RS preamble transmission for continuous synchronization and neighborhood scanning

Document Number:
IEEE C802.16j-06/156
Date Submitted:
2006-01-08
Source:
Gamini Senarnath , Wen Tong, Peiying Zhu Voice: 613 7631315
Hang Zhang, David Steer, Derek Yu, Wang G-Q E-mail: gamini@nortel.com; wentong@nortel.com
Israfil Bahceci
Nortel, 3500 Carling Avenue
Ottawa, On K2H 8E9 Canada

Mark Naden, Dean Kitchener Voice: +44 1279 402715
Nortel Fax: +44 1279 402100
London Road E-mail: jmn@nortel.com
Harlow, Essex, CM17 9NA
Venue:
IEEE 802.16 Session #47, London, UK
Base Document:
None
Purpose:
To address the issue of RS synchronization and neighborhood monitoring

Introduction and Background

- **In C802.16j-06 240, a cyclic RS preamble transmission scheme is proposed coupled with a random monitoring scheme.**
- **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 (can be as small as 30 msec – depends on hardware complexity)**. 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)
- **Therefore two types of RS preambles may be used: RS preamble for synchronization (RPS), RS preamble for neighbor scanning (RNS). It is also possible the same preamble be used for both purposes.**
  - **The RSs who is not supposed to have child RSs are not required to transmit the RPS but may require to transmit a RNS.**
  - **Fixed RS may not need to transmit RNS but require RPS.**

In this document we discusses potential solutions to achieve both requirements. Different solutions have different overhead and reliability levels. More studies with performance evaluations are needed in order to facilitate particular scheme(s) in the standard.

Proposed RS Preamble Transmission Schemes

- For RPS, the RS preamble transmission is done regularly within a certain time (Tsync), so that the child RSs connected to an RS could remain in sync by listening to it (adjust small clock shifts in time). This time is usually very small but depends on the hardware design. For example, 30 msec would be sufficient as per the current technology and the costs in implementation.
- RNS should be preferably transmitted by all the stations. However, preferably only one station out of a neighboring group should monitor it, in order to have quick measurement on all the neighbors. These monitoring instances should be rotated among neighboring RSs.

There are two methods already proposed for monitoring and synchronization

(1) The odd-even frame alternate RS preamble transmission scheme based on the hop-length from the BS

(2) The random RS preamble monitoring scheme

First we describe these two methods as general schemes together with some proposed enhancements. Then, discuss several potential solutions for both synchronization and neighborhood scanning.

Proposed RS Preamble Transmission Schemes

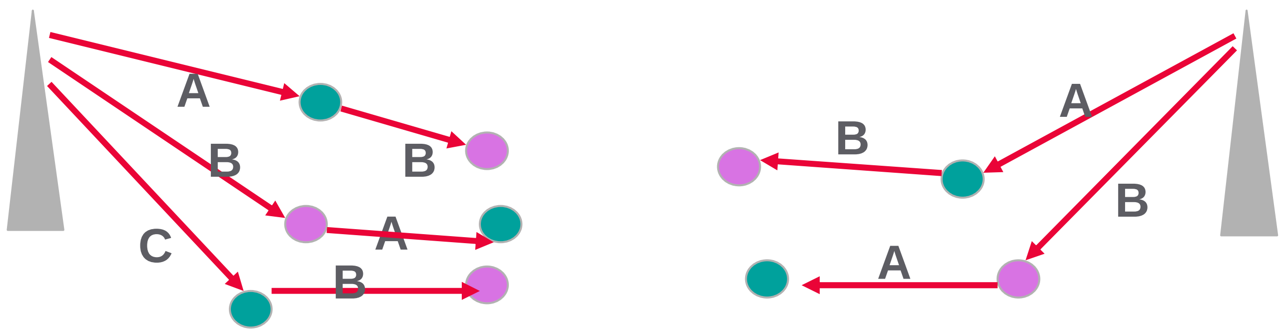
Alternate frame RS preamble Tx scheme for Synchronization (RPS):

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 ≠ 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. Note that the other frames may be used for RNS transmission.

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

Proposed RS Preamble Transmission Scheme

Now, each first tier hop listens to the BS's either A or B RS preambles. The children of an RS has to listen to its parent's preamble (either A or B cycle) and transmit its own RS preamble in the other cycle.



Note that the first tier RSs can listen to either A or B RS cycles. This can be randomly allocated to the BS or BS can deterministically allocate to improve the listening capability of RSs to each other. This way, the tier 1 RSs can listen to tier 1 RSs. As seen in the figure, there is larger visibility of neighbors (neighbors using different cycle so that they can monitor the neighbors).

In another variation, BS may have more than two cycles say 6 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).

Proposed RS Preamble Transmission Scheme

RS Preamble for Neighborhood Scanning (RNS):

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

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

6

Overhead for RS Preambles

Overhead:
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.

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

In the above example, we need to have 2 RS 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.

Different Neighborhood Monitoring and Synchronization Schemes

There are several possible schemes depending on the environments relay operate and the complexity and overhead we can afford. Selection of one may be up to the operator and we may facilitate all of them.

The previous description provides a general way of combining monitoring and Scanning with Synchronization. The following schemes are specific methods to be used for monitoring/scanning and synchronization.

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..

Different Neighborhood Monitoring and Synchronization Schemes (Contd..)

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.

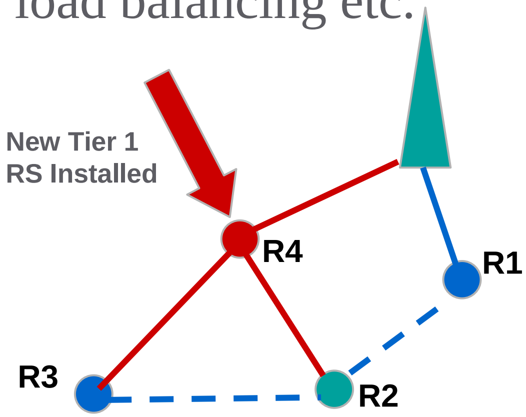
- If an MRS does not need to transmit the RS preamble it can listen to both cycles and quickly assess the neighborhood changes and take a handover and other actions.
- This may be used for a network where MRS do not want to support another RSs synchronization.

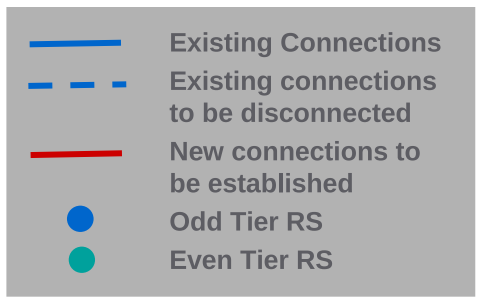
For fixed RSs the measurements of neighbors at the beginning can be stored. Once the RS is connected to a parent, it does not need to be changed unless for overloading reasons, an installation of a new RS or removal of an existing RS.
During a forced topology change by the BS, the BS has the neighbor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

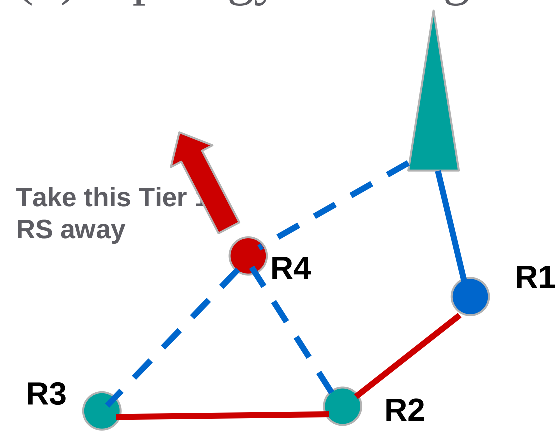
Different Neighborhood Monitoring and Synchronization Schemes (Contd..)

> **Scheme (2) contd..**

No need to monitor other RSs continuously. Needs only when: (1) a new RS is entered to the infra-structure, (2) RS is removed or (3) topology is changed for load balancing etc.







- New RS (R4), connects to the network using normal RS network entry procedure. During that process it measures the RSS from all the RSs/BSs using frame start preamble and inform the BS.
- BS advice R2 and R3 to handover to R4 based on R4's report. Since BS understand that is the best option based on RSS results and individual loading).
- BS update RSS tables of all the other RSs and neighboring BSs to include new RS's measurements.
- R2 can measure R4's RSS as it is a Tier 1 RS. So sync can be continued without an issue. However, R3 cannot measure R4's RSS because R3 and R4 both belong to the odd tier. BS decides handover of R3 based on R4's RSS report. When advised to handover R3 can immediately stop transmission of its RS preamble and listens to R4's odd frame RS preamble and continue to sync using that. Also sends UL ranging signal to fine tune the UL frame.

- R2 and R3 gets to know that their parent is non-functional. Then, they try to re-enter as a new RS.
- BS informs all the other RSs and BSs about the removal to update their measurement reports.

During initial entry, it can happen that two RSs try to enter the network during same period. Then, they cannot measure each other and if they enter to the same tier, there is no way they can re-connect to one of them even that path is better. This is a common problem for odd-even RS preamble scheme (one solution is not to assign the tier to both in the same frame. At least wait few frames to assign the next one)

Different Neighborhood Monitoring and Synchronization Schemes (Contd..)

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

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 slow changes in the channel in a fixed RS network:

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.

(2) For MRS:

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

Different Neighborhood Monitoring and Synchronization Schemes (Contd..)

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

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 slow changes in the channel in a fixed RS network:

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.

(2) For MRS:

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

Different Neighborhood Monitoring and Synchronization Schemes (Contd..)

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

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.

{There are other schemes which can use the locally planned schemes with random selection to avoid monitoring collision among different BSs, complete deterministic scheme with BS-BS co-ordination, and deterministic schemes with the aid of measurements. See schemes 6, 7 and 8 for examples)…

Different Neighborhood Monitoring and Synchronization Schemes (Contd..)

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.

14

Different Neighborhood Monitoring and Synchronization Schemes (Contd..)

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.

Different Neighborhood Monitoring and Synchronization Schemes (Contd..)

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.

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.**