<table>
<thead>
<tr>
<th>Project</th>
<th>IEEE 802.16 Broadband Wireless Access Working Group <a href="http://ieee802.org/16">http://ieee802.org/16</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Frame Alignment Requirement in Relays</td>
</tr>
<tr>
<td>Date Submitted</td>
<td>2007-01-17</td>
</tr>
<tr>
<td>Source(s)</td>
<td>Gamini Senarath, Hang Zhang, Peiying Zhu, Mo-Han Fong, Wen Tong, Israfil Bahceci, David Steer, Derek Yu, Mark Naden, G.Q. Wang</td>
</tr>
<tr>
<td>Voice:</td>
<td>+1 613 7631315</td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:wenTong@nortel.com">wenTong@nortel.com</a>, <a href="mailto:pyzhu@nortel.com">pyzhu@nortel.com</a></td>
</tr>
<tr>
<td>Nortel</td>
<td>3500 Carling Avenue, Ottawa, Ontario K2H 8E9</td>
</tr>
<tr>
<td>Wendy C Wong</td>
<td>(<a href="mailto:wendy.c.wong@intel.com">wendy.c.wong@intel.com</a>)</td>
</tr>
<tr>
<td>Jerry Sydir</td>
<td>(<a href="mailto:jerry.sydir@intel.com">jerry.sydir@intel.com</a>)</td>
</tr>
<tr>
<td>Hyunjung Hannah Lee</td>
<td>Kerstin Johnsson</td>
</tr>
<tr>
<td>Intel Corporation</td>
<td>2200 Mission College Blvd., Santa Clara, CA 95054, USA</td>
</tr>
</tbody>
</table>


Abstract
The relay has an additional requirement of aligning its downlink transmissions with the BS compared to the MS alignment requirement in 802.16e. Since relay is re-transmitting the preamble and data to its mobiles this is required to avoid deterioration of performance. In addition, a relay may obtain sync from another relay thus any misalignment could accumulate when the number of hops increased. Uplink too needs similar alignment.

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

1 Introduction

Usually, a RS (relay station) can use the same mechanism as a MS (mobile station) to synchronize its downlink frame and uplink frames in order to receive data from the BS (base station) over the downlink and transmit data to the BS over the uplink.

When doing so, MS’s receive frame from the BS over the downlink would be shifted from that of the BS’s transmission frame approximately by an amount equal to the propagation delay of the strongest path from the BS to the MS. MS’s uplink transmission frame would be about round trip delay shifted from the BS’s downlink transmission frame due to the requirement that the BS requires to receive the signals from all the MSs aligned in time. This is shown in Figure 1.

802.16e MS Frame Synchronization Process

In the diagram the propagation delay and the TTG is enlarged than the actual value in order to understand the effects clearly.

Adjustment needed to the transmit frame of MS
Rx Frame from MS when the RS is not in sync.

$\Delta t =$ TDL + TUL

Adjustment of $\Delta t$, aligns the received signal at BS for the MS uplink transmissions.

After UL ranging is adjusted by $\Delta t$, since DL is not adjusted, TTG should be larger than $\Delta t$ to avoid overlapping of frames and still keep some gaps for transition from reception to transmission for the mobile.

Figure 1  MS Frame alignment in 802.16e

However, a RS has two additional functions above 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 allowed to be delayed compared to that of the BS by an amount approximating propagation delay similar to that of a MS, the tolerances in the system relating to the prefix duration used to address multi-path delays, the TTG/RTG gaps kept for receive and transmission transitions in the radio and propagation delay variation among different MS-BS links, and UL ranging slot duration may not be sufficient and may cause severe interference and performance issues.

In addition, any difference in the timing at the RS and the BS may impact measurement systems as well. For example, RS preambles send by different relays and BS may be not time-aligned and RSs outside the coverage area may cause problems. In addition, the performance of the operations such as SHO and fast cell switching may be impacted.

Furthermore, for networks including multi-hop relaying, the delays would add up when we go along the paths and potentially cause even more severe issues due to non-alignment of frames. Some times the relays are used to extend the coverage area and the delays if added up that could make the limits allowed in the system in sufficient.

In this contribution, we show that this alignment can be adjusted by the relay in a TDD system using the information it receives for the uplink frame alignment used currently by the MS under 802.16e standard and we propose that strict alignment requirement be specified in the standard for smooth operation of the relay under diverse environments.

2 Proposal

There are four frames with different timing advances.

(1) RS receive from its parent in the Downlink
(2) RS Transmission to the parent in the uplink
(3) RS Transmission to its child over the downlink
(4) RS receive from MS in the uplink

In order to have proper operation we propose that:

(1) the relay RX and TX signals with BS be synchronized with the BS similar to a MS as indicated above;

(2) the relay TX and Rx signals with its children be time-aligned with the BS Tx and Rx frames respectively to a certain achievable accuracy.

The BS frames, above four RS frames and MS frames after alignment are shown in Figure 2.
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.

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 would not be impacted. RS uplink transmissions are aligned such that all its children’s transmissions would receive in the same time as the BS would receive from its children.

A simple method to establish above alignment is explained below.

The RS DL receive frame from the BS is shifted from that of the BS due to the propagation delay and the frame times may be little bit different from RS to RS. An uplink frame is received at the BS from the RS when there has been no adjustment is shown in Figure 1. Thus the amount of adjustment $\Delta t$ needed to have the receiving frames from different mobiles or relays receive at the BS in the same time, can be determined by the BS and is transmitted to the MS under 802.16, so that MS can adjust its uplink transmission frame. Due to inaccurate adjustment evaluation, this process may be repeated several times until accurate alignment happens at the BS reception. We propose that 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 its round-trip delay to its parent.

Now if relay transmission in the downlink to its children is 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 we can assume these two delays are same and therefore, if the round trip delay is evaluated as mentioned above the adjustment needed for the RS downlink frame to its children is half of the round trip delay.
Once downlink frame is aligned, the uplink alignment can be done similar to the current 802.16e method by child sending an uplink ranging signal and parent informing the adjustment needed relative to the already adjusted downlink frame.

Since the amount of adjustment needed can be achieved using the local information to the RS, there is no extra messaging required but it is proposed that the requirement be specified in the 802.16j document in order to guarantee proper operation of the system. Alternatively, MR-BS or the parent node may send a message to its child RS the adjustment needed for the child’s downlink frame.

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).

In order to achieve proper operation, the relay downlink transmission to its children (RS or MS) should be time-aligned with the MR-BS’s downlink transmission to its children (RS or MS).

For the TDD mode, an example of an RS frame structure is shown in Figure <xxx>.

---

![Diagram of RS frame structure](image)

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

- Frame (1) is $T_{DL}$ duration delayed and Frame (2) is $T_{UL}$ duration advanced relative to the BS frames.
- Frame (3) is fully aligned with BS TX and Frame (4) is fully aligned with BS RX.