Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Frame Alignment Requirement in Relays**
Date Submitted	**2007-03-05**

Source(s)		
	Gamini Senarath, Hang Zhang, Peiying Zhu, Mo-Han Fong, Wen Tong, Israfil Bahceci, David Steer, Derek Yu, Mark Naden, G.Q. Wang Nortel 3500 Carling Avenue Ottawa, Ontario K2H 8E9	Voice: +1 613 7631315 [mailto:wentong@nortel.com] [mailto:pyzhu@nortel.com]
	Wendy C Wong Jerry Sydir Hyunjeong Hannah Lee Kerstin Johnsson Intel Corporation 2200 Mission College Blvd, Santa Clara, CA 95054, USA	(wendy.c.wong@intel.com) (jerry.sydir@intel.com)
	Dorin Viorel, Fujitsu Microelectronics Canada Inc, and Chenxi Zhu, Fujitsu Labs of America.	dviorel@fmci.fujitsu.com Voice: +1-403-207-6311 chenxi.zhu@us.fujitsu.com Voice: +1-301-486-0671
	Kanchei (Ken) Loa, Yung-Ting Lee, Yi-Hsueh Tsai, Chih-Chiang Hsieh, Heng-Iang Hsu, Shiann-Tsong Sheu, Hua-Chiang Yin, Youn-Tai Lee, Frank C.D. Tsai Institute for Information Industry 8F., No. 218, Sec. 2, Dunhua S. Rd., Taipei City, Taiwan.	loa@iii.org.tw Voice: +886-2-2739-9616

Re:	A response to a Call for Technical Proposal, http://wirelessman.org/relay/docs/80216j-07_007r2.pdf
Abstract	The relay has an additional requirement for aligning its DL and UL transmissions with the BS beyond the basic MS alignment requirement in 802.16e. Since the relay is also transmitting the

	preamble and data to its mobiles, signal alignment at the BS is required to avoid deterioration of performance due to propagation delays and possible overlapping slots. In addition, a multi-hop relay may obtain sync from another relay and delay accumulation across a number of hops must be avoided. This alignment must be assured for both uplink and downlink transmissions.
Purpose	To adopt the proposed text
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 <http://ieee802.org/16/ipr/patents/policy.html>, including the statement "IEEE standards may include the known use of patent(s), including patent applications, provided the IEEE receives assurance from the patent holder or applicant with respect to patents essential for compliance with both mandatory and optional portions of the standard." 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:chair@wirelessman.org> as early as possible, in written or electronic form, if patented technology (or technology under patent application) might be incorporated into a draft standard being developed within the IEEE 802.16 Working Group. The Chair will disclose this notification via the IEEE 802.16 web site <http://ieee802.org/16/ipr/patents/notices>.

Frame Alignment Requirement in Relays

Gamini Senarath, Hang Zhang, Peiying Zhu, Mo-Han Fong, Wen Tong, Israfil Bahceci, David Steer, Derek Yu, Mark Naden, G.Q. Wang

Nortel

Dorin Viorel

Fujitsu Microelectronics Canada Inc

Chenxi Zhu

Fujitsu Labs of America

Kanchei (Ken) Loa, Yung-Ting Lee, Yi-Hsueh Tsai, Heng-Iang Hsu, Shiann-Tsong Sheu

Hua-Chiang Yin, Frank C.D. Tsai,

Institute for Information Industry

1 Introduction

The RS (relay station) can synchronize its downlink frame and uplink frames with its parent BS (or parent RS) using a similar mechanism to that used in 802.16e to synchronize the MS (mobile station).

In this synchronization process, the frame received by the MS from the BS in the downlink is shifted from that of the BS's transmission frame time by an amount approximately equal to the propagation delay of the strongest path from the BS to the MS. To maintain synchronization of all the MS signals at the BS, the MS's uplink transmission is shifted by a time approximately equivalent to the round trip delay from the BS to the MS. The time alignment and the propagation delays are shown in Figure 1.

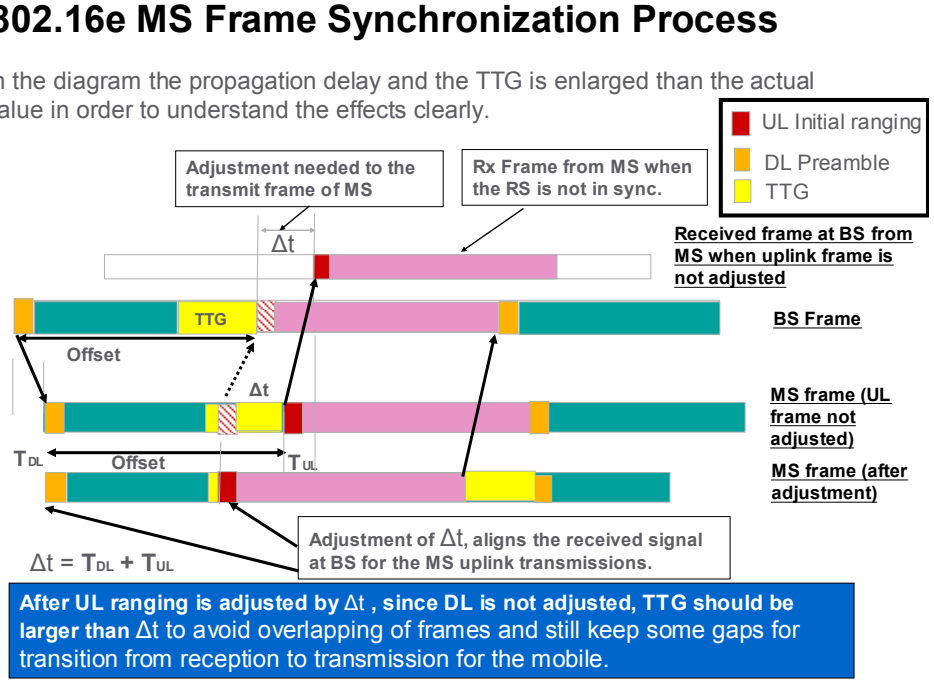


Figure 1 MS Frame alignment for BS and MS (as in 802.16e)

However, a RS has two additional functions beyond the MS's functions:

(1) a RS has to send data to its children (MS or another RS) over the downlink.

(2) a RS has to receive data (and uplink ranging messages) from its children.

If the timing at the RS is not kept aligned with the parent BS, many system parameters may need to be adjusted and proper operation of many functions may be impacted. Some of these are:

(1) Accumulation of the misalignment over multi-hops would impact RS and MS several hops away from the BS;

(2) The system parameters such as prefix durations, TTG, RTG, UL ranging may need to be adjusted to account for multiple propagation delays

For example, for the range extension case, the prefix may not be enough. A major advantage of the RS is to enable the mobiles outside BS coverage areas to be served – as BS may not be able to support them even if there is enough signal strength due to insufficient prefix duration.

(3) Various measurements may be impacted by accumulated delays

(4) System operating performance may be impacted for features which depend on synchronized transmissions such as MDHO and FBSS.

These are described in more detail below:

The system timing allowances relating to the prefix duration used to address multi-path delays, the TTG/RTG gaps used for receive and transmission transitions in the radio, the propagation delay variation among different MS-BS links, and UL ranging slot duration may not be sufficient for multi-hop relay configurations, or range extensions and may cause severe interference and performance degradation.

In addition, any difference in the timing at the RS and the BS may impact measurement systems. For example, RS preambles sent by different RS and BS may be not time-aligned and RSs outside the coverage area (aligned to the BS or another parent) may have difficulty making measurements. In addition, the performance of the operations such as soft handover (SHO) and fast cell switching may be impacted unless all of the signal timing is closely aligned with the BS and the network..

Furthermore, for networks including multi-hop relaying, the delays accumulate along the paths and potentially cause even more severe issues due to non-alignment of frames. For example, RS that are used to extend the coverage area may accumulate delays that exceed the limits allowed by the system design.

In this contribution, we show that time alignment can be maintained by the relay in a TDD system using the information received for the uplink frame alignment and the technique as currently employed by the MS under the 802.16e standard. This contribution also proposes that the RS time alignment requirement be specified in the standard to be coincident with the parent BS timing. This timing alignment will ensure smooth operation of the RS and its MS under diverse environments.

2 RS time alignment

The signals at the RS system may be considered in four frames with different timing advances:

(1) RS Reception (Rx) from its parent in the Downlink (DL)
(2) RS Transmission (Tx) to the parent in the Uplink (UL)
(3) RS Transmission (Tx) to its child over the downlink
(4) RS Reception (Rx) from MS in the uplink

In order to minimise interference among these frames, it is proposed that:

- the relay DL Rx and UL Tx signals from/to BS be synchronized with the BS with a technique similar to that used by a MS to synchronize to its BS (i.e.as indicated in 802.16e);
- the relay DL Tx and UL Rx signals to/from its children be time-aligned with the BS DL Tx and BS UL Rx frames respectively.

The BS frame, together with the four RS frames and MS frames are shown in Figure 2 after alignment.

Proposed Relay Frame Synchronization Scheme

RS rx and RS tx does not happen in the same time. They happen in different zones. But this diagram is only to show that how the frames are aligned.

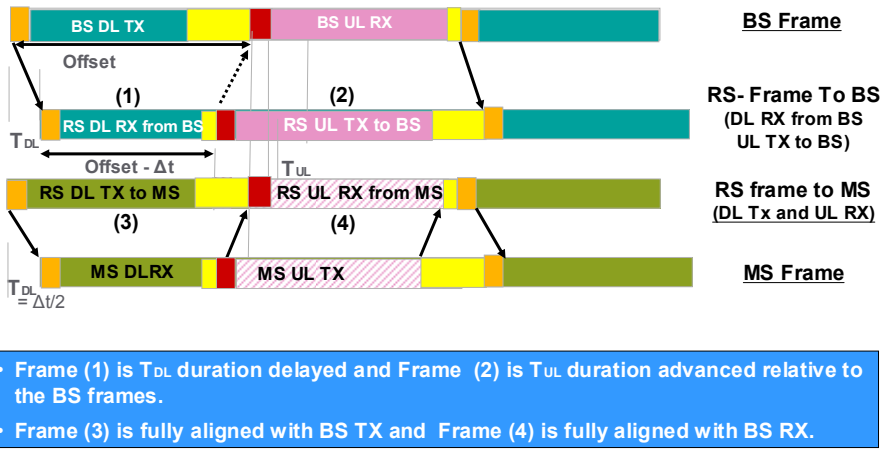


Figure 2 RS Frame alignment in 802.16j

In the above figure, RS downlink transmissions are exactly aligned with the BS downlink frame. Thus the current prefix requirements need not to be changed and measurement accuracy are not impacted. The RS uplink transmissions are aligned such that all its children's transmissions are received in time alignment as the BS would receive from its children.

A method to establish this required time alignment is explained in the following paragraphs.

The RS DL frame received from the BS is shifted from that of the BS due to the propagation delay (T_{DL}) and the received frame times may be little bit different from RS to RS. This T_{DL} may also include the processing delay at the receiver and at the transmitter. The timing for an uplink frame received at the BS from a MS when there has been no adjustment is shown in Figure 1 (top). Thus, the amount of adjustment Δt needed to have the frames from different mobiles or relays received at the BS at the same time, can be determined by the BS and can transmitted to the MS using existing 802.16 procedures. With this information, the MS (and RS) can adjust its uplink transmission frame to arrive at the BS at the correct time.**.** Due to possible inaccuracies in measurement, this process may be repeated several times until accurate alignment happens at the BS reception. It is proposed that the RS follows the same method to align its uplink frames to its parent and adjusted frame is also shown in Figure 1. As can be seen the total adjustment required for a given RS is the round-trip delay to its parent, $\Delta t = T_{DL} + T_{DL}$.

For the RS transmission in the downlink to its children to be aligned with the BS downlink transmission to its children, the RS downlink transmission frame (to its children) should be advanced T_{DL} (the parent to child propagation delay). In a TDD system it may be assumed the uplink and downlink delays are same and

therefore, if the round trip delay is measured, the adjustment needed for the RS downlink frame is half of the round trip delay.

Once the downlink frame is aligned, the uplink alignment can be done similar to the current 802.16e method. In this method, the child sends an uplink ranging signal and the parent informs the child of the adjustment needed relative to the already adjusted downlink frame.

Since the amount of adjustment needed can be determined using information local to the RS, there is no extra messaging required. But, it is proposed that the requirement for time alignment of all signals at the BS be specified in the 802.16j standard in order to guarantee proper operation of the system.

3 Proposed Text Modifications

[Insert following text into **8.4.4.7.2.2***]*

8.4.4.7.2.2 Relay frame structure

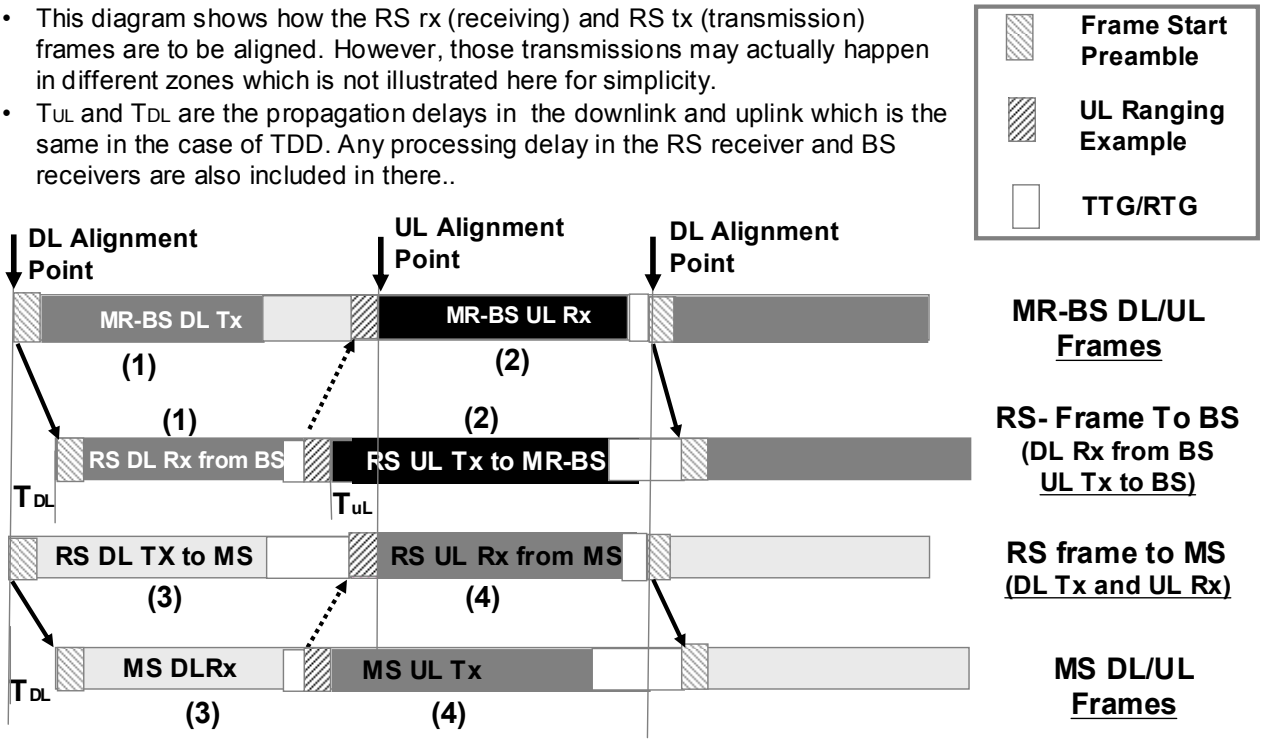
XXX Alignment Requirements for Relay Transmission and receive frames for communication with its child nodes (RS and MS).

To assure synchronization of signals in the BS-RS network, the relay downlink transmission to its subordinate stations (RS or MS) shall be time-aligned with the MR-BS's downlink transmission to its subordinate stations (RS or MS).

Figure <xxx> illustrates the frame alignment required for the TDD systems.

Notes:

- This diagram shows how the RS rx (receiving) and RS tx (transmission) frames are to be aligned. However, those transmissions may actually happen in different zones which is not illustrated here for simplicity.
- T_{UL} and T_{DL} are the propagation delays in the downlink and uplink which is the same in the case of TDD. Any processing delay in the RS receiver and BS receivers are also included in there..



- Frame (1) of RS is T_{DL} duration delayed and Frame (2) of RS is T_{UL} duration advanced relative to corresponding BS frames.
- Frame (3) of RS (RS DL Tx to MS) shall be fully aligned with Frame (1) of MR-BS (MR-BS DL Tx) as shown and Frame (4) shall be fully aligned with Frame (2) of MR-BS (MR-BS UL Rx).

Figure XXX Frame Alignment Illustration