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Title	**Additional Scan Measurement Metric, Triggers and Reporting Modes**	
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Re:	IEEE P802.16e/D7	
Abstract	This contributions discusses methods for improving interoperability for SS handoff measurement by allowing the serving base station to specify the metrics that should be used for scanning, enabling event-based scan reports from the mobile and creation of two prioritized levels of handoffs.	
Purpose	Discuss and approve.	
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Introduction

In the deployment of cellular systems, configurations can exist where mobile stations require transition from one class, or tier, of cells to another. Examples of such transitions are from micro- to macro-cells, from hot-spot coverage cells to a cell with ubiquitous coverage, or across seams in a system where the effective number of carriers are reduced. For each of these scenarios, a system engineer typically will configure a handoff behavior or contour to achieve desired performance in capacity, coverage, and transition reliability. Currently within this standard, the only way to engineer a specific handoff behavior, or contour, is through use of feedback measurements from the mobile station (which may be sent too frequently in the absence of triggers). These measurements consume precious reverse link capacity, and can significantly reduce capacity of transition sectors or cells. Feedback measurements can also reduce the capacity of non-transition cells when the handoff region requires control to ensure adequate reliability and performance. Other technologies such as UMTS or IS2000 use handoff trigger events defined by the system to provide this functionality, without reduction in reverse link overhead and capacity. Additionally, prioritized neighbor sector lists, or sets, have been used to allow system engineers to focus scarce mobile scanning resources to the most desired or highly probable candidate sites for handoff.

The major goals of this contribution are:

1. To enable the mobile to use a broader set of metrics when scanning neighbor base stations (besides CINR and RSSI). To allow the serving base station to specify the metrics that should be used by the mobile for scanning.
2. To enable event-based scan reports from the mobile. In other words, to allow the base station to specify the trigger conditions used to issue a scan report.
3. To create two prioritized levels of handoff neighbors, by adding a Supplemental list while modifying the meaning of the current Recommended list. Both of these lists are subsets of the advertised neighbor list, and have an explicit scanning priority set between them.

Scanning Trigger Mechanism Description:

Definition of Terms:

Recommended BS list: BSs that are received by the MS with sufficient strength to indicate that the associated downlink channels could be successfully demodulated.

Supplemental BS list: BSs that are not in the Recommended set but still are potential candidates for handoff.

Serving Absolute Trigger: Defined when the serving BS *metric* remains below a specified absolute threshold for a specified duration.

Neighbor Absolute Trigger: Defined when a neighbor BS *metric* remains above an absolute threshold for a specified duration.

Neighbor Relative Trigger: Defined when a neighbor BS *metric* remains above the serving BS *metric* by a specified relative threshold amount and for a specified duration.

Metric: Typically refers to either RSSI or CINR, but can also include Round Trip Delay (RTD).

Trigger Procedure:

The MS sends a single MOB_SCAN-REPORT message when one of the defined triggers is satisfied. To meet the trigger criteria, the value of the specified metric, averaged over the specified measurement duration, must agree with the specified trigger action (i.e,. averaged value is above or below the specified threshold). Time qualification for a trigger allows the system engineer to define the desired level of confidence in a threshold crossing versus the fading profile. Once a trigger criteria is met and the MOB_SCAN-REPORT message is sent, the mobile will not issue another report for that BS-trigger pairing until another MOB_SCN-RSP is received from the base station. This allows the infrastructure to determine the best action in response to the report, options of which could be handoff, change of the Recommended and/or Supplemental BS set, or

alteration of the scanning rate and reporting conditions. Sending only one response also minimizes the impact to the reverse link capacity.

While complex mechanisms could be derived for defining the scanning rate and priorities for neighbor sets, a simple two-tier approach is suggested. In this mechanism, the Recommended list represents the desired higher priority list, while the Supplemental list indicates sites with a lower priority. Assuming a scanning process that sequentially considers the items within the lists, each Recommended list BS will be measured in between each successive measured Supplemental list BS. To illustrate this concept, assume cells R1,R2, and R3 are in the Recommended list, and S1,S2, andS3 are in the Supplemental list. The following would depict the scanning action at the mobile station:

R1R2R3 S1 R1R2R3 S2 R1R2R3 S3 R1R2R3 S1……..

An algorithm such as this guarantees priority of the sites within the Recommended list as well as opportunities to visit all of the lower priority BSs in the Supplemental list.

The earlier stated goals are addressed by the proposed text changes as follows:
BS Side:

1. In MOB_SCN-RSP message, new fields are included to specify the list of metrics that should be used. The same fields are introduced in MOB_SCAN-REPORT to indicate which metrics are included in the report.
2. In MOB_SCN-RSP message, new fields are introduced for the BS to specify the trigger conditions that should be used. For each trigger, a mode is specified, indicating how the trigger should be used, followed by appropriate fields specifying the trigger values. The response is only sent after a trigger condition is set.
3. The interpretation of the Recommended BS list that currently exists in MOB_SCN-RSP message is modified, so that the MS is explicitly required to scan the BSs identified in this list. Also a separate "Supplemental BS list" is introduced in the same message, which specifies a lower-priority level of neighbor BS scanned by the MS at a lower, interleaved rate.

MS side:

1. In MOB_SCAN-REPORT, the serving cell metrics are also included so that the information is readily available at the time of processing the message and determining an appropriate action.

Proposed text changes:

[Change the text in section 6.3.21.1.2 as indicated]
A BS may allocate time intervals to MS for the purpose of MS seeking and monitoring available BS suitability as targets for HO. The time during which the MS scans for available BS will be referred to as a Scanning Interval.

An MS may request an allocation of a Scanning Interval using the MOB_SCN-REQ MAC Management message. The MS indicates in this message the estimated duration of time it requires for the scan.

The MS or BS may request group of Scanning Intervals with Interleaving intervals of Normal Operation be allocated through a single exchange of MOB_SCN-REQ/RSP management messages for the purpose of reducing the number of MOB_SCN-REQ and MOB_SCN-RSP messages required to create multiple scanning opportunities when frequent scanning is required. Scanning Interval and Interleaving interval repeat with the number of Scan iteration.

When sending a MOB_SCN-RSP message, the serving BS indicates in the Metric ID bitmap what metrics the MS should measure when scanning neighbor BSs and report when sending a triggered response.

In the MOB_SCN-REQ MAC management message the MS, and in the MOB_SCN-RSP MAC management message the BS shall indicate either Scanning, Scan type = 0, or Association, Scan type = 1, as the intended MS activity during the Scanning Interval. ~~If Scan type = 1, Association, then t~~The MS and BS may include, in their respective messages, one or more Recommended BS IDs (forming the Recommended BS list). When the BS includes a Recommended BS list, the MS is required to scan the neighbor BSs included the list, to measure the specified metrics and include them in the next response (such as the MOB_SCAN-REPORT message).

The serving BS may include a separate list of BSs, called the Supplemental BS list, in the MOB_SCN-RSP message. The MS shall measure the specified metrics of BSs in the Supplemental BS list with a priority no greater than those BSs included in the Recommended BS list.. The MS shall measure the specified metrics of BSs in the Supplemental list according to the supplied parameter of Multiplicity for Recommended BS scanning, which is the ratio of the number of scans performed by the MS for the Recommended BS list to the number performed for the Supplemental BS list. The MS shall include in its response message (such as the MOB_SCAN-REPORT) measurements for BSs in the Supplemental list according to the reporting parameters supplied by the BS.

In addition to the scanning mandated by the Recommended BS list, and the optional Supplemental BS list, the MS may determine and perform any additional scanning or ranging or Association activities during Scanning Interval, and as the time in the scanning interval permits, at its own discretion.

The BS may negotiate over the backbone with the Recommended BS ID allocation of non-contention based ranging opportunity, at the appropriate timing interval, for MS to conduct Association ranging with the Recommended BS ID. When conducting initial ranging to Recommended BS ID, MS shall use allocated non-contention based ranging opportunity, if available. ~~Regardless of value of Scan type and the presence of one or more Recommended BS IDs, MS may determine and perform any scanning or ranging or Association activities during Scanning Interval at its own discretion.~~

Upon reception of the MOB_SCN-REQ message, the serving BS shall respond with a MOB_SCN-RSP MAC Management message. The MS may retransmit the MOB_SCN-REQ message if it does not receive the MOB-SCN-RSP message within the T31 timer. The serving BS may also send MOB_SCN-RSP MAC management message unsolicited. The MOB_SCN-RSP MAC Management message shall either grant the requesting MS a Scanning Interval that is at least as long as requested by that MS, or deny the request. A value of zero for Duration in MOB_SCN-RSP shall indicate the request for an allocation of Scanning Interval is denied, and the BS may omit scan parameters (e.g., Start frame, Scan type, Interleaving interval) except Scan Duration in the MOB_SCN-RSP MAC Management message.

Following reception of a MOB_SCN-RSP MAC Management message granting the request, beginning at Start frame an MS shall scan for one or more BS during the time interval allocated in the message. When available BS are identified through scanning, the MS may attempt to synchronize with their downlink transmissions, and estimate the quality of the PHY channel. MS may also perform contention, or non-contention if available, based initial ranging during the Scanning Interval to one or more available BS to more completely evaluate PHY channel characteristics with available BS, obtain Service Level Predictions for MS service flows, and assess for Association.

The serving BS may buffer incoming data addressed to the MS during the Scanning Interval and transmit that data after the Scanning Interval during any Interleaving interval or after exit of the Scanning Mode and resumption of Normal Operation.

An MS may terminate scanning and return to Normal Operation anytime by sending a PDU to the serving BS during any Scanning Interval. If a serving BS receives a PDU during any Scanning Interval from an MS that is supposed to be in Scanning Mode, the BS shall assume that the MS is no longer in Scanning Mode. Any UL message from the MS to the serving BS during a Scanning Interval shall interrupt the Scanning Interval, and shall signal the serving BS that the MS is still active and has not dropped the connection during the Scanning Interval. The group of intervals is terminated at any time if the MS sends MOB_SCN-REQ message or serving BS sends MOB_SCN-RSP message during any Interleaving interval with Scan Duration set to zero.

The BS optionally includes in MOB_SCN-RSP message a list of trigger conditions. When the reporting trigger list is present, the MS should use the triggers in order to determine when to send a response once the conditions described in a trigger are satisfied. This mechanism of triggering the response is supplemental to the mechanism specified by the Report Mode field. For example, if Report Mode = 0b01 (periodic report) and Reporting Triggers are specified in MOB_SCN-RSP, then the MS should send a report when a condition specified by a trigger is met or when the time for a periodic report occurs.

The BS optionally also includes in the MOB_SCN-RSP message a set of actions for the MS to perform upon satisfying the specified trigger. The BS may direct the MS to respond with a MOB_SCAN-REPORT message, to respond with a request to handoff service to the triggering BS, or to autonomously promote/demote the triggering BS between the Recommended and Supplemental BS lists.

[Change table 108i as indicated]

Table 108i—MOB_SCN-RSP message format

Syntax	Size(bits)	Notes
MOB_SCN-RSP_Message_Format() {	—	—
Management Message Type = 55	8	—
Scan duration	8	In frames
If (Scan Duration ==0) {	—	—
HMAC Tuple	(21 bytes)	—
} else {	—	—
Start frame	4	—
Scan_type	1	0: Scanning 1: Association
Reserved	7	Shall be set to zero.
Interleaving interval	8	Duration in frames
Scan iteration	8	—
Report mode	2	0b00: no report 0b01: periodic report 0b10: event triggered report 0b11: reserved
Metric_ID bitmap	8	Bit 0: BS RSSI mean Bit 1: BS CINR mean Bit 2: RTD (Round Trip Delay)

		Bits 3-7: reserved, set to zero
Scan report period	8	Available when the value of Scan Report Mode is set to 0b01. Period value is indicated as frames.
Multiplicity for Recommended BS scanning	3	Number of scans performed across Recommended BS set as compared to Supplemental BS set: 0x0: same amount 0x1: two times as many scans 0x2: four times as many scans 0x3: eight times as many scans 0x4: sixteen times as many scans 0x5: thirty-two times as many scans 0x6-0x7: reserved
reserved	~~2~~3	Shall be set to zero.
N_Reporting_Triggers	4	The number of reporting triggers that are included in this message
For (j=0; j<N_Reporting_Triggers) {		
Reporting Trigger ID	8	0x00: Reserved 0x01: Serving BS RSSI Less Than Absolute Threshold 0x02: Neighbor BS RSSI Greater Than Absolute Threshold 0x03: Neighbor BS RSSI Greater Than Serving BS RSSI by Relative Threshold 0x04: Serving BS CINR Less Than Absolute Threshold 0x05: Neighbor BS CINR Greater Than Absolute Threshold 0x06: Neighbor BS CINR Greater Than Serving BS CINR by Relative Threshold 0x07: Serving BS RTD Greater Than Threshold 0x08-0xff: For future use
Reporting Trigger Value	8	Conditional on value of Reporting Trigger ID as follows 0x01: BS_RSSI_Thresh 0x02: BS_RSSI_Thresh 0x03: BS_RSSI_Relative_Thresh 0x04: BS_CINR_Thresh 0x05: BS_CINR_Thresh 0x06: BS_CINR_Relative_Thresh 0x07: BS_RTD_Thresh 0x08-0xff: reserved, set to zero
Trigger action bitmap	4	Respond upon trigger with the following action(s):

		Bit 0: send scan report Bit 1: send request for handoff (target triggering BS) Bit 2: autonomously promote triggering BS from the Supplemental to the Recommended BS list Bit 3: autonomously demote triggering BS from the Supplemental to the Recommended BS list
}		
Qualify Duration for Serving and Recommended Set	4	0x0: 0 second (Immediate) 0x1: 0.1 second 0x2: 0.2 second 0x3: 0.5 second 0x4: 1.0 second 0x5: 2.0 second 0x6: 5.0 second 0x7: 10.0 second 0x8: 15.0 second 0x9-0xf: Reserved
Qualify Duration for Supplemental Set	4	0x0: 0 second (Immediate) 0x1: 0.1 second 0x2: 0.2 second 0x3: 0.5 second 0x4: 1.0 second 0x5: 2.0 second 0x6: 5.0 second 0x7: 10.0 second 0x8: 15.0 second 0x9-0xf: Reserved
}		
N_Recommended_BS_Scanning	4	—
For (j=0; j<N_Recommended_BS_Scanning; j++) {	—	N_Recommended_BS can be derived from the length field in the MAC header of the message. The MS is required to scan the BSs in the recommended BS list and include a report for these BSs in MOB_SCAN-REPORT.
Recommended BS ID Scanning	48	BS IDs of Available BS for Association
}	—	—
N_Supplemental_BS_Scanning	4	—
For (j=0; j<N_Supplemental_BS_Scanning; j++) {	—	The MS has the option of scanning these BSs if the time available specified by “Scan Duration” allows it.

Supplemental BS ID Scanning	48	
}	—	—
If (Scan type = 1) {	—	—
N_Recommended BS_Association	4	—
For (j=0; j<N_Recommended_BS_Associations; j++) {	—	—
Recommended BS ID Association	48	—
Rendezvous_time	16	—
}	—	—
HMAC Tuple	16	—
}	—	—
}	—	—
Padding bits	*variable*	Bits to round-up to closest byte
}	—	—

[Add the following fields to the description of table 108i]

Metric_ID bitmap

This bitmap specifies which metrics should be measured by the MS during scanning with a value of one indicating metric presence.

N_Supplemental BS Scanning

The number of BSs in the supplemental BS list.

Supplemental BS ID Scanning

BS IDs of those BSs that the serving BS wants to include in the supplemental BS list

BS RSSI Thresh

The BS RSSI Thresh parameter indicates the value of Received Signal Strength against which the MS will compare its measured Received Signal Strength from a particular BS (either serving or neighboring). The value shall be interpreted as an unsigned byte with units of -0.25dB and have 40dBm subtracted from it (such that 0x00 is interpreted as -40dBm and 0xff is interpreted as -103.75dBm), so that a MS shall be able to report values in the range -100dBm to -40dBm. The measurement for comparison shall be performed on the frame preamble and averaged over the duration of the measurement period. For Reporting Trigger ID = 0x01, the comparison will result in a triggered action if the serving BS's averaged RSSI is less than the indicated threshold. For Reporting Trigger ID = 0x02, the comparison will result in a triggered action if any neighbor BS's averaged RSSI is greater than the indicated threshold.

BS CINR Thresh

The BS CINR Thresh parameter indicates the value of CINR against which the MS will compare its measured CINR from a particular BS. The value shall be interpreted as a signed byte with units of 0.5dB. The measurement shall be performed on the frame preamble and averaged over the duration of the measurement period. For Reporting Trigger ID = 0x04, the comparison will result in a triggered action if the serving BS's averaged CINR is less than the indicated threshold. For Reporting Trigger ID = 0x05, the comparison will result in a triggered action if any neighbor BS CINR is greater than the indicated threshold.

BS RTD Thresh

The BS RTD Thresh parameter indicates the RTD Threshold the MS will compare the measured RTD against from a particular BS. The value shall be interpreted as a unsigned byte with units of 1μsecond (10^{-6} second). The measurement shall be performed during scans of the BS and averaged over the duration of the measurement period. If the serving BS's average RTD exceeds the threshold, a triggered action will occur.

BS RSSI Relative Thresh

The BS RSSI Relative Thresh parameter indicates the threshold for relative dB difference in average RSSI from a neighboring BS to the serving BS. The MS will compare the measured relative dB difference in averaged RSSI from a neighboring BS to that of the serving BS against the indicated threshold. The value shall be interpreted as a signed byte with units of 0.25dB. The measurement shall be performed on the frame preamble and averaged over the measurement period. The comparison will result in a triggered action if the measured dB difference is greater than the threshold.

BS CINR Relative Thresh

The BS CINR Relative Thresh parameter indicates the threshold for relative dB difference in average CINR from a neighboring BS to the serving BS. The MS will compare the measured relative dB difference in averaged CINR from a neighboring BS to the serving BS against the threshold. The value shall be interpreted as a signed byte with units of 0.25dB. The measurement shall be performed on the frame preamble and averaged over the measurement period. The comparison will result in a triggered action if the measured dB difference is greater than the threshold.

Qualify Duration for Serving and Reccomended Set
Qualify Duration for Supplemental Set

Time in seconds used to qualify a trigger. The measured quantity for the trigger must be averaged for this period of time. The MS may or may not accomplish multiple measurements during this period according to its scanning capabilities. If, at the end of the period, regardless of whether more measurements have been taken, the trigger condition is satisfied, a triggered action will occur, such as a measurement report that includes at least the information for the neighboring BSs that satisfied the trigger condition.

[Change table 108j as indicated]

Table 108j—MOB_SCAN-REPORT message format

Syntax	Size(bits)	Notes
MOB_SCAN-REPORT_Message_Format() {	—	—
Management Message Type = 60	—	—
Report Mode	1	00 0: Event-triggering 1: reserved
Comp_NBR_BSID_IND	1	—
If (Comp_NBR_BSID_IND == 1){	—	—
Configuration Change Count for MOB_NBR_ADV	8	Configuration Change Count value of referring MOB_NBR_ADV message
}	—	—
Reported Metrics ID bitmap for Serving BS	8	Bit 0: BS RSSI mean Bit 1: BS CINR mean Bit 2: RTD (Round Trip Delay) Bits 3-7: reserved

For (j=0;j<8) {	-	-
If (Reported_Metrics_ID_ServingBS[j]==1) {	-	-
Value	8	The values are reported in the same increasing order (from Bit 0 to Bit7) in which the metrics are specified in the Reported Metrics ID bitmap for serving BS
}	-	-
}	-	-
N_NEIGHBORS	8	—
For (i=0; i<N_NEIGHBORS; i++) {	—	—
If (Comp_NBR_BSID_IND == 1){	—	—
Neighbor BS index	8	—
}	—	—
Else{	—	-
Neighbor BSID	24	The least significant 24 bits of the Neighbor BSID
}	—	—
Reported Metrics ID bitmap for Neighbor BS	8	Bit 0: BS RSSI mean Bit 1: BS CINR mean Bit 2: RTD (Round Trip Delay) Bits 3-7: reserved
For (j=0;j<8) {	-	-
If (Reported_Metrics_ID_NeighborBS[i][j] == 1) {	-	-
Value	8	The values are reported in the same increasing order (from Bit 0 to Bit7) in which the metrics are specified in the Reported Metrics ID bitmap for Neighbor BS
}	-	-
}	-	-
}	—	—
Padding bits	*variable*	
}	—	—