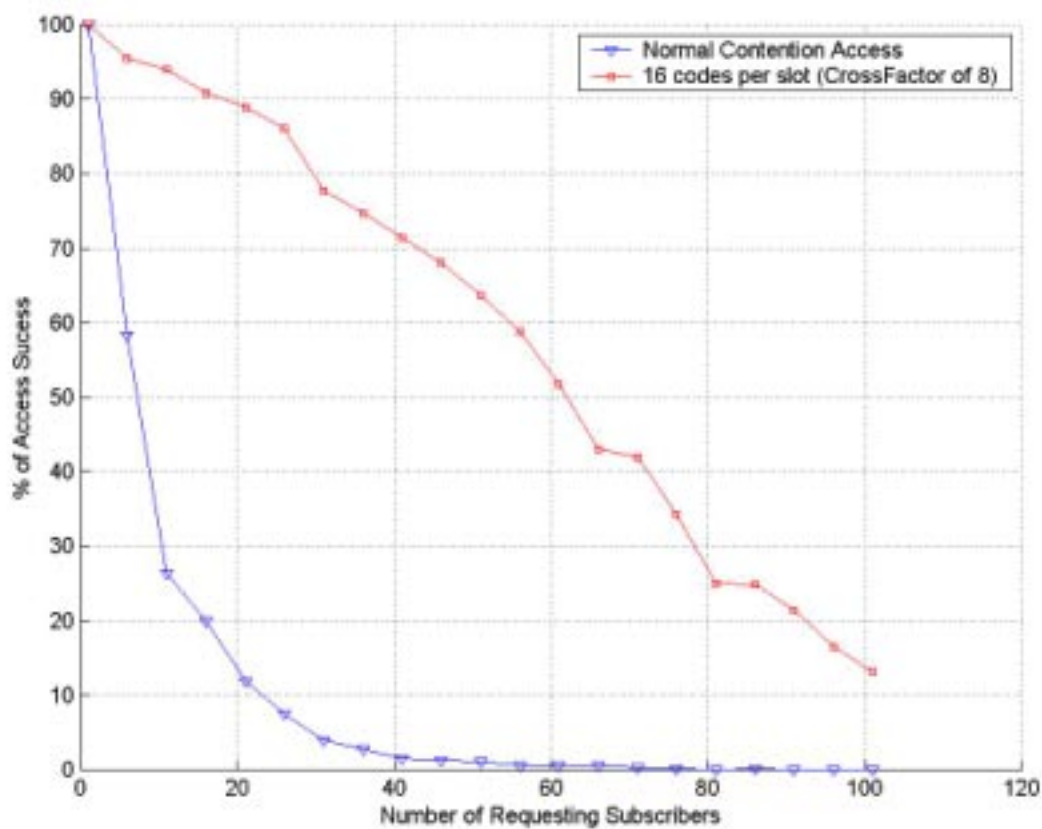
Figure 4 describes the simulation results:



**Figure 4. CDMA Request Vs. Contention Request for 10 time symbols**

The X-axis defines the number of users sending requests, the Y-axis defines the access success in percentage.

As can be seen, for 10 users the contention access results with ~35% of success while the CDMA scheme results with ~95% of success. For 50 users the contention access drops down to only 1% of success while the CDMA access results with ~63% of success. The results clearly show that for one access attempt, the CDMA scheme is

much better than the normal Contention scheme, adding backoff exponential retry algorithm will improve the results for both cases but will introduce side effects such as latency and jitter.

The results show that for dense cells with more then 20 simultaneous contention requests, in normal Random Access window of 10 slots, the probability to fail at first request is about 90% while in the CDMA access with same conditions, the probability to fail is about 10%.

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.

[6]  I.Kitroser, Z.Hadad and Y.Segal. OFDMA/OFDM based Ranging Enhancement for TG3 & TG4. April 2001.

[7]  802163p-01_27.pdf. Traffic Models for Broadband Wireless Access Systems. January 2001