Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Neighbor Path Metric in Neighbor Information**
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Re:	IEEE 802.16j technical contribution in response to call IEEE 802.16j-07/019.
Abstract	This contribution proposes a method to deliver to RSs the path metric between its neighbor RSs and the MR-BS.
Purpose	Discussion and adoption of the proposed text changes in IEEE 802.16j.
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Neighbor Path Metric in Neighbor Information

Problem Statement

The path selected by the RS to reach the MR-BS might have been the best available at the time of network entry. However, due to constantly changing physical link characteristics and network traffic load, the current path to the MR-BS might no longer be the best. It is possible that a path through a different access station might prove to be a better choice. Therefore, it is essential that each RS be continuously aware of its neighbors and path options to the MR-BS through them.

This proposal enables a RS in a MR cell to determine the end-to-end (ETE) path cost of reaching the MR-BS through its neighbors.

Consider the exemplary MR network shown in Figure 1. BS is a MR-BS. RS1, RS2 and RS3 are relay stations that have entered the MR cell directly through BS. C_{b1} is the path cost of the path between BS and RS1. C_{b2} is the cost of the path between BS and RS2. C_{b3} is the cost of the path between BS and RS3.

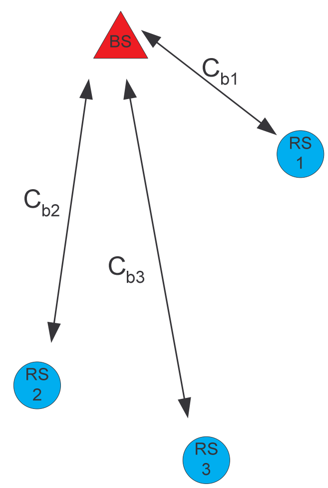

Figure 1 - Exemplary IEEE 802.16j network with relay stations

In the example shown in Figure 1, if RS3 wants to reach the BS through any other RS, it needs to learn of the presence of RS1 and RS2. Further, it needs to determine the ETE path metric to BS through RS1 and RS2. For this purpose RS3 must measure the quality of the air interface link between itself and the other two relay stations. Further, RS3 must also determine the existing path metric from the BS to RS2 and RS1, i.e. the path metric values Cb2 and Cb1.

RS3 can detect the presence of neighboring RSs and may perform the 1-hop air interface measurements to RS1 and RS2 using postamble or other signature sequence transmissions being proposed by other contributions. This is out of the scope of this contribution. However, in order to decide whether the path to the BS through RS1 is better or worse than the path through RS2; or to decide if either path options through RS1 or RS2 is better than its current direct path, RS3 must learn the current path metrics Cb1 and Cb2. This contribution proposes a method to enable RS3 learn these path metric values.

Proposed Solution

The current IEEE 802.16j working document (802.16j-06/026r3) has already adopted a message MR_NBR-INFO, which permits the MR-BS to inform each RS of the other neighbors in its neighborhood. This message also includes the preamble index being transmitted by these neighbors. In the context of the example shown in Figure 1, BS sends a MR_NBR-INFO message to RS3 including RS1 and RS2 as neighbors.

The MR_NBR-INFO message has the option of carrying TLV encoded values as shown in section 11.XX.

It is proposed that the path cost from the neighbor to the MR-BS be included as a TLV parameter.

It is also proposed that the metric used to denote the path cost also be specified as the metric identifier.

This enables RS3 to learn of Cb1 and Cb2 via the MR_NBR-INFO message sent by BS.

Discussion on the Proposed Solution

This contribution proposes that, for the purpose of facilitating relay path selection the MR-BS inform an RS of the path metric from its neighboring RSs to the MR-BS. Whenever the RS must undergo a path change this end-to-end view of the path through its neighbors will result in an improved path selection process.

The intent of this document is to inculcate discussion on the concepts proposed in 07/209r3. The topology shown in Figure 2 will be used for this discussion. The topology comprises one MR-BS and six RSs. Each RS is assumed to have completed RS network entry and is serving its own micro-cell (not shown). The existing paths are as shown with bidirectional arrows.

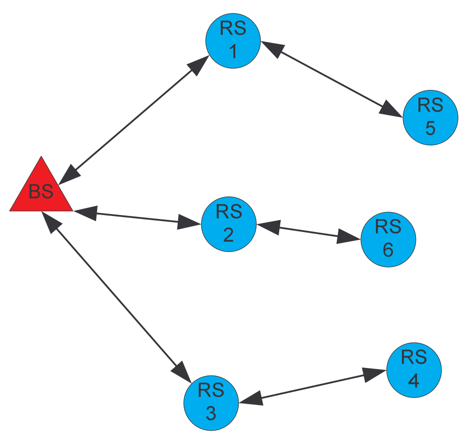

Figure 2 - Example Topology

We will discuss the path re-selection or path change process for RS6.

<u>**One way of performing path selection for RS6 is as follows.**</u>

Step 1- RS6 measures preambles from all of its neighbors. This is shown in Figure 3. In this example RS6 measures all its neighbors (RS1, RS5, RS3, RS4)

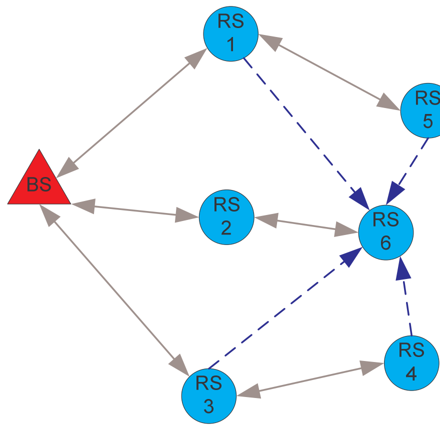

Figure 3 - RS6 measures neighbor preambles

Step 2- RS2 reports the measurements to the BS. In this example, this report contains 4 records. This can be done by employing the RS Neighbor Station measurement report message (6.3.2.3.68 in the 802.16j baseline).

Step 3- The BS uses the measurements reported by RS6 to decide the new attachment point for RS6.

Step 4- The BS instructs RS6 to attach to the new attachment point and proceed with path updating procedure.

Another method of performing path selection using path metrics is described below.

Figure 4 shows the example network with path metrics. The path metric from RS1 to the BS is 100. The path metric from RS5 to the BS is 500. Similarly, the path metric from RS2, RS3, RS4 and RS6 is 200, 150, 500 and 400 respectively.

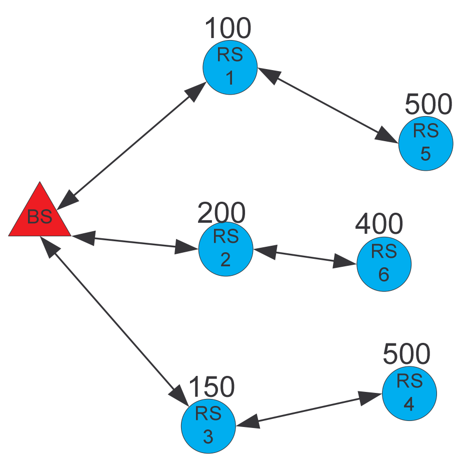

Figure 4 - Example network with path metrics denoted

Step 1- The BS informs RS6 of the path metrics of its neighbors RS1, RS2, RS3, RS5 and RS6. This can be done by way of proposed text in 07/209r3 which adds to the MR-NBR-INFO message (6.3.2.3.63in the 802.16j baseline).

Step 2- RS6 has the option of using the metric information and scanning for RS1 and RS3 preambles only, because RS5 and RS4 already have worse path metrics. RS6 can not expect better performance that it already experiences if it selects RS4 or RS5. This is shown in Figure 5.

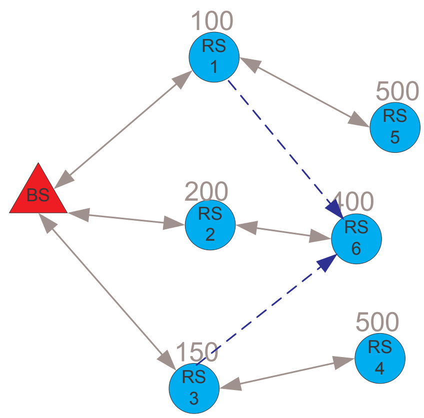

Figure 5 - RS6 measures RS1 and RS3 only

Step 3- RS2 reports the measurements to the BS. In this example, this report contains 2 records. This is 50% savings over the previous method. This can be done by employing the RS Neighbor Station measurement report message (6.3.2.3.68 in the 802.16j baseline).

Step 4- The BS uses the measurements reported by RS6 to decide the new attachment point for RS6.

Step 5- The BS instructs RS6 to attach to the new attachment point and proceed with path updating procedure.

Frequently Asked Questions

What are path metrics?

Path metrics can be operator/vendor defined. For simplicity, a simple “hop-count” path metric can be specified in the 802.16j TG. Contribution 07/209r3 provides a framework for the definition of multiple operator/vendor specific metric. It also specifies “hop-count” as one example metric for standardization. Additionally it permits identification of the metric type in use by using the IEEE Organizationally Unique Identifier.

What could be some examples of path metrics?

A vendor or operator may be interested in using higher-layer performance metrics to represent path metrics. For example, load or congestion could be used.

Why is path re-selection needed?

Path re-selection may be need because of a change in network characteristic or performance. In the above example shown in Figure 4, if the load or congestion in RS2’s micro-cell increases, RS6 might have to perform path selection.

Whether path selection is needed or not is something that vendors/operators can control using threshold values.

What exactly does a RS need to know in order to employ the methods of 209r3?

An RS needs to know the end-to-end path metrics from one or more of its neighbor to the MR-BS. The metric could mean anything in a real network. The meaning of the metric should be indicated to the RS by means of the “metric type” field, which is also sent in the MR_NBR-INFO message.

Who informs the RS of the path metrics of its neighbors?

The MR-BS informs the RS of the path metric of its neighbors.

What is the advantage of using 07/209r3?

In centralized path selection approach this allows for sending smaller measurement reports back to the base station.

Additionally, it permits distributed implementations, where no measurement reports need to be sent to the MR-BS at all. This capability is not being specified in the standard. This is an implementation issue, but 07/209r3 permits it.

Who decides what should be the new attachment point for a RS performing path selection?

In the centralized path selection approach the MR-BS decides the new attachment point. The example in this document clearly shows the centralized approach where the MR-BS decides.

Optionally, in a distributed approach, an RS can also decide the new attachment point.

What if I want the MR-BS to be the decision authority even in the distributed approach? Is it possible? How?

Yes. It is possible to keep the MR-BS as the central deciding authority. In the example shown in Figure 4, assume that for some reason the MR-BS does not want RS6 to even consider attaching at RS1. The MR-BS can achieve this by informing RS6 that the path metric of RS1 is >500. This is possible because the MR-NBR-INFO message that is used to convey the metric to RS6 is a unicast message.

Then RS6 will not attempt attaching to RS6.

What about overhead? How is overhead lower?

In the centralized path selection approach - If an RS that must switch its path is made aware of the path metric of its neighbors, it can report back a subset of measurements to the BS. It needs to only measure and report on those neighbors that can provide equal or better performance that what the RS experiences already.

In the distributed path selection approach - If an RS that must switch its path is made aware of the path metric of its neighbors, it need not report measurements to anybody. It simply makes its one-hop measurements and combines them with the path metrics of the neighbors to get the true end-to-end view of its path options.

Does the overhead grow with the number of links in the MR network?

No. The overhead here is the BS informing the RS of the path metrics of its neighbors. Even if the BS informs an RS of the path metrics of ALL its neighbors, the overhead is dependent on number of complete paths, and not the number of links in the MR network. This overhead can be further reduced. (See the following answer.)

What about the overhead of informing the RS of the path metric of each of its neighbors?

The periodicity of reporting metrics depends on the metric itself. If the metric is hop count, the MR-BS need not inform an RS of the path metrics of it neighbors frequently. If the metric is load or congestion, there is a good possibility that this changes slowly and therefore will not require frequent updates.

Further optimizations are possible. For example in Figure 4, if the path metric of RS4 or RS5 becomes worse that 500, the BS need not inform RS6. If the metric becomes better that 500 and approaches 400, the BS still need not inform RS6 because RS6 already has as good a path. There can be implementation specific thresholds set for this purpose. For example, the MR-BS may use a simple rule "inform an RS of neighbors only if their metric is X better than its own metric". These are all implementation specific optimizations that are discussed here as examples. 07/209r3 does not require them.

Doesn't using 209r3 make the MR network an ad hoc network?

No. The methods in 209r3 can be used in any multihop network. The network still remains a very structured tree, rooted at the MR-BS. As discussed in the previous answers, the MR-BS remains in control of all the centralized procedures in the network.

Proposed Text

Insert the following text at the end of subclause 6.3.2.3.63

The following TLV parameter may be included.

ETE Metric

This value represents the cost of the path between the neighbor RS and the MR-BS. This value is interpreted as shown in section 11.24.

Insert new subclause 6.3.25.YY

6.3.25.YY Neighbor Path Metric for Relay

The MR-BS may report an ETE metric of the path between the MR-BS and a neighbor RS in the MR_NBR-INFO message. The ETE metric is carried in the form of a TLV described in section 11.24.

Insert new rows to table in subclause 11.24:

11. 24 MR_NBR-INFO Management Message Encoding

Name	Type (1 byte)	Length (bytes)	Value
ETE Metric	7	1	Bit #0-2: Hop Count Bit #3-7: Reserved