Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	RS DL Synchronization and Radio Environment Measurement – Introduction of RS-Preamble
Date Submitted	**2007-01-08**
Source(s)	Hang Zhang, Peiying Zhu, Wen Tong, Gamini Senarath, Derek Yu, Mark Naden, G.Q. Wang, David Steer Nortel 3500 Carling Avenue Ottawa, Ontario K2H 8E9 Israfil Bahceci Visiting Researcher from University of Waterloo Voice: +1 613 7631315 [mailto:WenTong@nortel.com] [mailto:pyzhu@nortel.com]
Re:	A response to a Call for Technical Proposal, http://wirelessman.org/relay/docs/80216j-06_034.pdf
Abstract	In this contribution, we propose RS-preamble to allow a RS continuously monitor its radio environment for the purpose of path maintenance and update.
Purpose	To incorporate the proposed text into the P802.16j Baseline Document (IEEE 802.16j-06/026r1)
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>.

RS DL Synchronization and Radio Environment Measurement – Introduction of RS-Preamble

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

Nortel

Introduction

If a RS is configured to be a serving station (deliver/collect traffic to/from MSs), during the normal operation, this RS may need to transmit the 802.16e preamble to facilitate MS's cell selection and synchronization. At the same time, due to the radio link change, removal of existing RSs and removal of new RSs, a RS may need to continuously monitor its radio environment for the purpose of path maintenance and update.

An intuitive way is to use 802.16e preamble for this purpose. However, when a one-radio RS wants to monitor 802.16e preamble, it has to stop its own 802.16e preamble transmission. This may cause issues for MS's normal operation.

In this contribution, we propose a solution to solve the above problem by introducing a RS-Preamble in UL sub-frame. The RS-preamble could be conceptually similar to 802.16e DL Preamble. However, due to the facts that a RS needs to transmit and monitor the preamble and the connection between RS could be meshed, we propose a scheme to enable the link scanning based on a single RS-Preamble.

The performance of the proposed methods for RS-preamble selection and on-going DL RS preamble synchronization is studied using the parameters from [1]. This contribution describes the simulation setup and assumptions for the performance evaluation of RS preamble selection and provides the simulation results.

RS-Preamble

RS-Preamble is transmitted in every N frames, called as a RS-Preamble cycle. The parameters for RS-Preamble (e.g., index, PN sequence) may be the same as its 802.16e for a RS who is configured with an 802.16 preamble transmission. By introducing RS-Preamble, a one-radio RS doesn't need to stop its 802.16e preamble transmission for the purpose of its own radio environment measurement.

In order to obtain reasonable environment measurement, the ideal way is that at any RS-Preamble transmission time, only one RS is monitoring and all others are transmitting. Thus, a network-wise RS-Preamble plan (avoid more than one RS monitoring RS-Preamble simultaneously) may be required. It would be very difficult to plan due to RS removal, adding and the moving of MRS.

In fact, only a small number of RS-Preambles can be detected by a RS. Those RSs whose RS-Preambles can be detected by the RS may be within a relative small geographic area around this RS. Thus if we define a time interval including M RS-Preamble cycles, and each RS randomly selects one RS-Preamble cycle within this interval for monitoring RS-Preamble transmission, the possibility that more than one RS within this small geographic area monitoring RS-Preamble would be very small.

Thus M RS-Preamble transmission cycles form a base, called as RS-Preamble monitoring cycle selection base, from which a monitoring cycle is randomly selected by a RS.

To enable this operation, MMRBS needs to configure following parameters:

- RS-Preamble transmission cycle (N): defines the transmission period of RS-Preamble (e.g., RS-Preamble is transmitted every N frames). The first frame in each cycle is the frame, called as RS-Preamble frame, where a OFDM symbol is reserved for RS-Preamble transmission
- RS-Preamble monitoring cycle selection base (M): define the number of cycles within which a RS randomly select a cycle to stop its own RS-Preamble transmission and monitor other RS-Preambles in the corresponding RS-Preamble frame
- Base starting frame offset (k): identify the index of frame which starts a base. Thus a RS-Preamble transmission base starts from a frame indexed as i with i meeting the formula: mod(i ,MxN) = k. Each base includes MxN frames and M cycles. The cycle can be indexed from 0 to M-1.
- RS-Preamble OFDM symbol offset within RS-Preamble frame (j): identify the OFDM symbol index within RS-Preamble frame, referring to the first OFDM symbol in the frame

An example is shown in Figure 1, where N = 2

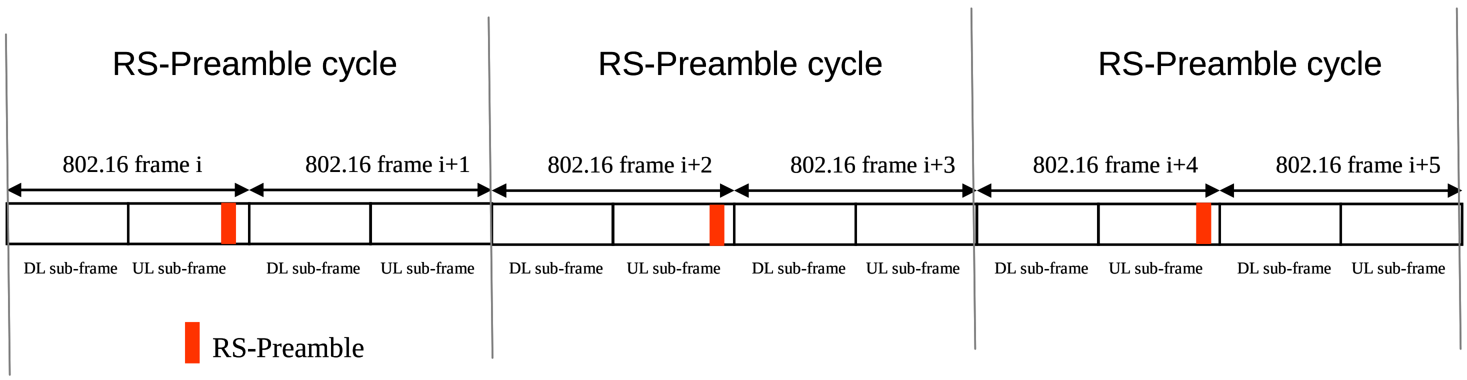

Figure 1 RS-Preamble transmission

Simulation Setup

The performance of the proposed method for on-going DL RS preamble synchronization is evaluated using the parameters from [1]. The following sections describe the simulation setup and assumptions for the performance evaluation of RS preamble selection.

BS deployment:

We consider a multi-cell layout assuming a 2-tier cell coverage model with 19 hexagonal cells (including the central BS cell). The relay deployment is performed within the 2-tier cell area. To cover the effect of base stations on the first and second tiers (with respect to the central cell), we also model the third and fourth tiers; however, we neglect the relay deployment in these two outer tiers.

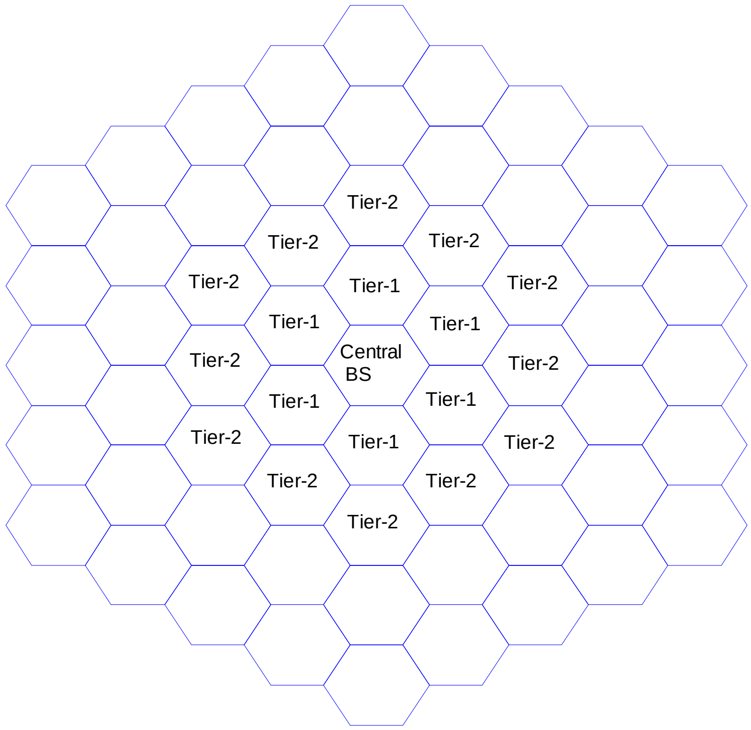

Figure 2 Hexagonal grid for BS deployment

Each cell is separated into 3 sectors and each BS is equipped with a 3-sector antenna. Each sector is assigned a cell_ID and a segment_ID which together determine the PN sequence (preamble index) to be employed for preamble transmission. By convention, we assume that sectors within the same cell have the same cell_ID. A preamble index can be reused by a BS only if that index is not being used by any other BS within the 2-tier cell coverage area.

RS deployment:
In our simulation for fixed relays, RSs are created randomly within the 2-tier cell area with the following constraints

- The distance between any BS and any RS can not be smaller than a specified value
- The distance between any two RSs can not be smaller than a specified value

Any relay, whenever created, starts monitoring the preamble transmissions (which happens at the first OFDM symbol of every DL subframe period) from 19 BSs and any RSs if there exists any in the coverage area. After a sufficient observation period, it determines a set of PN sequences for which the correlation metric (whose computation is described below) is less than some threshold and the PN index for which the correlation metric is the maximum one. We initially assume that the PN sequence with the maximum correlation metric belongs to the serving station and those PN sequences that have a segment_ID different from the segment_ID of the serving station are considered for potential PN sequences to be assigned to the RSs.

Signal Model

The preamble symbols are generated and modulated according to the IEEE 802.16e-2005 standard. Basically, a preamble symbol consists of a number of left and right guard tones and a PN sequence, all specified by the standard. Let $\mathbf{p}_l = [p_l[0], p_l[1], \ldots, p_l[K-1]]^T$ denote the transmitted symbols at tone-*k*, *k=0,..,K-1*, of the preamble symbol, where $l = 0, \ldots, 113$, is the index of the PN sequence, and *K* is the FFT size (that can be 128, 512, 1024 or 2048). The signal received by a RS at tone-*k* can be expressed as (assuming synchronized transmissions from all nodes)

$$r[k] = \sum_m p_m[k] h_m[k] + z[k]$$

where the summation over *m* refers to the superposition of signals from all surrounding base or relay stations and *h[k]* and *z[k]* denotes the channel gain and additive Gaussian noise, respectively, at tone-*k*. The channel gains (that govern the effect of path loss, shadowing and small scale fading) are simulated using the methods and parameters in [1] and references therein. Let $\mathbf{r} = [r[0], r[1], \ldots, r[K-1]]^T$ denote the received signal in vector form. Once a relay receives the preamble symbol, it computes the cross correlation between the received signal and each PN sequence:

$$\rho_l = \frac{|\langle \mathbf{p}_l, \mathbf{r} \rangle|}{\|\mathbf{p}_l\| \|\mathbf{r}\|}, \ l = 0, \ldots, 113.$$

This is repeated over a number of frames, say F frames, and the resulting cross correlation is averaged by a moving average window

$$\overline{\rho}_l[f] = \begin{cases} \rho_l[0] & f = 0 \\ (1-\alpha)\overline{\rho}_l[f-1] + \alpha \rho_l[f] & f = 1, \ldots, F-1 \end{cases}. \quad (1)$$

For fixed RSs, we set $\alpha = \frac{1}{\mathrm{f}+1}$ so that the resulting correlation is the mean of the cross-correlation values across F frames. For a moving RS, it is possible to adjust this parameter appropriately to account for the variations of the RSs and BSs that cover the RS.

Evaluation of Interference:

To assess the effect of interference on the preamble selection and monitoring, we define two interference metrics

- Interference based on average cross correlations

$$\Gamma_l = \frac{\overline{\rho}_l}{\sum_{m \neq l} \overline{\rho}_l} \quad (2)$$

- Interference based on received signal power

$$\gamma_l = \frac{\|\mathbf{p}_l . \mathbf{h}_l\|}{\|\mathbf{r} - \mathbf{p}_l . \mathbf{h}_l\|}. \quad (3)$$

Note that the product in (**Error! Reference source not found.**) is point-wise product, e.g., $\mathbf{p}_l . \mathbf{h}_l = [p_l[0] h_l[0], \ldots, p_l[K-1] h_l[K-1]]^T$.

Performance Criteria and Simulation Results

In the following, we study the monitoring collision rate for the downlink preamble synchronization method.

Parameters:

Table 1 provides the parameters for the OFDM signaling.

Table 1 OFDM Parameters

OFDM Size	1024
Carrier Frequency	2.35 GHz
Bandwith	11.2 MHz

The channel gains are generated using the channel parameters provided in [1]. For fixed or nomadic RSs, the small scale fading is simulated using the SUI fading channel models. For mobile scenarios, e.g., at high speeds with large Doppler shifts, we resort to the legacy channel models.

We include several system parameters in Table 2.

Table 2 System parameters

Number of BSs	19
Number of Sectors per cell	3
BS separation	750 m
BS Tx Power	43 dBm (~19.95 W)
BS antenna Height	3-sector antenna with 20 dB front-to-back ratio 25 m
Min RS-Rs and RS-BS separation	144 m
RS Tx Power	27.78 dBm (~600 mW)
RS antenna Height	Omni antenna (-1 dB gain) 15 m
Thermal Noise Density	-174 dBm

On-going Downlink Synchronization:

After the PN index acquisition, RSs start to transmit their own preambles during the downlink subframe. In order to synchronize RSs to the variations in the surrounding relay nodes, Nortel proposes to transmit RS preambles at system-wide specified time instances at every RS_Preamble_Cycle (a pre-specified number of frames, say N frames). The RSs randomly choose one of those instances to monitor the environment. For that purpose, RSs are provided a time period over a number of RS_Preamble_Cycles, say M such cycles and over these M cycles, they monitor once and transmit RS Preamble at all other instances. This is repeated over K periods. At the end of KMN frames, if one or more relays have always selected the same monitoring instances, a collision occurs.

In Figures 2.a and 2.b, we plot the collision rate curves in the case of 10 RSs and 15 RSs per cell, respectively. In these examples, we define the set of *visible* RSs relative to a certain RS, RS_0, as those which has the interference metric (**Error! Reference source not found.**) above a threshold, Γ_{th}. Here, we set

$$\Gamma_{th} = 0.2 \arg\max_{0\le l\le 113}\{\Gamma_l\}.$$

From the plots, it is clear that we need a compromise between the parameters M and K. For example, from Figure 3.a for 10 RSs/cell, to attain a collision rate of about 1%, we need about 20 frames when M=10 and about 16 frames when M=4. By setting a smaller value for M, although we need a larger K, the required number of frames, KM, becomes less.

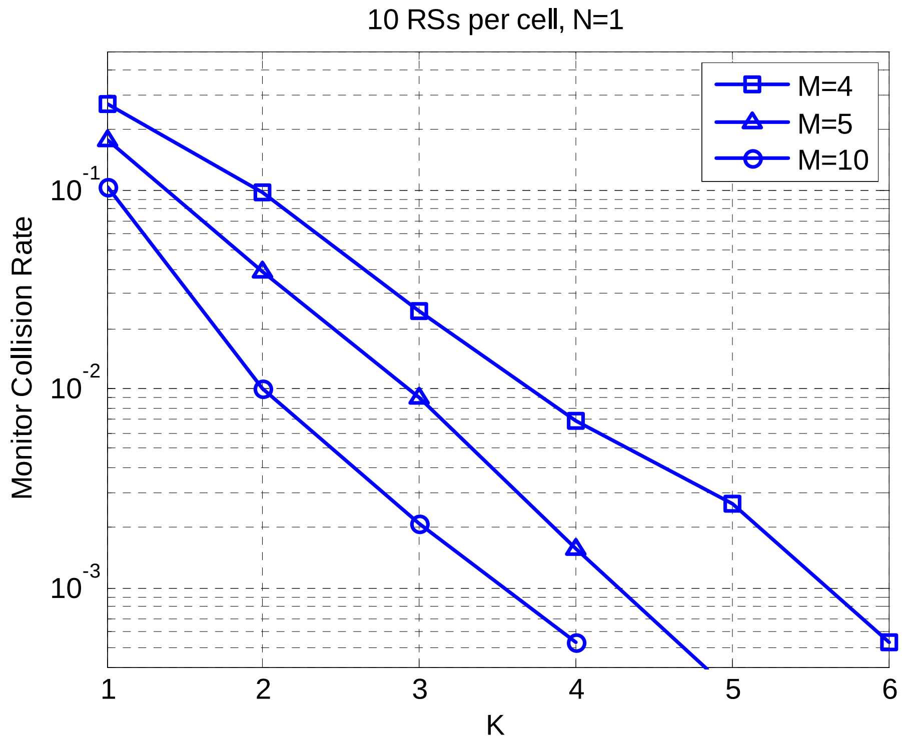

Figure 3a Monitoring Collision Rate

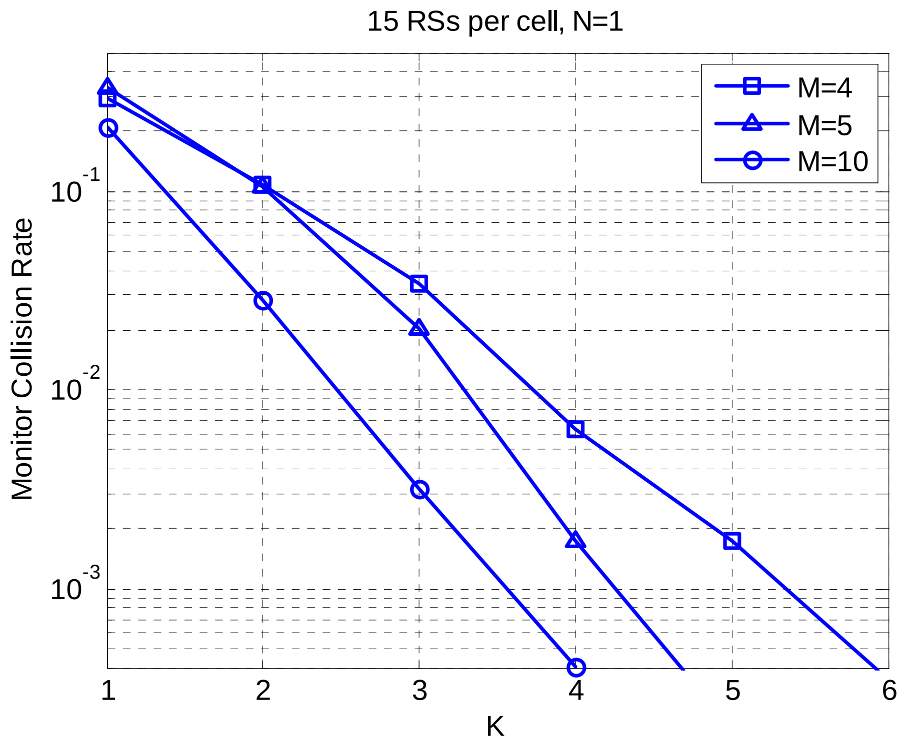

Figure 2b Monitoring collision rate

Conclusions

Based on the simulation results, the proposed R-preamble works well. We can have a compromise between M and K to minimize the time required to attain a desired monitoring collision rate.

Proposed text change

3.1. RS-Preamble

[Insert new section 8.4.6.1.1.3 after Table 309d in Page 527]

8.4.6.1.1.3 RS Preamble

The RS preamble transmission may be used for RS on-going radio environment measurement to enable on-going path update.

The RS preamble may be transmitted every N frames, which is defined as RS-Preamble cycle. The frame where an OFDM symbol is reserved for RS Preamble transmission is called as RS-Preamble frame. The index offset of the RS Preamble OFDM symbol within a RS-Preamble frame is j. Both N and j are configurable and shall be broadcasted by a MMRBS. The RS Preamble indexing method and corresponding modulation PN series definition are the same as 802.16e preamble, as described in 8.4.6.1.1.

3.2. RS preamble transmission procedure

[Insert new section XXX in Page XXX] (not sure where we shall insert yet)

To enable this operation, MMRBS needs to configure following parameters:

- RS-Preamble transmission cycle (N): defines the transmission period of RS-Preamble (e.g., RS-Preamble is transmitted every N frames). The first frame in each cycle is the frame, called as RS-Preamble frame, where a OFDM symbol is reserved for RS-Preamble transmission
- RS-Preamble monitoring cycle selection base (M): define the number of cycles within which a RS randomly select a cycle to stop its own RS-Preamble transmission and monitor other RS-Preambles in the corresponding RS-Preamble frame
- Base starting frame offset (k): identify the index of frame which starts a base. A RS-Preamble transmission base starts from a frame indexed i with i meeting the formula: mod(i ,MxN) = k. Each base includes MxN frames and M cycles. The cycle can be indexed from 0 to M-1.
- RS-Preamble OFDM symbol offset within RS-Preamble frame (j): identify the OFDM symbol index within RS-Preamble frame, referring to the first OFDM symbol in the frame

The parameters, N, M, k, j are configurable and shall be broadcast by MMRBS. At the time when a RS starts performing RS functions, RS shall start RS-Preamble operation.

Within an RS-Preamble monitoring cycle selection base, a RS shall transmit RS-Pramble in RS-Preamble frame in all cycles, except one cycle called as monitoring cycle. A RS shall randomly select an RS-Preamble cycle within the base as a monitoring cycle.

3.3. RS-Preamble operation parameter broadcast

We propose to add a new TLV to 802.16e DCD management message

[Insert the following into the end Table 358 in Page 675]

Name	Type (1 byte)	Length	Value	PHY scope
RS Preamble parameter	156	4	Bits#0-7: RS-Preamble tramsission cycle (N) Bits #8-15: RS-Preamble monitoring cycle selection base (M) Bits#16-23: Base starting frame offset (k) Bits#24-31: RS-Preamble OFDM symbol offset within RS-Preamble frame (j)	OFDMA

[1] IEEE 802.16j-06/013r1 “Multi-hop Relay System Evaluation Methodology (Channel Model and Performance Metric)”