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Source(s)	Gamini Senarath, Hang Zhang, Peiying Zhu, Wen Tong, 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-07_007r2.pdf
Abstract	This contribution, proposes an efficient RS-preamble transmission scheme that allows RS to continuously monitor its radio environment for synchronisation, for path maintenance and for neighborhood update.
Purpose	To incorporate the proposed text into the P802.16j Baseline Document (IEEE 802.16j-06/026
Notice	
Release	
Patent Policy and Procedures	

	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 patente technology (or technology under patent application) might be incorporated into a draft standar 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 amble transmission for continuous synchronization and neighborhood scanning

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

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1. Introduction

An RS operating as a serving station (deliver/collect traffic to/from MSs) will need to transmit the 802.16e amble signal to facilitate cell selection /reselection and synchronization for its subtending MSs. At the same time, the RS will also need to continuously monitor its radio environment for the purpose of its synchronization, path maintenance and update. Changes in the radio link performance, changes in neighboring RSs, addition of new RSs and arrival of moving RSs may require changes in the RS links. The RS, in addition to its communication with MS, thus needs to monitor signals to maintain synchronization and to maintain paths to its neighbors. This contribution outlines a RS-amble transmission technique which assures synchronization and neighbor link scanning with a minimum overhead.

It is generally not possible to use 802.16e amble for these purposes. For example, an RS with a single radio would need to stop its own 802.16e amble transmission in order to monitor transmissions from other stations. Absence of the 802.16e amble signal during these monitoring intervals may cause issues for MS's normal operation.

In IEEE 802.16j meeting number 46 [1], an RS-amble transmission is introduced, which is conceptually similar to 802.16e DL preamble, but which is located at another time in the frame. These RS-amble signals are transmitted by the RSs in a specific location (specific frame and a symbol). This is also submitted for inclusion in the 802.16j meeting number 48 [2].

The RS amble transmission is to be used for two main purposes:

1. To acquire/keep in synchronization for subordinate RSs. This requires transmissions within strict time limits in order to maintain synchronization.
2. To monitor the neighborhood of RSs and BSs using the RS amble transmissions of the neighbors. Such monitoring may be accomplished with somewhat less regularity than that required for synchronization.

The first involves monitoring the RS amble of one's parent as well as transmitting its own RS amble for its subordinate RSs to get synchronization. This should happen in two different frames (e.g. odd and even frames) if only a single radio is available with an RS. In addition, this monitoring and transmissions should be repeated. This is refereed to as Alternative Transmission and Monitoring Scheme (ATMS) in this document.

The neighborhood monitoring requires each RS to monitor all others and since it is difficult to have a co-ordinated monitoring scheme among RSs connected to different BSs this is best done by having a random monitoring and transmission scheme.

In [1], Random Transmission and Monitoring Scheme (RTMS) was introduced. At intervals, each RS within a group of neighbors does not transmit its RS-amble in order to permit it to monitor the others and to measure the signal strengths.

The RS-amble repetition scheme proposed in this contribution is a combination of the ATMS and RTMS schemes to meet the requirements for accurate synchronization and neighborhood monitoring in an efficient way for RS networks with single or multiple hops. .

2. Description of the proposal

It is proposed that both random monitoring RS amble pattern (RTMS) and the pattern previously proposed for synchronization be used in combination avoiding overlapping of the patterns. This combination assures that both synchronization as well as neighborhood monitoring requirements can be met.

A system can be configured to either implement one of them or both of them. Since ATMS can be used for neighborhood monitoring as well and the RTMS can be used for synchronization this would provide a very flexible system to the operator.

There are a number of possible combinations of these two transmission patterns depending on the need and implementation. This contribution proposes a generalized scheme that can accommodate flexibility using a single configuration message.

As shown in the example shown in Figure 2, A and B frames are used by the ATMS scheme mainly for synchronization while C frames are used by the RTMS scheme mainly for neighborhood monitoring.

FN1 A (ATMS)	**FN2 B (ATMS)**	**FN3 C (RTMS)**	**FN4**	**FN5 A (ATMS)**	**FN6 B (ATMS)**	**FN7**	**FN8**	**FN9 A (ATMS)**	**FN10 B (ATMS)**	**FN11 C (RTMS)**	

Figure 2. An example frame implementation of the RS-amble scheme (FN: Frame Number)

RS Ambles used for synchronization: Each alternate hop in a multi-hop network uses A and B frames alternatively so that parent/child synchronization is accomplished, as illustrated in the example shown in Figure 2 and Figure 3. In addition, Group A RSs can monitor group B RSs as well supporting to a certain level the neighborhood scanning process. In figure 3, the RSs branching off from the MR-BS (first tier RSs) can select either A or B for synchronization. This assignment can be done in a random manner so as to increase the probability of monitoring close to 50%. Note that, depending on the number of tiers, the RSs with odd number of hops may not be equal to the number of RSs with even number of hops.

Accordingly, in Figure 3, the RS4 located in the first hop may be randomly selected to listen and synchronize to frame A. Then, RS4 may transmit its RS amble in frame B and their children monitor in frame B for synchronization. These children transmit on A for the synchronization of their children (etc.). Note that in this example, the BS always transmits the RS-amble at both A and B ATMS frames. This may be configured such that BS always transmit RS amble only in one of them, so that the RSs do not have to randomly select a frame to monitor. This would however, reduce the neighborhood monitoring capability of the ATMS scheme.

In this scheme, the parameter, N ($N \geq 2$) indicates how often the ATMS frames are repeated (In the example in Figure 2, N = 4. In this case 4 frames make a Synchronization Multiframe).

RS ambles used for neighborhood monitoring: The C frames are used by the RTMS scheme to randomly monitor neighbors as discussed before and present at every Lth frame where L is an integer multiple of N. In this scheme, in every M RTMS frames, each RS monitors once by randomly drawing a number from 1 to M. In all other M-1 frames it transmits the RS-amble.

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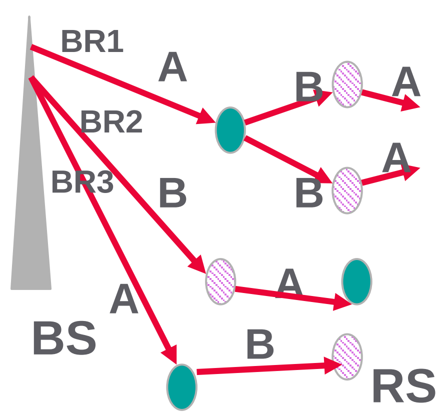


Figure 3. Alternate Frame Monitoring Transmission Scheme (AMTS)

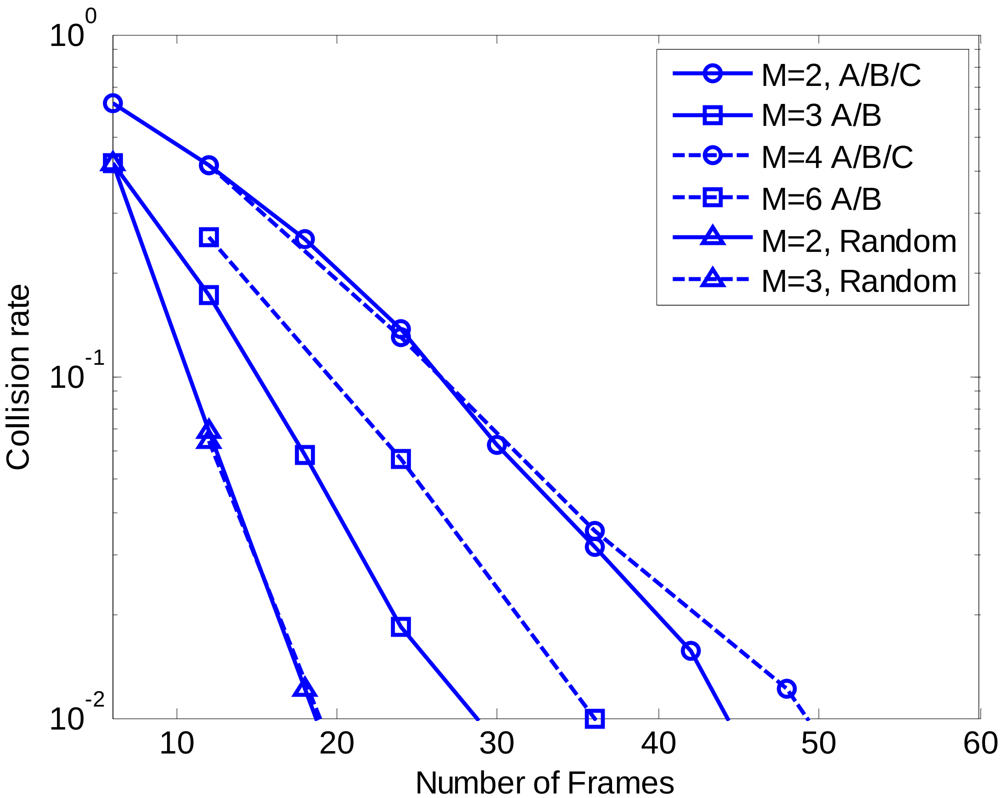
- Note that, in the case where N=2, the ATMS frame used to transmit the RS-amble is also used for monitoring, i.e. there is no separate C frames, the RTMS uses one of A or B which is the transmission cycle for a given RS. Thus, if an RS used A frames for transmitting RS-amble and B frames for monitoring, that RS would additionally monitor in one of the A frames out of M such frames randomly as defined by the RTMS scheme. This means, however, the synchronization is not done in every Nth frame and it can happen at the 3N intervals in the worse case.

- L, M and N are configurable and are broadcast by a MR-BS to its RSs.

3. Some design considerations and Performance:

Figure 5 shows the monitoring performance of several schemes for comparison. Basically, the results indicate that the following parameter ranges provide acceptable level of monitoring capability. The A/B/C schemes refers to N=3, L=3 case (a combined scheme with different M values) and that the A/B schemes are for N=2 and L =1 case (a combined scheme in which random monitoring is done on A or B - for different M values) and "Random" cases are when only RTMS scheme is used with L = 2 (and for different M values).

The results show that, for all the cases, a complete monitoring of all the neighbors can be achieved within 200 msec (with a collision probability of 0.001) which is more than sufficient for neighborhood scanning.
The overall overhead, synchronization time and the neighborhood monitoring capability is compared below for several schemes.



Overhead of RS Ambles and Synchronization Time for different schemes:

A metric for the overhead of an RS-amble scheme can be calculated as the average percentage of symbols per frame that are needed to be able to synchronize 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. Therefore, in designing an RS-amble scheme, the number of symbols used for RS-amble transmissions should be minimized (to minimize the overhead).

Each RS-amble requires at least 1 TTG, 1 RTG and 1 symbol. Each 802.16e frame has [48] symbols. Thus, if the RS-amble is transmitted in each frame there is a cost of about 6% overhead. In the case, when the RS amble is in the end of downlink subframe only one extra TTG/RTG gap is necessary and therefore, the overhead is only 4%. In the following evaluations w assume the overhead is 6% per frame.

In the multi-hop example shown in Figure 3, there are 2 synchronization (ATMS) RS-ambles in every 4 frames plus one monitoring (RTMS) RS-amble at every 8^{th} frame. This is about 3.125% overhead.
These are several implementation examples with there respective overhead (Every letter corresponds to a frame.
"+" is to indicate that is not used for RS amble and can be fully used for traffic.

<u>N=4, L=4</u>
ABC+ABC+ABC+ABC+ABC+ABC+_
Minimum Synchronization Time: 4 frames
Overhead: ¾ * 6%

<u>N=4, L=8</u>
ABC+AB++ABC+AB++ABC+ABC++_
Minimum Synchronization Time: 4 frames
Overhead: 5/8 * 6%

<u>N=8, L=8</u>
ABC+++++ABC+++++ABC+++++ABC
Minimum Synchronization Time: 4 frames
Overhead: 3/8 * 6%

In designing the RS-amble scheme, in many cases the limiting condition is the synchronization interval. Thus, the designer may first define the synchronization (ATMS) frames to satisfy the minimum synchronization monitoring interval. Then, the random monitoring frame repetition scheme can be defined (within the RTMS frames) taking into consideration that the ATMS frames can also used to scan 50% of neighbors in average.

Therefore, in order to monitor the other 50% of users, the random monitoring scheme is employed. In order to reduce the overhead as much as possible, it is best not to insert an RS-amble in every synch multiframe. Instead an RS-amble is included only in every Lth frame, where L is an integer multiple of N.

For a minimum requirement for the synchronization time of Tsync, then, N should be selected so as to satisfy the condition that Tsync > N * frame_time. For example, if Tsync = 40 msec, frame_time = 5 msec, N = 8 can be used. Then, depending on the neighborhood monitoring requirements, the parameters of the RTMS scheme, L and M can be defined.

4. Proposed text change

4.1 RS Amble Repetition Scheme Operation

{The following text proposal is 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}

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

8.4.6.1.1.3 RS Amble Repetition Scheme

The RS amble transmission is used for two purposes:

1. To acquire/keep in synchronization for subordinate RSs. This requires transmissions within strict time limits in order to maintain synchronization.
2. To monitor the neighborhood of RSs and BSs using the RS amble transmissions of the neighbors and interference measurements.

For synchronization, an RS shall monitor its parent RS's amble shall tranmit its own RS amble for its subordinate RSs to get synchronization. These two RS amble transmission and monitoring should happen in two different frames when only a single radio is available with an RS. In addition, this monitoring and transmissions should be repeated in order to keep in sync. Since RS is an infrastructure sation, the operation of which will effect all the users connected through that relay, the synchronization of an RS may be more improant than a normal mobile terminal.

These two objectives shall be accomplished with two repetition schemes indicated below. The MR-BS system can be configured to implement either of them or both of them.

Once acquired synchronization during the initial entry using the 16e preamble, an RS shill keep in sync by monitoring an RS amble.transmited by its parent station (RS or MR-BS) within regular intervals.

Therefore, the system has to use a minimum of 2 frames within this repeating interval, exclusively for synchronization, i.e. this time limit ≥ 2 frame_times. Therefore, the synchronization enforces to use 2 frames within N frames which is called a sync multiframe. These multiframes are synchronized across the network. The synchronization shall be done using the frame number. The first frame of a multiframe satisfies the equality, 1 = Frame_Number * N. The first two frames of the multiframe are used for synchronization, an RS monitor its parent's RS amble in one frame and transmitting in the other frame for its child to synchronize with it according to the following rules. See figure 2 below for the example with N = 4.

(1) MR-BS transmit may transmit the RS amble in either first (A), second (B) or both first and second frames.
(2) In the case where MR-BS sends the amble in both frames, the RS will choose one of them randomly.
(3) Each RS connected to MR-BS monitors the RS amble transmitted by the MR-BS and transmits the RS amble in the other frame so that its child can monitor its RS amble. For example, if the first tier RS uses frame A for listening to the MR-BS, this RS transmits its RS-amble in frame B. Then its children listen to it in frame B and transmit their own ambles in frame A. This is alternated as in Figure 5 when more hops are added to the system.

In the above scheme, the group of RSs listening in the same frame, cannot listen to each other. In order to monitor those RSs, for the case where N > 2, the third frame (C) of the multiframe may be used for a random transmission and monitoring scheme (RTMS). An RS amble may be transmitted in every Lth frame, where L is an integer multiple of N. In Figure 4, L = 8. M such RS ambles (or L* N frames form a RTMS transmission/ monitoring block. Out of M RTMS ambles in this block, each RS randomly select one to stop transmission and instead monitor others. The MR-BS also follows the same transmission /monitoring scheme on the 3rd frame of a multiframe.

FN1 A (ATMS)	FN2 B (ATMS)	FN3 C (RTMS)	FN4	FN5 A (ATMS)	FN6 B (ATMS)	FN7	FN8	FN9 A (ATMS)	FN10 B (ATMS)	FN11 C (RTMS)	

Figure 4. An example implementation of the combined synchronization and monitoring scheme, N = 4, L = 8 (FN = Frame Number)

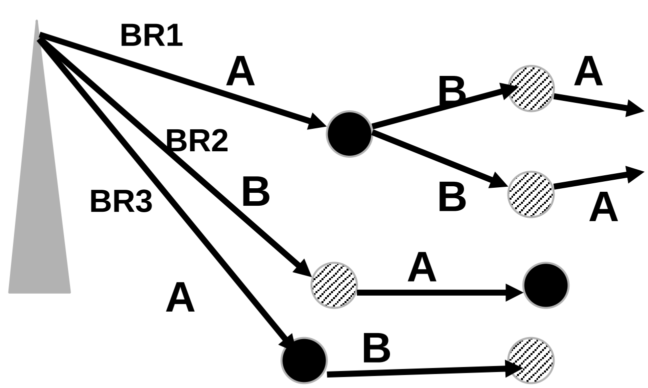


Figure 5. An Example implementation of the Alternate Frame Transmission Monitoring Scheme (ATMS)

In the case where N=2, the ATMS frame used to transmit the RS amble is also used for monitoring and an RS uses its ATMS amble transmission frame (either A or B) for the RTMS scheme. Thus, if an RS used A frames for transmitting the RS amble and B frames for monitoring, that RS would additionally monitor in one of the A frames out of M such frames randomly
L, M and N are configurable and shall be broadcast by a MR-BS.
The following example configurations are provided for further clarification.

"+" is to indicate that a particular frame is not used for RS amble and can be fully used for traffic.

N=4, L=4
ABC+ABC+ABC+ABC+ABC+ABC+_
Minimum Synchronization Time: 4 frames

N=4, L=8
ABC+AB++ABC+AB++ABC+ABC++_
Minimum Synchronization Time: 4 frames
N=8, L=8
ABC+++++ABC+++++ABC+++++ABC
Minimum Synchronization Time: 4 frames
If the MR-BS uses optional common sync then RS shall not transmit RS amble in that frame. In that case, the selection of the configuration paramters should be done not to have such overlapping, for example, by making N an integer multiple of 4.

4.2. RS-Amble operation parameter broadcast message

[Add new section 6.3.2.3.63 in page 172. Note that the same message is also proposed in C802.16-07-243r2]
6.3.2.3.Y MR-BS configuration description message

This message is transmitted by a MMR-BS for the purpose of RS configuration. A MMR-BS can use this message to set operation parameters for a RS. MMR-BS can transmit this message as a response. This message can also be sent to activate or deactivate a particular RS amble/transmission monitoring process over a certain period. The deactivation or activation of the functionalities of individual RSs can be done using the unicast message in Section 6.3.2.3.X. In the case of conflict, broadcast message pareamters supersede the unicast message parametes except for the case of the parameter M which is decided only by the unicast message..

Syntax	Size	Notes
RS_CD_format {		
Management message type = 68	8 bits	
Configured_para_type	8 bits	b0b1 = 11: R-amble for synch is present; Measurement done using Sync RS ambles sent to the MR-BS

		b0b1 = 10: R-amble for synch is present; No measurements using Sync RS ambles sent to the MR-BS b0b1 = 0x: R-amble for Sync is not present b2 = 1: R-amble for random monitoring is present; if b2 = 0 any current monitoring is to be stopped. b3 – b7: reserved
If (b0 of Configured_para_type = 1) {		
R-amble_Synch_Frame Repetition	8 bits	R-amble repitition for synchronization in number of frames
}		
If (b2 of Configured_para_type = 1) {		
R-amble_Monitoring Frame Repitition	8 bits	R-amble repetition rate for random monitoring scheme in number of frames
R-amble Random Monitoring Cycle_	4 bits	R-amble period for monitoring in number of frames
Monitor_Allocation_Start_Time	8 bits	The time to start monitoring cycle in number of frames starting from the current frame
Monitor_Allocation_Duration	8 bits	The number of monitoring cycles to be used. Monitor_Allocation_Start_Time If b0, b1, b2, …., b7 = 0, monitoring is to be continued until further notice.
}		

Configuration_para_type
The first bit is used as R-amble indicator to indicate the preamble_index field appearance in this message. The second bit is used for indicating the presence or absence of R-amble configuration parameters.
R-amble_Synch_Cycle
This field is used to indicate the synchronization R-amble period if present.
R-amble_Monitor_Cycle
This field is used to indicate the monitoring R-amble period if present.

4.3. RS-Amble operation context unicast message

6.3.2.3.X MMR-BS configuration response message

This message is transmitted by a MMR-BS for the purpose of RS configuration. A MMR-BS can use this message to set individual operation parameters for a RS. MMR-BS can transmit this message as a response to RS_Config-REQ or as a unsolicited message. This can be sent either during initialnetwork entry or during normal operation.

Syntax	Size	Notes
RS_Config-RSP format {		
Management message type = 68	8 bits	
Configured_para_type	8 bits	b0 = 1: preamble configuration is included; b1b2 = 11: R-amble for synch is present; Measurement done using Sync RS ambles sent to the MR-BS b1b2 = 10: R-amble for synch is present; No measurements using Sync RS ambles sent to the MR-BS b1b2 = 0x: R-amble for Sync is not present b3 = 1: R-amble for random monitoring is present; if b3 = 0 any current monitoring is to be stopped. b4 – b7: reserved
If (b0 of Configured_para_type == 1) {	8 bits	
Preamble_index }	7 bits	Preamble index
}		
If (b1 of Configured_para_type = 1) {		
R-amble_Synch_Frame Repetition	8 bits	R-amble repitition for synchronization in number of frames
}		
If (b3 of Configured_para_type = 1) {		
R-amble_Monitoring Frame Repetition	8 bits	
R-amble Random Monitoring Block Size	4 bits	
Monitor_Allocation_Start_Time	8 bits	The time to start monitoring cycle in number of frames starting from the current frame
Monitor_Allocation_Duration	8 bits	The number of monitoring cycles to be used. Monitor_Allocation_Start_Time

		If b0, b1, b2, …., b7 = 0, monitoring is to be continued until further notice.
}		

Configuration_para_type

The first bit is used as preamble index indicator to indicate the preamble_index field appearance in this message

Preamble_index

This field is used to indicate the preamble index assigned by MMRBS

R-amble_Monitoring Frame Repitition

R-amble repetition rate for random monitoring scheme in number of frames

R-amble Random Monitoring Block Size

This defines the number of frames in an R-amble monitoring block.

The number of frames in an R-amble monitoring block = R-amble_Monitoring Frame Repetition * R-amble Random Monitoring Block Size

Monitor_Allocation_Start_Time

The time to start monitoring cycle in number of frames starting from the current frame

Monitor_Allocation_Duration

The time to stop monitoring cycle in number of monitoring cycles starting from Monitor_Allocation_Start_Time

+++++++++++++++ *end text* ++