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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	This contribution proposes a procedure regarding how to reuse 802.16e preamble resource among MR-BS and RSs
Purpose	To incorporate the proposed text into the P802.16j Baseline Document (IEEE 802.16j-06/026r1)
Notice	
Release	
Patent Policy and Procedures	

RS 802.16e Preamble Transmission

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

Nortel

Introduction

A RS may need to transmit the 802.16e preamble to facilitate a MS to perform cell selection and etc. Based on the 802.16e-2005 standard, there are total 114 preamble sequences (identified by preamble and characterized by IDcell, segment and PN sequence). This preamble resource pool now needs to be shared by not only MR-BSs, but also RSs which are configured to transmit the 802.16e preamble. This contribution proposes a procedure regarding how to reuse 802.16e preamble resource among MR-BS and RSs.

RS 802.16e preamble selection

During RS initial network entry, a RS needs to perform the cell selection as a MS does. This procedure can be enhanced to enable the RS assistant preamble PN sequence selection. The procedure includes the following steps:

- A RS maintains a table with each entry contains preamble index, corresponding PN sequence and strength
- A RS shall measure each preamble listed in the table
- The strength of each preamble is recorded in the table for the corresponding entry
- This measurement may take relative long time to minimize the impact of fading
- When the measurement procedure is finished (e.g., reach the required number of frames and so on), the RS may use certain criteria to determine its serving station (MMRBS or a RS)
- There are tow options regarding how to select a preamble for a RS
    - i. The RS uses the same table to determine the candidate preamble pool for purpose of a preamble selection for its own transmission after it assumes RS function
    - ii. The candidate preambles in the candidate pool are those preambles whose strengths measured by this RS are lower than a pre-defined threshold
    - iii. The RS then randomly selects N preambles from the candidate pool and reports to its MMRBS (may via other RS(s)). The selected preambles are indicated by preamble index
    - iv. The MMRBS may assign a preamble based on information from the list reported by this RS and information such as preamble currently used within the cell and by its neighbor cell (assume this information can be shared by neighbor MMRBS through backhaul) and signal the determination to the RS

The benefits of this approach include

- By reasonable setting of threshold and measure time, the preamble collision can be minimized
- Complex preamble plan can be fully avoided

RS 802.16e preamble selection based on Index Subsets

In the above scheme, any RS can assume the value of any preamble index from 0 to 113. A rule for preamble index assignment is proposed by Fujitsu [2] where the preamble indices are divided into two subsets each consisting of 57 preamble indices. Our scheme can readily be extended to cover this rule. In this case, since the set of available PN sequences to be assigned is smaller, the chance that RSs within the vicinity of each other use the same preamble index may be higher.

Simulation Setup

The performance of the proposed method for RS-preamble selection 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.

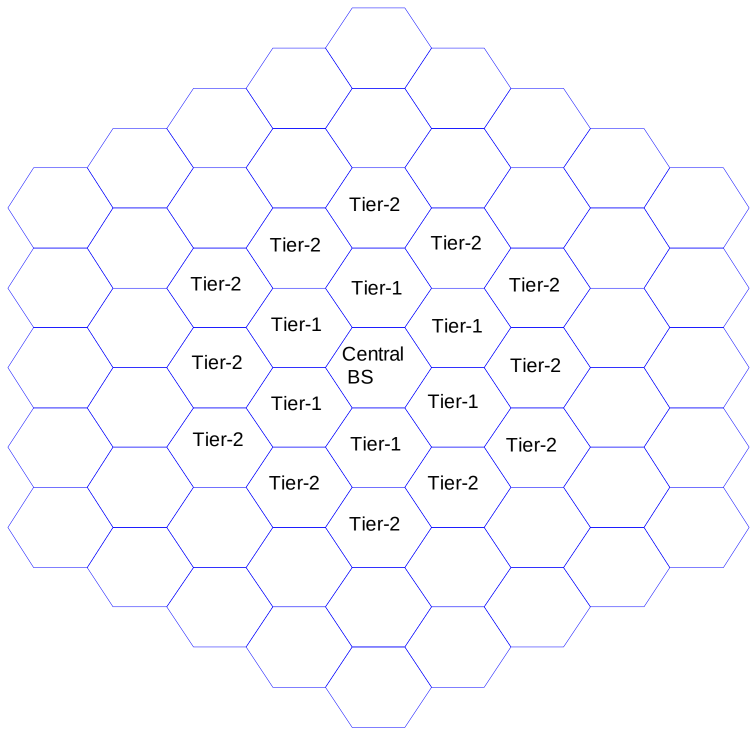

Figure 1 Hexagonal grid for BS deployment

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 $\mathbf{p}_l = \left[p_l[0], p_l[1], \ldots, p_l[K-1]\right]^T$ 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 $\mathbf{r} = \left[r[0], r[1], \ldots, r[K-1]\right]^T$ 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:

$$\rho_l = \frac{\left|\langle \mathbf{p}_l, \mathbf{r} \rangle\right|}{\|\mathbf{p}_l\| \|\mathbf{r}\|}, \; l = 0,\ldots,113, \tag{1}$$

which is then used to compute the interference metric based on correlation scores:

$$\Gamma_l = \frac{\rho_l}{\sum_{m \neq l} \rho_l}. \tag{2}$$

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

$$\Gamma_l[f] = \begin{cases} \Gamma_l[0] & f = 0 \\ (1-\alpha)\overline{\Gamma}_l[f-1] + \alpha\Gamma_l[f] & f = 1,\ldots,F-1 \end{cases}. \tag{3}$$

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, we employ interference metric in (3).

Performance Criteria and Simulation Results

Parameters:
Table 1 provides the parameters for the OFDM signaling.

Table 1 OFDM Parameters

OFDM Size	1024
Carrier Frequency	3.5 GHz
Bandwith	10 MHz
Sampling Frequency	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 ITU channel models. For the BS-BS and BS-RS path loss models, we assume either type-e or type-d cases described in [1].

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	100 m
RS Tx Power	27.78 dBm (600 mW) for 20 RSs/cell 34.77 dBm (3 W) for 10 RSs/cell
RS antenna Height	Omni antenna (-1 dB gain) 15 m
Thermal Noise Density	-174 dBm
MS antenna Height	Omni antenna (-1 dB gain) 1.6 m

RS preamble selection:

Each RS is required to generate a number of potential candidates for the preamble indices based on their measurements. The following method is studied:

During the preamble selection period:

1. After each preamble symbol, calculate the correlation coefficient using (1)
2. After a specified number of frames, determine the PN index with the largest average correlation coefficient. Get this PN sequence’s segment_ID, which is 0, 1 or 2
3. To ensure that the RS employs a different set of OFDM tones for preamble transmission, determine those PN indices whose segment_IDs are not equal to the segment_ID determined in the previous step

4. Generate a subset of PN sequence indices which consists of those with the signal-to-interference metric given by (3) below some threshold

A critical step in this method is the number of potential candidates obtained at step 4.
Figure 2 plots the cumulative distribution function of the interference metric (3) obtained over *F=100* Frames (0.5 sec). It is seen that the interference in terms of correlation has a sharp CDF. For example, 94% of the available PN sequences results in a value less than 0.02 and about 84% results in a value less than 0.01. Hence, we have sufficient number of potential PN candidates for a dynamic PN index allocation.

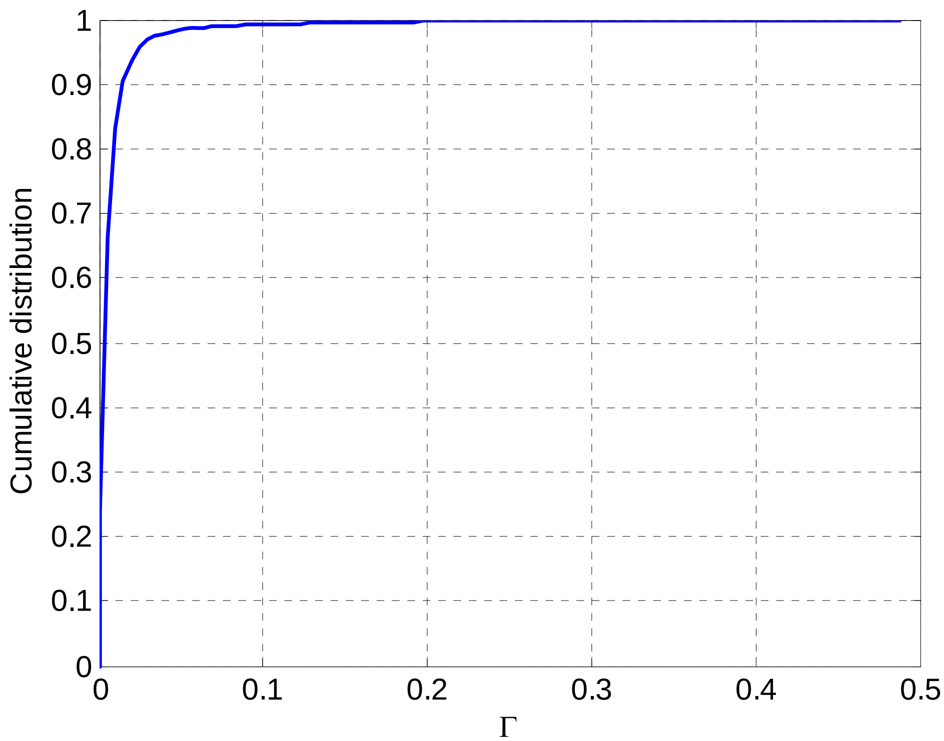

Figure 2 CDF of interference metric in (2)

Nortel proposal on RS preamble selection suggests the feed-back of N preamble candidates to the BS and letting the BS finalize the RS index assignment. Hence, it is possible to avoid preamble collisions, i.e., the existence of neighbor RSs with the same PN index.

On the other hand, we can leave the PN index selection to the individual RSs. One way to do is to let each RS choose the PN index with the smallest interference metric given by (3) and having a segment_ID different from the one with the highest interference metric (see step 3 of the preamble selection method). We simulate the collision rates with this method assuming 10 RSs and 20 RSs per cell. We calculate the interference using (3).

As an example, we set threshold to 3 dB and *F=5*. Thus, if $\Gamma_l[F-1] > 3$ dB for some PN index, the RSs using the same PN sequence and having the signal-to-interference ratio larger than this threshold is assumed to result in a PN collision. Table 2 provides the collusion rates in the case of 100 and 300 mobile stations per cell in the presence of 10 and 20 relay stations in each cell. We observe that even in this individual PN index assignment, the collision rates can be low (which can be made even smaller by leaving the preamble index assignment to the BSs). We also note that as the density of the RSs increase from 10 to 20, the rate of preamble collisions increase. The collision rates increase when the preamble indices are divided into two subsets as described in [2]. In such cases, the use of a central planning may be necessary, in particular for networks with densely located RSs.

Table 3 Collision Rates without PN subset rule

# of RSs/cell	# of MSs/cell	Collision rate
10	100 300	0.00043 0.0102
20	100 300	0.00085 0.0218

Table 4 Collision Rates with PN subset rule

# of RSs/cell	# of MSs/cell	Collision rate
10	100 300	0.0013 0.0202
20	100 300	0.0037 0.0381

Conclusions

Based on the above simulation, with the proposed dynamic preamble index assignment method, we can have a large set of potential PN sequence candidates.

Proposed text change

RS preamble measuring and selection

[Add the following section]

6.3.9.16 Network entry and initialization

6.3.9.16.1 RS network entry and initialization

6.3.9.16.1.1 Preamble selection

The preamble selection operation is only applicable to the RS which is configured to transmit 802.16d/e preamble to facilitate MS's cell selection.

During RS initial network entry, a RS needs to perform the cell selection as a MS does. If a RS is configured to transmit 802.16d/e preamble, this network entry procedure can be enhanced to enable RS assistant preamble PN sequence selection. The procedure includes the following steps:

- A RS maintains a table with each entry contains preamble index, corresponding PN sequence and strength
- A RS shall measure each preamble listed in the table
- The strength of each preamble is recorded in the table for the corresponding entry
- This measurement may take relative long time to minimize the impact of fading
- When the measurement procedure is finished (e.g., reach the required number of frames and so on), the RS may use certain criteria to determine its serving station (MMRBS or a RS)
- The RS uses the same table to determine the candidate preamble pool for purpose of a preamble selection for its own transmission after it assumes RS function
    i. The candidate preambles in the candidate pool are those preambles whose strengths measured by this RS are lower than a pre-defined threshold
    ii. The RS then randomly selects N preambles from the candidate pool and reports to its MMRBS (may via other RS(s)) using preamble selection TLV in REG-REQ message. The selected preambles are indicated by preamble index
    iii. The MMRBS may assign a preamble based on information from the list reported by this RS and information such as preamble currently used within the cell and by its neighbor cell (assume this information can be shared by neighbor MMRBS through backhaul) and signal the determination to the RS through REG-RSP message

MAC management message modification

REG_REQ/RES is modified to include candidate preamble index TLV and preamble assignment.

[Insert the following text to the end of section 6.3.2.3.7 in Page 56]

The REG-REQ may include the following TLV:

Preamble selection
This TLV is used by a RS to indicate the preamble candidates to MMRBS.

[Insert the following text to the end of section 6.3.2.3.8 in Page 58]

The REG-RSP may include the following TLV:

Preamble selection
This TLV is used by a MMRBS to indicate the preamble assignment to a RS ..

[Add one type in Table 369a in page 685 of IEEE std 802,16e-2005]

Type	Parameter
45	Preamble selection

[Add a new section 11.7.27 as described]

11.7.27 Preamble selection

This field in REG-REQ message is used by a RS to report suggested preamble indexes to a MMRBS for the purpose of selection of a preamble to be used by the RS after it assumes a RS function.

This field in REG-RSP message is used by a MMRBS to indicate to a RS regarding the preamble assigned.

Type	Length	Value	Scope
45	N in REG-REQ (N is a parameter broadcast by MMRBS) 1 in REG-RSP	Each byte is used to indicate a preamble index	REG-REQ/RSP

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

[2] IEEE C80216j-06/150, “Proposed modifications to the PN sequence used by the Base Stations and Relay Stations in a MR enabled network”