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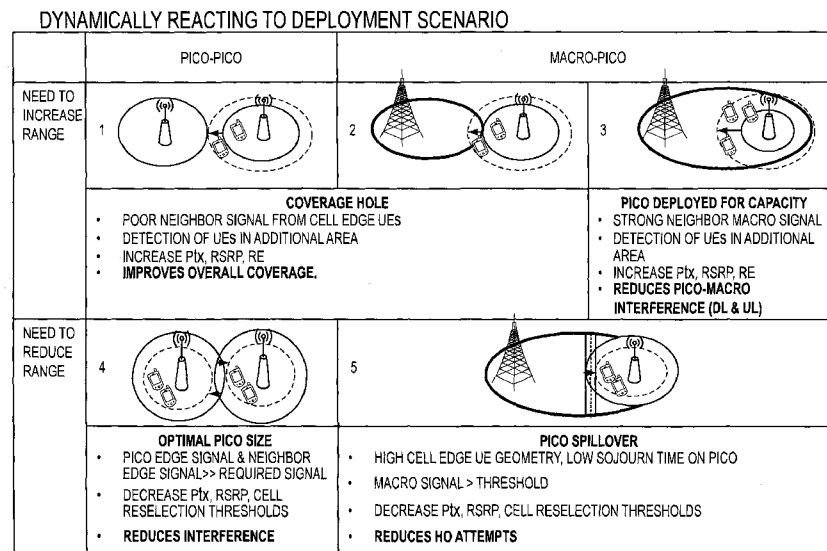
(54) Title: DOWNLINK POWER MANAGEMENT

FIG. 2

(57) **Abstract:** A system and related method for increasing or decreasing the range of a pico cell station. The system and method determine triggers for dynamic range change, measure operational conditions and make a change reactive to operational conditions. Range increase may be implemented to address a coverage hole, Range decrease may be implemented to address holdover attempts. Range changes are implemented by changing transmission power, reference signal received power and/or cell reselection thresholds.

DOWNLINK POWER MANAGEMENT

BACKGROUND OF THE INVENTION

1. Field of the Invention.

[0001] The present invention relates in general to radio communication systems for wireless networks. The present disclosure relates to communication networks including a plurality of pico cells. Specifically, aspects of the present disclosure relate to the management of pico cell communication.

2. Description of the Prior Art.

[0002] Heterogeneous networks combine macro and pico base stations within a wireless communication system. In general, locating several pico base stations within the cell coverage of a macro base station will increase the capacity of the network. However, interference between the macro and pico base stations must be managed. Macro deployments require Radio Frequency site planning and post deployment optimization to transmit power, provide antenna tilts and azimuths and the like. Such operations are difficult to scale as the number of small cells increase. Pico environments can also vary significantly based on Macro-Pico carrier choices, deployment (outdoor, indoor) and user densities. Basic parameters relating to cell size and coverage need to be determined dynamically to make small cell deployments easier and scalable. Accordingly, what is needed is a better way to manage pico environments. The present invention provides for such capability.

SUMMARY OF THE INVENTION

[0003] The present invention is a system and related method for managing transmissions among a plurality of pico cells in a communication environment. The system and method are configured to react dynamically to necessary changes in signal strength deployment based on whether there is a need to increase the range of transmission/reception or decrease the range of transmission/reception. Those situations for which range increase is needed include a coverage hole for adjacent pico cells and for macro and pico cells that are adjacent to one another, and when a macro adjacent to a pico has a strong signal that must be distinguished for local User Devices (UE). Those situations for which range decrease is needed include when there is a

desire for minimal adjacent pico cells to interfere with one another and in a macro-pico interface when the pico cell signal may interfere with the macro cell signal.

[0004] In those situations in which a range increase is desired, the system of the invention is configured to increase one or more of signal transmission power (P_{tx}), Referenced Signal Received Power (RSRP) and Cell reselection thresholds (RE). That either improves overall coverage or reduces macro-pico interference. In those situations in which a range decrease is desired, the system is configured to decrease one or more of P_{tx} , RSRP and RE. Such reduction can reduce interference and Handover (HO) attempts. This is accomplished by defining triggers based on measured conditions associated with any of coverage holes, hot spot interference, pico size optimization, and cell spillover. Based on the defined triggers, an increase or a decrease is initiated. These and other advantages will become apparent upon review of the following information.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. 1 is a representation of a pico cell antenna tower adjacent to a macro cell antenna tower.

[0006] FIG. 2 is a representation and description of scenarios in which pico cell range is increased or decreased.

[0007] FIG. 3 is a flow diagram representing steps of the method for determining pico cell range increase or decrease triggers.

[0008] FIG. 4 is a flow diagram representing steps of the method for implementing pico cell range increase or decrease.

[0009] FIG. 5 is a description of trigger conditions and range modification implementations.

[0010] FIG. 6 is a continuation of FIG. 5 with additional descriptions of trigger conditions and range modification implementations.

[0011] FIG. 7 is a description of range increase and range decrease steps.

[0012] FIG. 8 is a description of the analysis of UL interference over thermal for UEs.

DETAILED DESCRIPTION OF THE INVENTION

[0013] The present invention is a system and related method for managing pico cells in a signal transmission environment. FIGS. 1-7 illustrate and describe pico cell arrangements and conditions for initiating antenna transmission and reception functionality range increase or decrease. The figures provide the detailed description of the invention in which triggers are defined, conditions of operation are measured and an increase or a decrease of one or more of Ptx, RSRP, REs is implemented for operational improvements based on measurements carried out. The drawings further show and describe specific ways of conducting a review and carrying out one or more implementations of dynamically carrying out range changes and reactive actions.

[0014] With reference to FIG. 8, the detection of the UEs for implementation can be described as:

- * Measurement of avg. PUSCH IoT > IoT Thresh in UL silence intervals
 - * Avg. PUSCH IoT > IoT Thresh
 - * Variance and Avg. Peak PUSCH IoT
 - * Details in the next slide.
- * Based on detecting neighbor cell PRACH attempts
 - * $N_{RACH-N} > x$ (per hour)
 - * $P_{RACH_Offset} = (Prx_Preamble - P0_Preamble_N) - (P0_Preamble_N - P0_Preamble_S)$
 - * If $P_{RACH_Offset} > P_{RACH_Offset_Thresh}$

[0015] While illustrative embodiments have been disclosed and discussed, one skilled in the relevant art will appreciate that additional or alternative embodiments may be implemented within the spirit and scope of the present disclosure. Additionally, although many embodiments have been indicated as illustrative, one skilled in the relevant art will appreciate that the illustrative embodiments do not need to be combined or implemented together. As such, some illustrative embodiments do not need to be utilized or implemented in accordance with the scope of variations to the present disclosure.

[0016] Conditional language, such as, among others, "can," "could," "might," or "may," unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include,

certain features, elements or steps. Thus, such conditional language is not generally intended to imply that features, elements or steps are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without user input or prompting, whether these features, elements or steps are included or are to be performed in any particular embodiment. Moreover, unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey utilization of the conjunction "or" in enumerating a list of elements does not limit the selection of only a single element and can include the combination of two or more elements.

[0017] Any process descriptions, elements, or blocks in the flow diagrams described herein and/or depicted in the attached figures should be understood as potentially representing modules, segments, or portions of code which include one or more executable instructions for implementing specific logical functions or steps in the process. Alternate implementations are included within the scope of the embodiments described herein in which elements or functions may be deleted, executed out of order from that shown or discussed, including substantially concurrently or in reverse order, depending on the functionality involved, as would be understood by those skilled in the art. It will further be appreciated that the data and/or components described above may be stored on a computer-readable medium and loaded into memory of the computing device using a drive mechanism associated with a computer-readable medium storing the computer executable components, such as a CD-ROM, DVD-ROM, or network interface. Further, the component and/or data can be included in a single device or distributed in any manner. Accordingly, general purpose computing devices may be configured to implement the processes, algorithms and methodology of the present disclosure with the processing and/or execution of the various data and/or components described above. Alternatively, some or all of the methods described herein may alternatively be embodied in specialized computer hardware. In addition, the components referred to herein may be implemented in hardware, software, firmware or a combination thereof.

[0018] It should be emphasized that many variations and modifications may be made to the above-described embodiments, the elements of which are to be understood as being among other acceptable examples. All such modifications and variations are intended to be included herein within the scope of this disclosure and protected by the following claims.

WHAT IS CLAIMED IS:

1. A system for dynamically changing a range of a pico cell, the system comprising a device configured to determine trigger conditions, measure cell range status, and increase or decrease cell operation based on the measured cell range status, wherein the cell operation increased or decreased is selected from Ptx, RSRP and RE.
2. The system of Claim 1 wherein the system is configured to increase the pico cell range to address a coverage hole.
3. The system of Claim 1 wherein the system is configured to decrease the pico cell range to address pico spillover.
4. A method for dynamically changing a range of a pico cell, the method comprising the steps of:
 - determining trigger conditions;
 - measuring cell range status; and
 - increasing or decreasing cell operation by increasing or decreasing one or more of Ptx, RSRP and RE.

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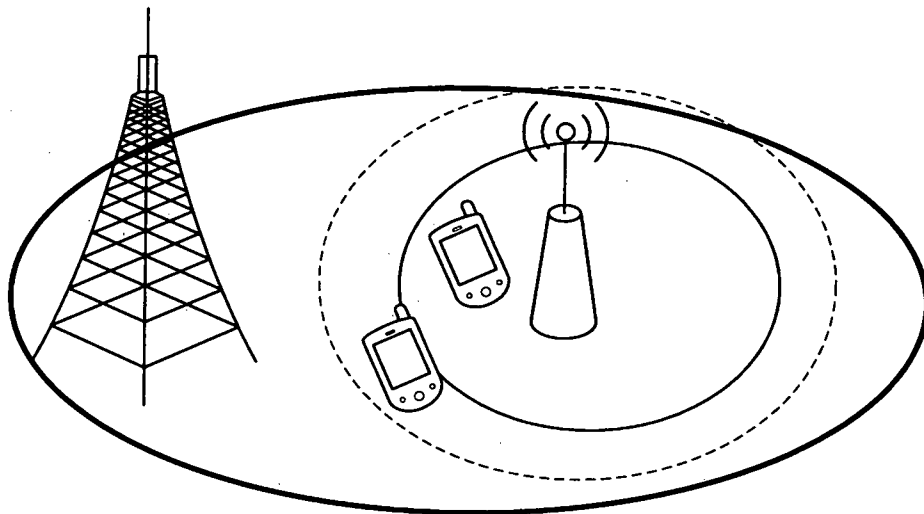


FIG. 1

DYNAMICALLY REACTING TO DEPLOYMENT SCENARIO

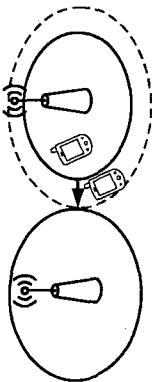
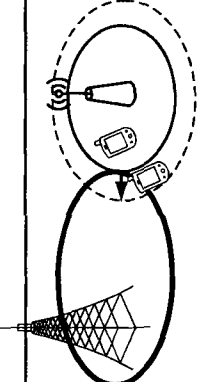
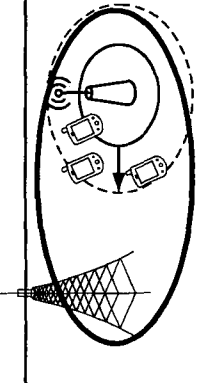
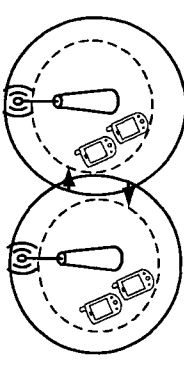
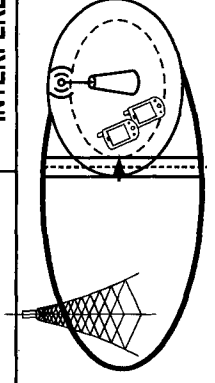
	PICO-PICO	MACRO-PICO	
NEED TO INCREASE RANGE	 1	 2	 3
	COVERAGE HOLE • POOR NEIGHBOR SIGNAL FROM CELL EDGE UES • DETECTION OF UES IN ADDITIONAL AREA • INCREASE Ptx, RSRP, RE • IMPROVES OVERALL COVERAGE.		PICO DEPLOYED FOR CAPACITY • STRONG NEIGHBOR MACRO SIGNAL • DETECTION OF UES IN ADDITIONAL AREA • INCREASE Ptx, RSRP, RE • REDUCES PICO-MACRO INTERFERENCE (DL & UL)
NEED TO REDUCE RANGE	 4	 5	
	OPTIMAL PICO SIZE • PICO EDGE SIGNAL & NEIGHBOR EDGE SIGNAL > REQUIRED SIGNAL • DECREASE Ptx, RSRP, CELL RESELECTION THRESHOLDS • REDUCES INTERFERENCE		PICO SPILLOVER • HIGH CELL EDGE UE GEOMETRY, LOW SOJOURN TIME ON PICO • MACRO SIGNAL > THRESHOLD • DECREASE Ptx, RSRP, CELL RESELECTION THRESHOLDS • REDUCES HO ATTEMPTS

FIG. 2

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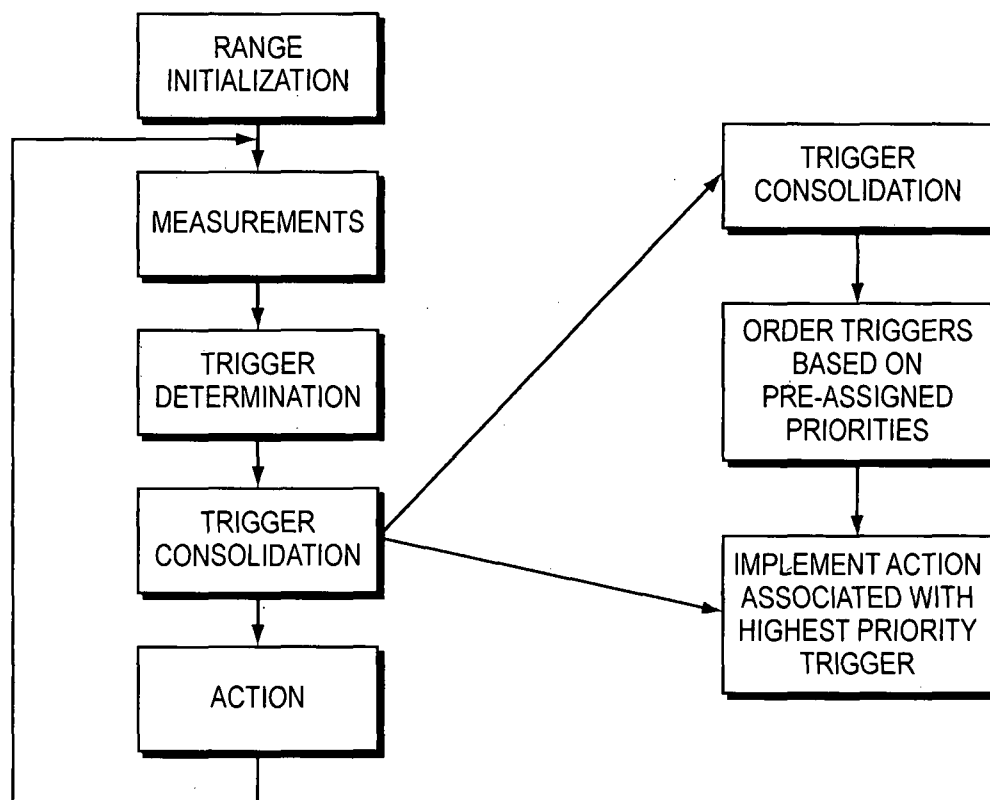


FIG. 3

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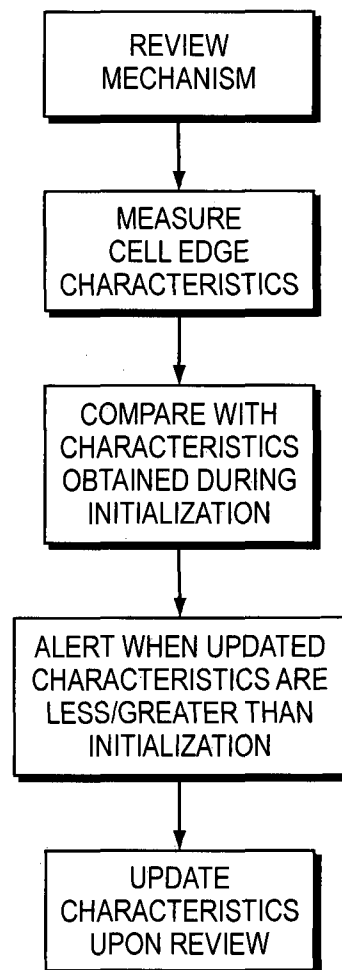


FIG. 4

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- Case 1 & 2 : Coverage Hole
- Trigger T1
 - Measurements
 1. $RSRP_{UEEdge-N} < RSRP_{UEEdge-S} - \Delta$ AND
 2. NEIGHBOR CELL $RSRP < RSRP_{Thresh-N}$
 3. Increment $N_{triggers}$
 - Condition
 - $N_{triggers} / N_{total_atts} > T1_{thresh}$
 - Reset $N_{triggers}$ and N_{total_atts} after time T_{T1}
- Trigger T2
- Measurements
 - Detection of UEs in surrounding area
 - Increment $N_{triggers}$
- Condition
 - $N_{triggers} / N_{total_measures} > T2_{thresh}$
 - Reset $N_{triggers}$ and $N_{total_measures}$ after time T_{T2}
- T1 AND T2 indicates coverage hole
 - Mapped to Action U
- Case 3 : HotSpot on Same Carrier as Macro
- Trigger T3
 - Measurements
 1. $RSRP_{UEEdge-N} \geq RSRP_{UEEdge-S} - \Delta$
 2. Is Neighbor a Macro? AND
 3. Increment $N_{triggers}$
 - Condition
 - $N_{triggers} / N_{total_atts} > T3_{thresh}$
 - Reset $N_{triggers}$ and N_{total_atts} after time T_{T3}
- Trigger T2
- Measurements
 - Detection of UEs in surrounding area
 - Increment $N_{triggers}$
- Condition
 - $N_{triggers} / N_{total_measures} > T2_{thresh}$
 - Reset $N_{triggers}$ and $N_{total_measures}$ after time T_{T2}
- T3 AND T2 indicates need for additional Pico coverage
 - Mapped to Action U

FIG. 5

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- Case 4 : Optimal Pico Size
- Trigger T4
 - Measurements
 1. $\text{RSRPUE-S} > \text{RSRPThresh-S-Max AND RSRPUE-N} > \text{RSRPThresh-N-Max}$
 2. Increment Ntriggers
 - Condition
 - $\text{Ntriggers} / \text{Ntotal_atts} > \text{T4thresh}$
 - Reset Ntriggers and Ntotal_atts after time T_{T4}
 - T4 indicates excessive Pico coverage
 - Mapped to Action D
- Case 5 : Pico spillover
- Trigger T5
 - Measurements
 1. $\text{RSRPUEEdge-N} > \text{RSRPThresh-N-Min AND}$
 2. Neighbor is a Macro
 3. Increment Ntriggers
 - Condition
 - $\text{Ntriggers} / \text{Ntotal_atts} > \text{T5thresh}$
 - Reset Ntriggers and Ntotal_atts after time T_{T5}
 - Trigger T6
 - Measurements
 - $\text{UESojourntime} < \text{SojournTimeThresh}$
 - Increment Ntriggers
 - Condition
 - $\text{Ntriggers} / \text{Ntotal_atts} > \text{T6thresh}$
 - Reset Ntriggers and Ntotal_atts after time T_{T6}
 - T5 AND T6 indicates excessive Pico coverage
 - Mapped to Action D

FIG. 6

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- Action : Moving Upward
 - Step 1 : Cell size increase
 - $P_{tx} = \min(P_{tx} + P_{UP}, P_{txmax})$
 - Update refSigPower in serving cell
 - Step 2 : If $P_{tx} = P_{txmax}$ Cell attach increase
 - $RSRP = \min(RSRP + P_{UP}, RSRP_{max})$
 - Update refSigPower in serving cell
 - Step 3 : If $RSRP = RSRP_{max}$ Range Extension
 - $RE = \min(RE + P_{UP}, RE_{max})$
 - $RxLevMin = RxLevMin - RE$
 - Notify SON of new $RxLevMin$ (to be used by other cells)
 - Step 4 : Clear all trigger counters
- Action : Moving Downward
 - Step 1 : Decrease cell reselection threshold
 - $RE = \min(RE - P_{DOWN}, 0)$
 - $RxLevMin = RxLevMin + RE$
 - Notify SON of new $RxLevMin$ (to be used by other cells)
 - Step 2 : If $RE = 0$ Cell attach decrease
 - $RSRP = \max(RSRP - P_{DOWN}, RSRP_{min})$
 - Update refSigPower in serving cell
 - Step 3 : Cell size decrease
 - $P_{tx} = \max(P_{tx} - P_{DOWN}, P_{txmin})$
 - Update refSigPower in serving cell
 - Step 4 : Clear all trigger counters

FIG. 7

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Detection of UEs in Surrounding Area based on PUSCH IoT measurement

- Measurement: time trace of pico cell UL interference over thermal (IoT) per RBG, in dB unit.
- Statistics: 1st raw moment (mean), 2nd central moment (variance) and 3rd standardized moment (skewness).

In general, based on the **skewness** (indicates where most of the IoT values lie in):

- High: fewer UEs in surrounding area
- Low: more UEs in surrounding area

Exceptions: when all UEs are far away or near the pico.

The skewness will be dependent on many other factors and is hard to predict (typically high). In these situations, the variance is low, and the mean will be low when all UEs are far away, and high in the other situation.

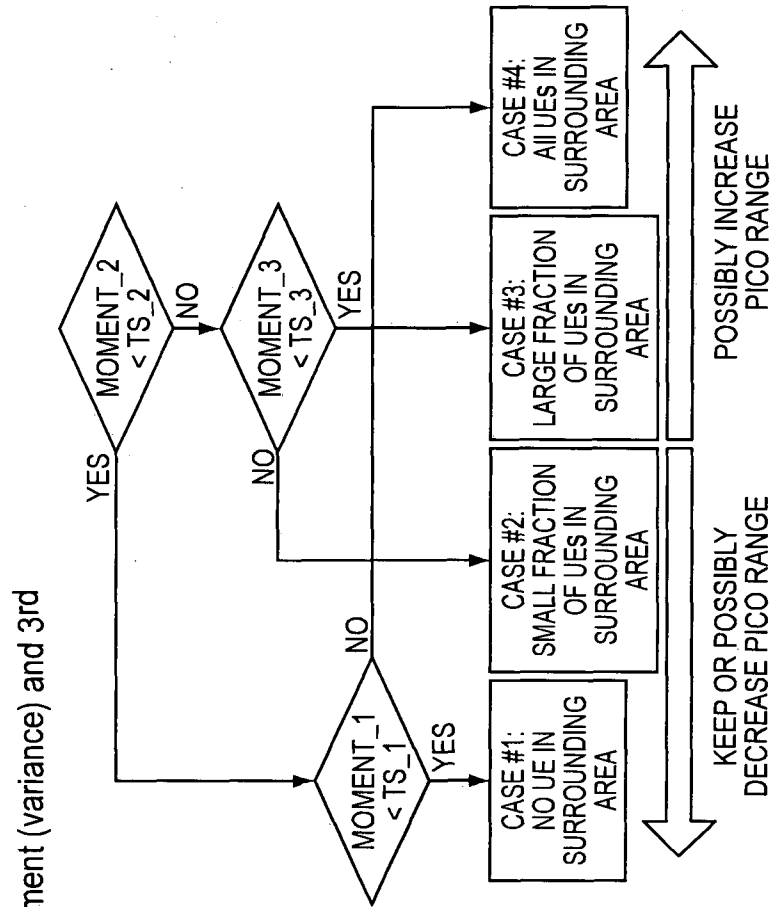


FIG. 8