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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-06/026
Notice	
Release	
Patent Policy and Procedures	

RS preamble transmission for continuous synchronization and neighborhood scanning

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1. 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 IEEE 802 Meeting number 46, we presented a contribution (C80216j-06/241r1), to solve the above monitoring problem by introducing an RS-preamble to be transmitted by the RS. 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 proposed a scheme to enable the link scanning based on an RS-Preamble. In the proposal, always all the RSs are to transmit preamble in a specific location except for one RS within a group of neighbors which would monitor the others and measure the signal strength during monitoring. This monitoring was done in random manner and in order to avoid the monitoring by two neighboring RS stations in the same time, the length of monitoring cycle need to be increased to a reasonable level.

However, We can categorize RS Preamble as having two functions

- To continue to be in sync with its parent RS or BS – frequent listening is needed **(**may be as small as 30 msec depending on hardware complexity)**.**
    - o The previous random monitoring scheme has limitations in achieving more regular monitoring for synchronization.
- To continuously monitor neighboring RSs for potential handoff – need not be very frequent (e.g. 200 msec).
    - o In the meeting #46, there are some proposals which used odd and even frame RS preambles which may be used by RSs with odd number of hops to the MR-BS and RSs with even number of hops to the MR-BS respectively. However, this scheme cannot be used for neighborhood

scanning since all the RSs with an even number of hops to BS cannot see each other's preamble (same for RSs with even number of hops)

In order to accommodate above two requirements, in this document we propose to combine the two methods with some modifications to each scheme so that a single scheme can be used for both purposes.
Details of the random monitoring scheme presented in meeting number 46 can be found in the resubmitted contribution C802.16j-06/241r1.

2. Description of the proposal

In the combined scheme there are two types of preambles used depending on their use..

RS Preamble for Synchronization (RPS) is used mainly to acquire synchronization for its subordinate RSs and this need to be done within a strict time limit in order to keep in synchronization. RPS may also be used for monitoring of the neighbor RSs and BSs as permitted by the transmission of an RPS by these neighbors in the same time,

Since the RPS might not guarantee full monitoring of the neighborhood, RS preamble for Neighborhood Scanning (RNS) may be done to guarantee the monitoring of the neighbors within a certain time limit using a random monitoring scheme.
We propose that since the limiting case is the synchronization scheme, that RPS symbols may be optimized to use for synchronization while those are also used for monitoring as much as possible.
Instead of odd and even frame, the RPS is to be transmitted in every Xth frame in order to reduce the overhead, if that can be tolerated by the synchronization requirements.

For example, if an RS has to listen to a parent RS within every Tsync second, with two types of odd and even hop categorization(every RS listen to every 2Xth frame), 2X * frame_time < Tsync. We can choose X such that this requirement is met. However in this occasion in average only 50% of users can be monitored.

Let, the minimum number of frames is 2N, where 2N* frame_time > Tsync. The idea is to have two RS groups, using two cycles A and B for its RS premable transmission. One group sends it starting from pth frame (p<N) and repeating it every 2Nth frame (p, p+2N, p + 3N, etc), the other group sends it starting from the qth frame ($p \neq q$, q < N) and repeating every Nth frame (q, q+2N, q + 3N, etc). The case, where 2N = 6, p = 1, q = 4 is shown below.

TS1 (RPS A)	**TS2**	**TS3**	**TS4 (RPS B)**	**TS5**	**TS6**	**TS7 (RPS A)**	**TS8**	**TS9**	**TS10 (RPS B)**		

Figure 1. RPS Frame Example

RPS A is the listening time for group A relays (for example, the RSs with an odd number of hops to the MR-BS) and RPS B is the listening cycle for the group B relays.

In the combined scheme, it is proposed that the other free frames (E.g. TS2, TS3) in which RPS is not sent may be used for RNS transmission.

In order to increase the monitoring capability, we propose the parent RS of different branches branching off from the MR-BS to have different cycles. This is shown in figure 2. Furthermore, the number of cycles can be increased to increase (E.g. A, B and C) the monitoring capability. With 3 cycles we can assume that 2/3rd of RSs can be monitored at a time. This comes however with an added overhead (meaning now,within the same synchronization time we need to have 3 RPS frames).

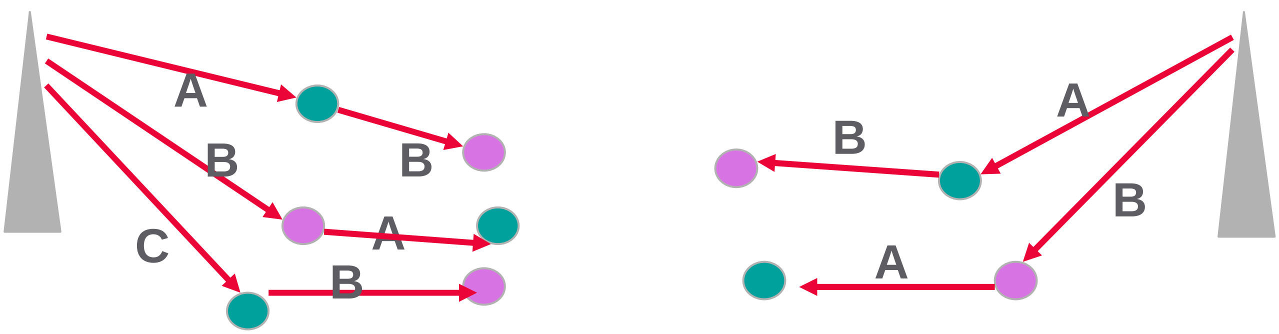

Figure 2. Different branches can start with different cycles as much as possible.

If MR-BS uses 6 different monitoring cycles (groups) and each RS connected to it can have a different cycle (if the total is less than 6 which is the case for most of it). Having six different cycle possibilities the children in each branch can randomize or deterministically transmit only one cycle. This way, there is a larger possibility that the neighboring RSs have use different cycles and hence can listen to each other for monitoring purpose.

In another variation, we can slightly alter the definition of the parent. RS may synchronize with a parent of a parent so that synchronization purposes it parents to a different node (RS or BS) to that of forwarding node. This is particularly useful as this might increase the reliability and even reduce the sync requirements (when a RS does not support another child RS to synchronize, it does not need to transmit a RS preamble that frequently (only for monitoring).

To enable this scheme following parameters need to be defined and broadcast to each RS at the initial entry.

- In certain frames, called RPS-frame, an OFDM symbol is reserved for RPS transmission. The index offset of the RS Preamble OFDM symbol within a RPS-frame is j. RPS frames are allocated every Xth frame in a cyclic manner, Base starting frame offset, K_s identifies the index of frame which starts a base. A RPS frame is the frame indexed i with i meeting the formula: mod(i ,X) = K_s.

- In each RPS-frame, an RS may monitor its synchronization parent access point, or transmit its RS preamble. In every Yth RPS-frame, an RS has to monitor it parent at least once for synchronization in a cyclic manner with an offset from the base Z, where Z indexed from 0 to Y.
- X, Y and K_s 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.
- The value of Z may vary from each RS to and RS and will be informed by the MR-BS whenever a new entry of an RS or any other topology change occurred.

In Figure 1, X = 3, Y = 2, Z can be 0 or 3 depending on the where the RS located related to a branch.

RNS may be used for monitoring purposes in addition to RPS when RPS is not adequate for monitoring and they can be used in the case of either X > 2 or when RPS frames are not used at all. For these cases, all the frames not used for RPS are available for RNS transmissions and called non-RPS frames.. (For RNS, we can use the same scheme proposed in 16j-06/240 (standard contribution) but only use the non-RPS frames as shown below.)

TS1 (RPS A)	**TS2**	**TS3 RNS**	**TS4 (RPS B)**	**TS5**	**TS6 RNS**	**TS7 (RPS A)**	**TS8**	**TS9 RNS**	**TS10 (RPS B)**		**TS12 RNS**

Figure 3 Some of the Non-RPS frames are used as RNS frames

If we assume that we need to select a multi-frame consisting of M frames, and in each multi-frame a fixed locations is reserved for the RNS preamble. Then, for each RS in a neighboring group one of them randomly select one of the M multi-frames for monitoring. For fixed RS, upon entering into the system, RS can know all the neighbors using preamble measurements and therefore, the BS can allocate different frame groups for these neighbor groups to avoid a monitoring collision. For the fixed RSs since we do not expect to quickly change a channel, these measurements can be done at a very slow frequency, and some collisions would be ok.

Since a solution need to be reached where overhead is minimum we include here an example overhead calculation.

<u>Overhead of RS Premables:</u>
For RS preamble we need at least 1 TTG, 1 RTG and 1 symbol.
If this happens in every frame this costs about 6% overhead.

In figure 3,, we need to have 2 RPS preambles in 6 frames. That is 1/3 of the frames. So overhead would be 1/3rd of the previous 6 symbols, or 2%

If RNS is to be transmitted in every 6 frames, the overhead for RNS is 1%.
So total overhead is 3%.

If RNS is to be transmitted in every 12 frames, we have about 0.5% overhead giving a total of 2.5% overhead.

A metric for effectiveness of a RS preamble scheme can be thus stated as the percentage overhead that would incur to be able listen to a parent RS within a given time, and to be able to monitor all the neighbors within a certain time with a certain reliability.

Depending on how much planning, measurements are needed different schemes may be applied as shown later in this document.

In order to increase the effectiveness of the combined synchronization and monitoring scheme, we propose that the following variations may be also supported by the standard. The objective is to present a generic messaging scheme and a configuration scheme to facilitate various options of monitoring and synchronization schemes. Some of he potential variations are provided below.

Scheme 1: Purely random monitoring for both synchronization and scanning

This is the scheme proposed in 802.16j_248 contribution. This may not achieve the strict synchronization needs. Simulation results show that the minimum monitoring time that can be achieved is > 20 frames to avoid monitoring collision. If the frame time is 5 msec this may not be sufficient for the synchronization purposes. However, by noting that monitoring collision should be avoided only with its parent (with whom it is trying to synchronize) a lower minimum monitoring time may be achieved. This need to be done based on further simulations and may possible to use depending on the hardware requirements for synchronization..

Scheme 2. Parent child alternate cycle transmission and monitoring for synchronization without additional NPS frames.

This is the previously mentioned scheme for the synchronization but with certain limitations of applications as mentioned below can be used for the system operation.

- If an MRS does not need to transmit the RS preamble it can listen to both cycles and quickly assess the neighborhood changes and take a handover and other actions.
- This may be used for a network where MRS do not want to support another RSs synchronization.

For fixed RSs the measurements of neighbors at the beginning can be stored. Once the RS is connected to a parent, it does not need to be changed unless for overloading reasons, an installation of a new RS or removal of an existing RS.
During a forced topology change by the BS, the BS has the neighbor information and request the RS to handoff. The next chart describes the solutions for the other two cases (removal and new RS installation).

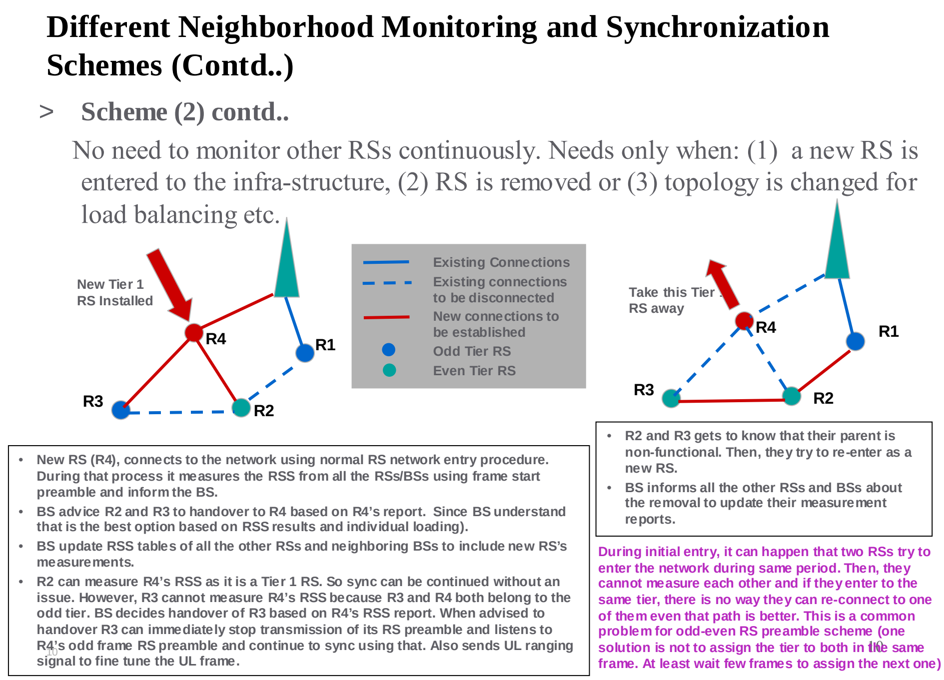

Figure 4. Fixed Relay Monitoring Scheme

<u>Scheme 3: Parent/child alternate RS preamble scheme with additional RPS frames for neighborhood scanning.</u>

This is same as the combined scheme (RPS and RNS frames) discussed previously, However, since neighborhood scanning for fixed RS is not required as regularly as for the MRS, the NPS monitoring scheme parameters may be changed depending on whether it is a MRS or fixed RS.

(1) For Fixed RS only (slightly improved version of above (1) to accommodate <u>slow changes in the channel in a fixed RS network</u>:

Since the propagation environment would not change very fast for fixed RSs a measurement done every day or every one hour time would be sufficient. For this purpose, each RS can send a RS preamble say every M frames (other than RPS frames) and during one of those K transmissions it decides to monitor randomly. K should be considerably larger than number of possible neighbors to avoid collision (e.g. M = 100 and K = 20). The BS should inform start frame so that every RS transmit at the same time.

(**<u>2) For MRS:</u>**

For this case, the monitoring scheme can be done in a more regular manner.

<u>Scheme 4: Parent/child alternate RS preamble scheme with additional RNS frames for neighborhood scanning.</u>

This is same as the combined scheme (RPS and RNS frames) discussed previously, However, since neighborhood scanning for fixed RS is not required as regularly as for the

MRS, the RNS monitoring scheme parameters may be changed depending on whether it is a MRS or fixed RS.

(1) For Fixed RS only (slightly improved version of above (1) to accommodate <u>slow changes in the channel in a fixed RS network</u>:

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(<u>2) For MRS:</u>

For this case, the monitoring scheme can be done in a more regular manner.

<u>Scheme 5: Parent/child alternate RS preamble scheme with a scheme that uses the RS preambles for synchronization as well as for neighborhood scanning.</u>

In the alternate RS preamble scheme (used for synchronization), the RSs cannot monitor the RSs using the same cycle for RS transmission. This can be relaxed by making RS to listen (instead of transmission) in certain instances in a regular manner. Since this would impact the monitoring for the synchronization, we propose that at least two RS preambles may be transmitted during the minimum synchronization period in a single cycle (A or B). Then, not sending one RS preamble to monitor the RSs using the same cycle in a random manner would not impact the synchronization process.

This random monitoring can be chosen using the same or similar algorithm proposed previously. However, we need to avoid monitoring collisions among RSs using the same cycle.

Scheme 6: Locally planned without inter_BS co-ordination

- In this scheme, we propose that since the BS is aware of the neighbors of all the RSs, the BS allocates a set of monitoring slots to each RS such that its neighbors do not posses same monitoring slots.
- If alternate cycle based scheme is used, that can be used to aid the monitoring process as well. Since an RS can always monitor RSs belong to other cycles, the monitoring collision should be avoided only among the RSs belong to the same cycle.

For example, Cycle A members assign monitoring slot group (MSG) (say G1 to G8) so that no neighboring cells (based on the initial frame start preamble measurement) receive the same group. E.g.: G1 monitoring slots: 1,3, 5; G2 monitoring slots: 7,9,11, G3: 13,15,17, G4 G5: 37, 39, 41

Now each RS selects one of the time slots out of its group to monitor in each multi-monitoring frame. This would avoid monitoring collisions with its own as well as minimize the collisions with the relays in the adjoining BSs.

Each new RS would be allocated a MSG based on its neighbor set that is determined by the measurements in the initial entry phase (using frame start preamble). After that the BS will allocate a parent node and inform the RS whether it belongs to Cycle A or Cycle B and whether it is supposed to transmit preamble and if so the MSG.

Scheme 7: Locally planned, measurement aided deterministic scheme

This is similar to scheme 3 but instead of having random transmission, after a certain settling time, each RS would monitor in a fixed slot. BSs share with its neighbors (this is the set of BSs that the RSs have identified as having considerable interference) the information about its RSs monitoring slot.

A new RS:

- RS is given the potential available monitoring slot list (similar to a MSG) at the entry by the BS considering its neighbors.
- RS listens to its neighbors for all the monitoring slots without transmitting its preamble. Then, identify that all the previously detected strong neighbors' monitoring slots (during initlal entry RS measures all the frame start preambles received from all the RSs and BSs). When during some slots it does not hear a neighbor it can decide that the neighbor is listening during that slot. When all the neighbors are accounted for it can select a different monitoring slot.

- In order to guarantee that there is no monitoring collision the RS may listen to an additional slot time to time. If additional neighboring RSs are detected it will update and may change its monitoring slot. This may be needed to detect MRSs approaching towards them.

Scheme 8: Locally planned with BS-BS co-ordination

This is similar to the Scheme 3 but instead of having random monitoring, allocate a fixed monitoring slot after getting information from the BS and having known the neighbors using the frame start preamble.

- A RS determines its neighbors
- BS inform the neighbor's monitoring slot information (exact one or a MSG group).
- RS decides to use non-colliding monitoring slot and inform the BS
- - BS updates all the neighbors on the monitoring slot.

3. Conclusions

- **Outlined and expanded the previously proposed schemes for synchronization and neighborhood scanning (Odd/even preamble transmission method and random monitoring scheme)**.

- **A combined method of alternate sync and random monitoring is proposed.**

- **Presented several schemes which can do both synchronization and neighborhood scanning for relay operation.**

The following text proposal I provided to support only limited number of cases. Given the interest authors are willing to include more generic messaging scheme to support many different monitoring and synchronization schemes..

4. Proposed text change

[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 two purposes. RS Preamble for Synchronization (RPS) is used mainly to acquire synchronization for its subordinate RSs and this need to be done within a strict time limit in order to keep in synchronization. RPS may also be used for monitoring of the neighbor RSs and BSs as permitted by the transmission of an RPS by these neighbors in the same time,

Since the RPS might not guarantee full monitoring of the neighborhood, RS preamble for Neighborhood Scanning (RNS) may be done to guarantee the monitoring of the neighbors within a certain time limit using a random monitoring scheme.

- In certain frames, called RPS-frame, an OFDM symbol is reserved for RPS transmission. The index offset of the RS Preamble OFDM symbol within a RPS-frame is j. RPS frames are allocated every Xth frame in a cyclic manner, Base starting frame offset, K_s identifies the index of frame which starts a base. A RPS frame is the frame indexed i with i meeting the formula: mod(i ,X) = K_s.

- In each RPS-frame, an RS may monitor its synchronization parent access point, or transmit its RS preamble. In every Yth RPS-frame, an RS has to monitor it parent at least once for synchronization in a cyclic manner with an offset from the base Z, where Z indexed from 0 to Y.
- X, Y and K_s 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.
- The value of Z may vary from each RS to and RS and will be informed by the MR-BS whenever a new entry of an RS or any othe topology change occurred.

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:

- RNS-preamble is transmitted once in every Nth non-RPS frame. RNS-Preamble transmission cycle (N): defines the transmission period of RNS-Preamble (e.g., RNS-Preamble is transmitted every N RNS frames). The first frame in each cycle is the frame, where the first RNS preamble is transmitted. However, all the RSs listen to the slot in a random manner time to time as defined by the following M, N and K_n parameters.

  - RNS-Preamble monitoring cycle selection base (M): define the number of cycles within which a RNS randomly (an uniform random number from 0 to M-1) selects a cycle to stop its own RNS-Preamble transmission and monitor other RNS-Preambles in the corresponding RNS-Preamble frame. Within an RNS-Preamble monitoring cycle selection base, a RNS shall transmit RNS in RS-Preamble frame in all cycles, except one cycle called as monitoring cycle
    - Base starting frame offset (k_n): identify the index of frame which starts a base. A RNS transmission base starts from a frame indexed i with i meeting the formula: mod(i ,MxN) = K_n. Each base includes MxN frames and M cycles. The cycle can be indexed from 0 to M-1.

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

3.3. RS-Preamble operation parameter broadcast and message between parent and child

We propose to add 3 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	6	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 for RNS (K_n) Bits#24-31: RS-Preamble OFDM symbol offset within RS-Preamble frame (j) Bits#32-39: X Bits#40-47-Y	OFDMA

Each BS or RS shall send a frame number to its subordinate RS for monitoring the parent RS preamble for synchronization using the message MON_RPS_REQ as defined below and sub-ordinate RS will send a response using the message MON_RPS_RSP

This message include RSID of the subordinate RS and the monitoring frame number, Z for synchronization.

Name	Type (1 byte)	Length	Value	PHY scope
MON_RPS_REQ	157	2	Bits#0-7: RS-ID Bit#8-11: The Monitoring Frame Number (Z) Bit#12-15: Reserved	OFDMA

Name	Type (1 byte)	Length	Value	PHY scope
MON_RPS_RSP	158	2	Bits#0-7: RS-ID (Sub-ordianted RSID) Bit# 8: Success(1), Failure(0) Bit#9-15: Reserved	OFDMA