



(86) **Date de dépôt PCT/PCT Filing Date:** 2008/02/05
(87) **Date publication PCT/PCT Publication Date:** 2008/08/14
(45) **Date de délivrance/Issue Date:** 2015/04/07
(85) **Entrée phase nationale/National Entry:** 2009/07/23
(86) **N° demande PCT/PCT Application No.:** CA 2008/000220
(87) **N° publication PCT/PCT Publication No.:** 2008/095288
(30) **Priorité/Priority:** 2007/02/05 (US60/888,167)

(51) **Cl.Int./Int.Cl. H04B 7/08** (2006.01),
H04L 27/00 (2006.01)

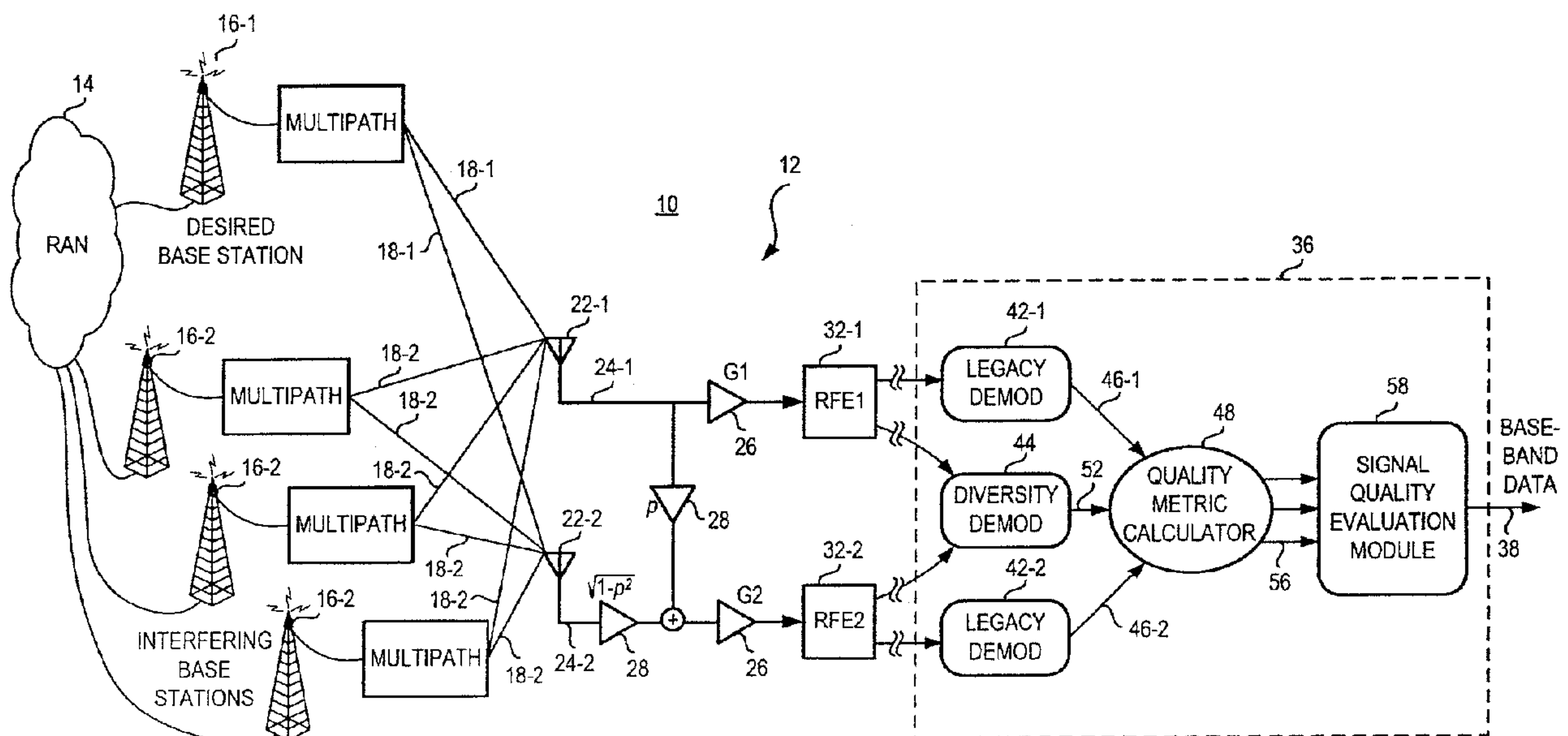
(72) **Inventeurs/Inventors:**
DWYER, JOHANNA, CA;
PECEN, MARK, CA;
SIMMONS, SEAN, CA;
WU, HUAN, CA

(73) **Propriétaire/Owner:**
BLACKBERRY LIMITED, CA

(74) **Agent:** PERRY + CURRIER

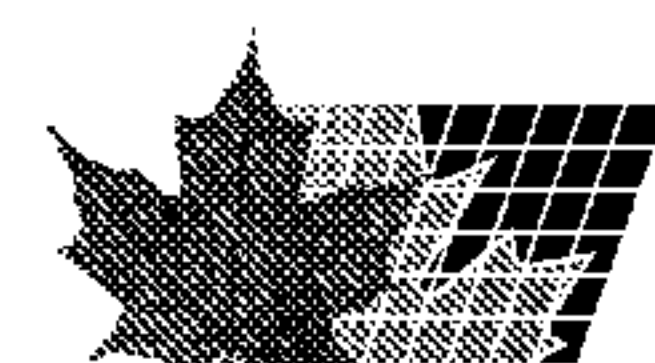
(54) **Titre : APPAREIL ET PROCEDE ASSOCIE POUR REALISER UNE OPERATION SUR DES DONNEES RECUES PAR UNE STATION DE RECEPTION CAPABLE D'UNE OPERATION DE RECEPTION SIMULTANEE**

(54) **Title: APPARATUS, AND ASSOCIATED METHOD, FOR OPERATING UPON RECEIVED DATA AT A RECEIVING STATION CAPABLE OF DIVERSITY OPERATION**



(57) **Abrégé/Abstract:**

Apparatus, and an associated method, for a receiving station, such as the receive part of a mobile station, that has diversity antennas. The receiving station includes both legacy demodulators and a diversity demodulator. Calculations are made to determine signal indicia associated with the signal energy detected at the diversity antennas. Responsive to the signal indicia, selection is made as to whether to utilize demodulation data, demodulated pursuant to a diversity demodulation technique or pursuant to a legacy demodulation technique. As the characteristics of received signals change, reselection of the demodulation is correspondingly made, such as on a frame-by-frame basis of frame-formatted data.



(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau(43) International Publication Date
14 August 2008 (14.08.2008)

PCT

(10) International Publication Number
WO 2008/095288 A1

(51) International Patent Classification:

H04B 7/08 (2006.01) **H04L 27/00** (2006.01)

(21) International Application Number:

PCT/CA2008/000220

(22) International Filing Date: 5 February 2008 (05.02.2008)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

60/888,167 5 February 2007 (05.02.2007) US

(71) Applicant (for all designated States except US): **RE-SEARCH IN MOTION LIMITED** [CA/CA]; 295 Phillip Street, Waterloo, Ontario N2L 3W8 (CA).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **DWYER, Johanna** [CA/CA]; 176 Columbia Street West, Waterloo, Ontario N2L 3L3 (CA). **WU, Huan** [CA/CA]; 20 Glen Meadows Circle, Kanata, Ontario K2M 2W8 (CA). **SIMMONS, Sean** [CA/CA]; 120 Sandford Fleming Drive, Waterloo, Ontario N2T 1E7 (CA). **PECEN, Mark** [US/CA]; 333 Old Post Road, Waterloo, Ontario N2L 5P3 (CA).(74) Agents: **MEASURES, Jeffrey M.** et al.; Borden Ladner Gervais LLP, World Exchange Plaza, 100 Queen Street, Suite 1100, Ottawa, Ontario K1P 1J9 (CA).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report
- with amended claims

(54) Title: APPARATUS, AND ASSOCIATED METHOD, FOR OPERATING UPON RECEIVED DATA AT A RECEIVING STATION CAPABLE OF DIVERSITY OPERATION

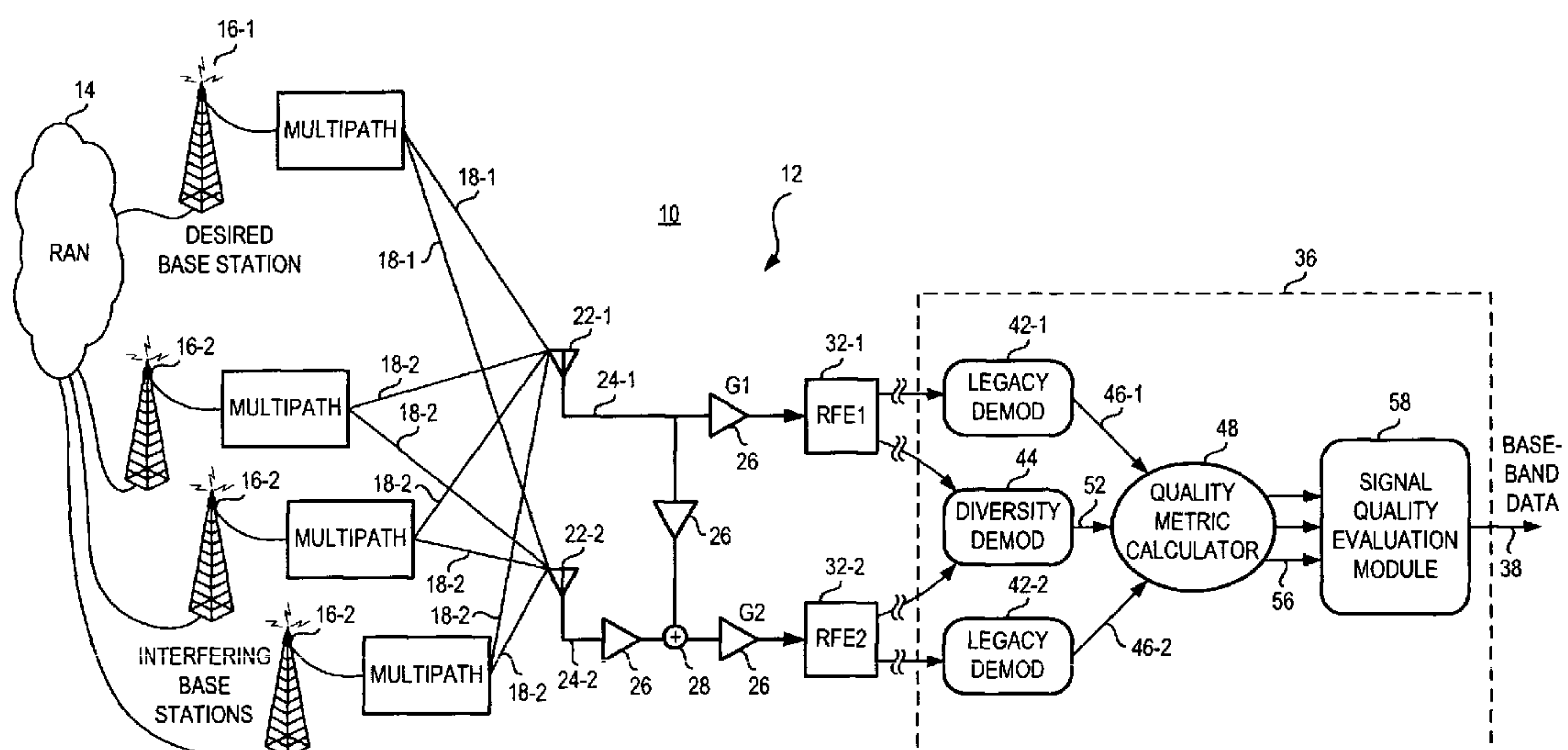


FIG. 1

(57) Abstract: Apparatus, and an associated method, for a receiving station, such as the receive part of a mobile station, that has diversity antennas. The receiving station includes both legacy demodulators and a diversity demodulator. Calculations are made to determine signal indicia associated with the signal energy detected at the diversity antennas. Responsive to the signal indicia, selection is made as to whether to utilize demodulation data, demodulated pursuant to a diversity demodulation technique or pursuant to a legacy demodulation technique. As the characteristics of received signals change, reselection of the demodulation is correspondingly made, such as on a frame-by-frame basis of frame-formatted data.

WO 2008/095288 A1

**APPARATUS, AND ASSOCIATED METHOD, FOR OPERATING UPON
RECEIVED DATA AT A RECEIVING STATION CAPABLE
OF DIVERSITY OPERATION**

[0002] The present invention relates generally to a manner by which to facilitate operation of a receiver, such as the receive part of a cellular mobile station, capable of providing receive diversity through the use of a set of receive antennas. More particularly, the present invention relates to apparatus, and an associated method, by which to select in what manner to demodulate received data. Depending upon the characteristics of the received data, either diversity demodulation is selected to be used or legacy, i.e., conventional demodulation, is selected to be used. Reselection of the manner of demodulation is further provided. If the characteristics of the received data change in a way to cause the preferred manner by which to demodulate the data to change, then the manner of demodulation is to be changed.

Background of the Invention

[0003] A variety of different types of mobile communication systems have been developed and deployed and are regularly utilized for communication. And, for many, ready access to a mobile communication system to communicate therethrough is a practical necessity. In a mobile radio communication system, as well as other types of communication systems, data is communicated between a set of communication stations including a sending station and a receiving station by way of a communication channel. In a mobile, or other radio, communication system, the communication channel is defined upon a radio link, part of the electromagnetic spectrum. The communication channel is non-ideal. During communication of the data upon the communication channel, the

signal containing the data can become distorted. Additional distortion is sometimes also introduced upon the data once received at a receiving station. If the distortion is significant, the informational content of the data cannot accurately be recovered. Various techniques are provided in order to make compensation for, or otherwise to overcome, the distortion introduced upon the data. Space diversity, for instance, is sometimes provided, either at a sending station or at a receiving station, or both. Space diversity is created at a sending station, for instance, through the use two or more spaced-apart transmit antennas, thereby to provide spatial redundancy. Analogously, at a receiving station, use of two or more receive antennas analogously provides spatial diversity. In a cellular, or other mobile radio, communication system in which mobile stations are used by which to communicate, spatial diversity techniques have conventionally been utilized only at the network part of the communication system.

[0004] Use of diversity antennas at a mobile station has been, to date, generally limited. Mobile stations are generally small form-factor devices. Their small physical dimensions limit the use of multiple antennas. Additionally, use of multiple antennas also requires a corresponding increase in RF (Radio Frequency), front-end and base band processing of received data. Increased processor complexity and computational ability is required. Such increases result in a corresponding increase in power dissipation, adversely affecting battery longevity.

[0005] However, various advancements in circuit, and other, technologies, have increased the feasibility of use of spatial diversity at a mobile station.

[0006] Efforts, therefore, have been directed towards providing spatial diversity to a mobile station. For instance, work related to DARP (Downlink Advanced Receiver Performance) attempts to utilize an advanced receiver in a mobile terminal, having a single antenna, to increase the tolerance of the receive part of the mobile terminal to co-channel interferers. MSRD (Mobile Station Receiver Diversity) requirements are set forth therein for evolved EDGE (Enhanced Data for GSM Evolution) and are based, in part, on the DARP efforts.

[0007] Advanced receivers are implementable in various different manners. For instance, such receivers variously include, e.g., Joint Space Time Optimizing Filters (JSTOFs) or Weiner filters, and utilize, e.g., joint detection (JD) techniques. In DARP-related standardizations, envisioned communication signaling pertained primarily to improvements of GMSK (Gaussian Minimum Shift Keying) signaling. For instance, such signaling pertained to GSM (Global System for Mobile Communications) voice services, GPRS (General Packet Radio Service) and the most-robust Modulation and Coding Schemes (MCS) used in EDGE-based communications at lower data interchange speeds, e.g., MCS-1 through MCS-4. Simple extension of the capabilities of DARP requirements to more-complex techniques, such as 8-PSK, 16-ary or 32-ary modulation techniques, used for higher-speed EDGE modulation and coding schemes, are generally envisioned to require, or be improved by the use of multiple RF receivers, amenable for multiple-antenna implementations.

[0008] Various issues remain with respect to use of spatial diversity at a small form-factor receive station, such as a mobile station. And, further efforts with respect to implementation of such receiving stations that have spatial diversity is required.

[0009] It is in light of this background information related to the use of spatial diversity in communication systems that the significant improvements of the present invention have evolved.

Brief Description of the Drawings

[0010] Figure 1 illustrates a functional block diagram of a radio communication system in which an embodiment of the present invention is operable.

[0011] Figure 2 illustrates a functional block diagram, similar to that shown in Figure 1, but in which a receiving station operates pursuant to an alternate embodiment of the present invention.

[0012] Figure 3 illustrates a method flow diagram representative of the method of operation of an embodiment of the present invention.

Detailed Description

[0013] The present invention, accordingly, advantageously provides apparatus, and an associated method, for a receiver, such as the receive part of a mobile station, that is capable of providing receive diversity through use of a set of spaced-apart, receive antennas.

[0014] Through operation of an embodiment of the present invention, a manner is provided by which to select in what manner to demodulate received data.

[0015] In one aspect of the present invention, depending upon the characteristics of the received data, either diversity demodulation is selected to be used or legacy, i.e., conventional, single-chain demodulation is selected to be used.

[0016] In another aspect of the present invention, reselection of the manner of demodulation is further provided. If the characteristics of the received data change in a way such that a different demodulation-type would better facilitate recovery of the informational content of the data, a change of the manner by which the received data is demodulated is made.

[0017] In another aspect of the present invention, a multiple-antenna arrangement is provided for a small form-factor mobile station. Through the use of separate antennas the strength of the signal energy of the communicated data that is detected at the respective antennas, and applied to receiver front-ends, might well differ. In addition, the signals received at the respective antennas and applied to the receiver front-ends may exhibit some correlation. Various factors affect the signal correlation and signal strength. The multi-path fading environment of the radio channel, the design of the antennas, their physical separation, and the construction, and configuration, of the mobile station are all exemplary affecting factors. Additionally, signal-strength-affecting factors include, e.g., channel fading conditions and even the position of a user as the user operates the mobile station. In addition, the frequency band of operation is an exemplary factor that affects signal strength and the correlation between two or more signal paths received by two or more separate receivers.

[0018] In another aspect of the present invention, a receiver structure is provided that includes a diversity demodulator that is connected to receive indications of signal energy detected at the separate antennas of the diversity-antenna arrangement. When the detected signal energy is of characteristics such that diversity demodulation would be the beneficial manner by which to demodulate the detected data, results of the diversity demodulation are used in the receive chain to recover the informational content of the detected data.

[0019] In another aspect of the present invention, the receiver structure further includes legacy, i.e., conventional, demodulators configured in separate receive-chain paths with the separate ones of the antennas of the set of diversity antennas. The legacy demodulators demodulate signal data of the single antennas to which the respective demodulators are coupled. Depending upon the characteristics of the receive signals, legacy-demodulated data, demodulated by a selected legacy demodulator, is used with additional receive chain elements to recover the informational content of the communicated data.

[0020] In another aspect of the present invention, signal indicia measurement is made of the detected data, such as to determine a quality metric associated with the detected data, correlation between signal energy detected at the separate ones of the antennas, amplitude differences there between, as well as any of various other measurements and indicia. Evaluation is made of the calculated or measured indicia, and determination is made as to which demodulated data, one of the legacy-demodulated data or the diversity-demodulated data, is to be used to recover the informational content of the received signal. Successive iterations of the measurements or calculations are made. If the conditions change to an extent that the manner by which the modulation is to be performed changes, a change is made. When, for instance, the communicated data comprises frame-formatted data, new measurements and calculations are made on a frame-by-frame basis, or intermittently, e.g., every selected number of frames. And, new selection of whether to utilize diversity demodulated data or legacy-demodulated data is

made. Thereby, as characteristics of the communicated data change, demodulated data that best facilitates recovery of the informational content of the detected data is made.

[0021] In another aspect of the present invention, indicia measurement, calculation, evaluation, and selection is made prior to demodulation of the data. And, responsive to the selection, the appropriate demodulator is made operable to demodulate the detected data. Alternately, all of the demodulators are concurrently operable, and selection is made as to which of the demodulated data is to be provided to additional receive chain elements for further processing.

[0022] Thereby, receive diversity is provided to a receiving station while providing for demodulation of the detected data in a manner that best facilitates recovery of its informational content.

[0023] In these and other aspects, apparatus, and an associated method, is provided for a receiving station that contains a first diversity antenna and a second diversity antenna. A receive signal indicia operator is adapted to receive a first signal indicia associated with first signal energy detected at the first diversity antenna and to receive a second signal indicia associated with second signal energy detected at the second diversity antenna. The receive signal indicia operator is configured to operate upon the first and second signal indicia, respectively, to ascertain an attribute thereof. A selector is adapted to receive an indication of the attribute ascertained by the receive signal indicia operator. The selector is configured to select which of diversity demodulation results of a combination of the first and second signal energy, and separate demodulation results of the first signal energy or the second signal energy, are to be used at the receiving station.

[0024] Referring first, therefore, to Figure 1, a radio communication system, shown generally at 10, provides for radio communications with mobile stations, of which the mobile station 12 is representative. The receive part of the mobile station 12 is represented in Figure 1. The mobile station communicates with a radio access network (RAN) 14 that includes a plurality of base transceivers 16 here, e.g., BTS, NODEBs or

eNODES. Here, the mobile station is positioned at a location permitting its reception of signals sent by a desired base station 16-1 and, additional base stations 16-2 whose signals that are sent on channels that interfere with the signals sent by the base station 16-1.

[0025] In the exemplary implementation, the communication system 10 forms a cellular radio communication system operable in general conformity with the operating procedures and protocols a GSM/GPRS/EDGE (Global System for Mobile communications/General Packet Radio Service/Enhanced Data for GSM Evolution) – capable cellular communication system. More generally, the communication system is representative of any of various types of communication systems that benefit from the use of diversity communication techniques. And, while downlink communications are described, more generally, the communications are representative of communications between any set of communication stations formed of a sending station and a receiving station.

[0026] The radio channels are multi-path channels and signals sent by both the base station 16-1 and the interfering base stations 16-2 are communicated upon multi-paths, here shown by paths 18-1 and 18-2. Multi-path communication results in fading conditions, both with respect to the desired signal and with respect to the co-channel, interfering signals.

[0027] The receive part of the mobile station that includes, here, a pair of receive antennas 22-1 and 22-2, positioned, such as by being spaced-apart from one another by appropriate, effective separation distances, to provide receive antenna diversity. Spatial diversity can be provided in other manners, too, e.g., by use of directional antennas. The antennas 22 operate in conventional manner to transduce electromagnetic energy into electrical energy that is representative of the detected signal energy. The detected signal energy includes both the desired signal and interference, both co-channel interference and interference caused by multi-path transmission. The signal energy and phases detected at the antennas are correlated. The correlation is modeled as a complex correlation and is

designated as “rho”. Correlation is modeled, e.g., in complex terms. The instantaneous value of the correlation is a function of the radio propagation environment, the antenna design, and the physical layout of the mobile terminal device.

[0028] Electrical indications representative of the detected signal energy at the antennas 22 are provided on lines 24-1 and 24-2. The indications are operated upon by conventional gain, and other, elements 26 and 28, in conventional manner to provide amplified indications to RF (Radio Frequency) elements 32. In addition to gain elements traditionally present, the gain elements illustrated here by factors G1 and G2 also include variable attenuation factors. These variable factors can include but are not limited to attenuation due to the mobile station user positioning, and can also account for noise-figure differences in the separate receive chains. The configuration of these elements provides for different signals detected at the separate antennas. The signals are correlated using weighting factors at the elements 26. An amplified indication of the electrical representation of the detected signal energy, detected at the antenna 22-1 is provided to the RF element 32-1. And, an amplified indication of the electrical representation of the detected signal energy, detected at the antenna 22-2, is provided to the RF element 32-2. RF operations are performed at the respective elements 32-1 and 32-2.

[0029] The receive part of the mobile station includes apparatus 36 of an embodiment of the present invention. The apparatus 36 is formed of functional elements, implementable in any desired manner, including, in part, by algorithms executable by processing circuitry. The apparatus forms demodulated, baseband data on the line 38 that is provided to additional receive-part elements (not shown), conventionally utilized to recover the informational content of data, such as data communicated pursuant to a GSM/GPRS/EDGE communication service.

[0030] The apparatus includes legacy, i.e., conventional, demodulators 42. The legacy demodulator 42-1 is coupled to the RF element 32-1 and receives an indication that is representative of the signal energy detected at the antenna 22-1. Analogously, the legacy demodulator 42-2 is coupled to the RF element 32-2 and receives an indication of

the signal energy detected by the antenna 22-2. The legacy demodulators demodulate, in conventional manner, the indications provided thereto. The demodulators 42-1 and 42-2 operate independently in that the indications applied to the respective demodulators 42 are representative of the signal energy detected at the separate antennas.

[0031] The apparatus 36 further includes a diversity demodulator 44. The diversity demodulator is coupled to both of the RF elements 32-1 and 32-2. The diversity demodulator demodulates, according to a diversity demodulation technique, a combination of the indications of the signal energy detected at both of the antennas 22-1 and 22-2.

[0032] Depending upon the characteristics of the signal energy detected at the antennas, one type of demodulation may provide a better error rate than the others. That is to say, the legacy demodulation is preferable to the diversity demodulation when the receive signal energy in each of the branches is of first characteristics. And, diversity demodulation is preferable to the legacy demodulation when the receive signal energy in each of the branches is of second characteristics. Lines 46-1 and 46-2 extend from the respective legacy demodulators to a quality metric calculator 48. And, line 52 extends from the diversity demodulator 44 to the quality metric calculator. The quality metric calculator operates to calculate selected quality metrics associated with the demodulated data, demodulated by the demodulators 42 and 44. Exemplary quality metrics calculated by the calculator include a BER (Bit Error Rate), a BLER (Block Error Rate), an FER (Frame Error Rate), an SNR (Signal-to-Noise) ratio, a C/I (Carrier to Interference Ratio), a SINR (Signal-to-Interference plus Noise ratio), an associated E_b/N_0 , or any other appropriate metric.

[0033] Calculated values formed by the calculator 48 are provided, here represented by way of the lines 56, to a signal quality evaluation module and selector 58. The element 58 makes selection, responsive to the quality metric value or values provided thereto of which of the demodulated data is to be formed on the line 38 and used pursuant to further receive chain operation. In one implementation, the evaluation

module and selector 58 employs a searching algorithm that operates, e.g., to perform a mathematical MIN operation that determines a mathematical minimization of a sum or a weighted sum of all error rate metrics. In another implementation, the evaluation module and selector 58 operates to perform a mathematical MAX operation that determines a mathematical maximization of a sum or a weighted sum of all signal quality metrics. Responsive to such calculations, a decision is made as to which demodulated data stream is to be forwarded on the line 38.

[0034] Figure 2 again illustrates the communication system 10. The communication system 10 again is shown to include a mobile station 12, a radio access network 14 having a plurality of base transceiver stations 16, and multi-paths 18 upon which signals generated at the base transceiver stations are communicated to the mobile station.

[0035] The receive part of the mobile station is again shown to include a set of receive antennas 22, which transduce electromagnetic energy into electrical energy on the lines 24. Circuit elements 26 and 28 and RF elements 32 are again shown at the RF part of the receive chain of the mobile station. And, the line 38 extends to additional receive chain elements (not shown). Here, the apparatus 36 operates pursuant to an alternate embodiment of the present invention. Again, the apparatus 36 includes legacy demodulators 42-1 and 42-2 and a diversity demodulator 44, each coupled in the same manners to the RF elements 32, either separately with respect to the legacy demodulators or to both of the elements with respect to the diversity demodulator. In this implementation, the legacy demodulators 42 are connected by way of the lines 66-1 and 66-2, respectively, to a first side of a switch element 68. And, a line 72 extends from the demodulator 44 to the first side of the switch element 68. A second side of the switch element 68 is connected to the line 38.

[0036] In this implementation, the apparatus also includes a correlation detector 74 and an amplitude difference calculator 76. The functions 74 and 76 are coupled to the RF elements 32 to receive indications of the signal energy detected at the respective

antennas 22. The correlation detector 74 operates to calculate the correlation between the signal energy and phase received at the input to the apparatus 36s. And, the amplitude difference calculator operates to calculate differences between the amplitudes of the signal energy.

[0037] Calculations made by the functions 74 and 76 are provided to a demodulation selector 78. Responsive to the values provided thereto, selection is made by the selector as to which of the demodulation types, i.e., legacy demodulation or diversity demodulation, is to be utilized to demodulate values on the line 38. And, responsive to the selection, the selected demodulation operation is performed only by the appropriate demodulator, 42 or 44.

[0038] In the embodiment shown in Figure 2, the demodulation decision is made prior to the demodulation rather than subsequent to demodulation, as utilized in the embodiment shown in Figure 1.

[0039] Determination is made at the elements 58 and 78 in Figures 1 and 2, respectively, to cause demodulated data to be formed on the line 38 formed alternately by a legacy demodulation technique or by a diversity demodulation technique. The selection is made of the demodulation technique that yields a best signal quality of the baseband data, e.g., subject to constraints. The constraints include, for instance, the constraint that both of the receive chain parts be available for diversity reception, that is, the second receive chain is not being used to receive additional information on a different receive frequency, and neither receive chain part is powered-down, such as might occur to reduce current consumption at the mobile station. An additional constraint is, e.g., that the mobile station has the processing capacity to demodulate the data individually at both of the receive chains as well as jointly by the diversity demodulator during each successive frame of the receive data. An additional constraint is, e.g., that the signal quality metric calculations performed on the receive data is updated during each frame. The quality metric values, in one implementation, are further averaged or filtered using different FIR

or IIR filter techniques over a time period, such as the duration of a call or packet transfer.

[0040] In the embodiment shown in Figure 1, the signals formed on the separate RF chains are demodulated individually with legacy demodulators as well as jointly with the diversity demodulator. Various quality metrics, such as those previously mentioned, are used to determine selection of which stream of demodulated data is to be formed on the line 38 and provided, e.g., to baseband processing elements.

[0041] In the embodiment shown in Figure 2, the signals formed on the separate RF chains are provided to the amplitude difference calculator 76 and to the correlation detector 74. Calculations performed thereat are provided to the selector 78. And, selection is made of the demodulation-type to be utilized responsive to such values. The selector, in one implementation, first analyzes the amplitude difference calculated by the amplitude difference calculator. If the amplitude difference between the signals on the separate paths is greater than a selected threshold, the selection chooses legacy demodulation using the legacy demodulator connected to the signal path on which the signal energy of the greatest amplitude to be utilized and to form the demodulated data generated on the line 38. The selected threshold is, e.g., based upon the diversity receiver implementation and system simulations and is set, e.g., to a level at which the diversity receiver no longer performs as well as a legacy demodulator.

[0042] In an alternate embodiment, further determination is made whether the signal energy amplitude generated on the separate RF paths is above a selected level, a "good signal threshold" level but in which the amplitude level difference is greater than the selected level. If the demodulator is capable of calculating the interference level, then the selector selects the demodulator on the receive path that exhibits the greater SINR level.

[0043] If the amplitude difference determined by the calculator 76 is less than the selected threshold, then calculations made by the correlation detector are examined. If the calculated correlation is greater than a selected threshold, then legacy demodulation is

utilized. The legacy demodulator connected in the receive chain that has the greatest power level is used. In an alternate implementation, in an occurrence in which the amplitude level difference is acceptable but the correlation between the signals on the respective receive chain branches is greater than a selected threshold, the selector operates to perform demodulation at the legacy demodulator in the branch that exhibits the greater SINR level while also having an energy amplitude level above the selected "good signal threshold". In another implementation of this occurrence, the two legacy demodulators perform certain initial processing (e.g. channel estimation and matched filtering) and then combine them to improve SNR. The combined signal is used for the rest of the demodulation.

[0044] If, conversely, the detected correlation is less than the selected threshold, and the amplitude difference is also less than a selected threshold, then diversity demodulation is selected to be utilized. In Figure 2, the selector 78 generates a signal on the line 82 that causes operation of the demodulators 42 and 44. And, the selector further generates a signal on the line 84 that controls positioning of the switch element 68 in a correspondingly appropriate manner.

[0045] That is to say, responsive to selection by the selector, an appropriate one of the legacy demodulator 42-1 or 42-2, or the diversity demodulator 44, is selected. And, the switch element 68 is caused to be positioned to pass the demodulated data on to the line 38 for further processing.

[0046] Figure 3 illustrates a method flow diagram, shown generally at 102, representative of the method of operation of an embodiment of the present invention. The method operates to facilitate data recovery at a receiving station that has a first diversity antenna and a second diversity antenna.

[0047] First, and as indicated by the block 104, a first and a second signal indicia are obtained. The first signal indicia is associated with first signal energy detected at the first diversity antenna. And, a second signal indicia associated with signal energy detected at the second diversity antenna is obtained.

[0048] Then, and as indicated by the block 106, an attribute associated with the first and second signal energy is ascertained. Then, and as indicated by the block 108, selection is made, responsive to the ascertained attribute, to which of diversity demodulation results of the combination of the first and second signal energy and separate demodulation results of the first signal energy or the second signal energy is to be used at the receiving station.

[0049] Thereby, a manner is provided by which to utilize demodulated data depending upon the characteristics of the detected signal energy. As characteristics of the detected signal energy change, reselection of the demodulation is correspondingly made and the demodulation-type is changed, if needed. Improved receiver performance thereby results.

What is claimed is:

1. Apparatus for a receiving station that contains a first diversity antenna and a second diversity antenna, said apparatus comprising:
 - a first receive signal operator adapted to receive a first signal associated with first signal energy detected at the first diversity antenna;
 - the first receive signal operator further adapted to receive a second signal associated with second signal energy detected at the second diversity antenna, the first receive signal operator configured to operate upon a combination of the first signal and the second signal to ascertain a first attribute thereof; and
 - a selector adapted to receive a first indication of the first attribute ascertained by said first receive signal operator, said selector configured to select which of: 1) a diversity demodulation result of a combination of the first and second signal energy or 2) a demodulation result of the first signal energy or 3) a demodulation result of the second signal energy is to be used at the receiving station based upon the first indication of the first attribute.
2. The apparatus of claim 1 wherein the first receive signal operator operates on the first and second signals prior to demodulation of the first and second signals, respectively.
3. The apparatus of claim 1 further comprising:
 - a second receive signal operator adapted to receive the first signal and the second signal;
 - the second receive signal operator configured to operate upon a combination of the first and second signals to ascertain a second attribute thereof; and
 - the selector further adapted to receive a second indication of the second attribute, the selector further configured to select which of: 1) a diversity demodulation result of a combination of the first and second signal energy or 2) a demodulation result of the first

signal energy or 3) a demodulation result of the second signal energy are to be used at the receiving station based upon the first indication of the first attribute and the second indication of the second attribute

4. The apparatus of claim 1 wherein the first attribute comprises a correlation value identifying correlation between the first signal energy and the second signal energy.

5. The apparatus of claim 1 wherein the first attribute ascertained by said receive signal operator comprises an amplitude difference value identifying a difference between amplitudes of the first signal energy and the second signal energy.

6. The apparatus of claim 3 wherein the first attribute comprises a correlation value identifying correlation between the first signal energy and the second signal energy, and the second attribute comprises an amplitude difference value identifying a difference between amplitudes of the first signal energy and the second signal energy.

7. The apparatus of claim 1 further comprising a diversity demodulator adapted to receive the first signal energy and the second signal energy, said diversity demodulator configured to demodulate the combination of the first and second signal.

8. The apparatus of claim 1 further comprising a first legacy demodulator adapted to receive the first signal energy and a second legacy demodulator adapted to receive the second signal energy, said first legacy demodulator and said second legacy demodulator configured separately to demodulate the first signal energy and the second signal energy, respectively, applied thereto.

9. The apparatus of claim 1 wherein the first signal energy and the second signal energy comprises frame-formatted data, and wherein selection made by said selector is successively made upon selected successive ones of frames of the frame-formatted data.

10. The apparatus of claim 1 wherein said selector is further configured to reselect which of: 1.) the diversity demodulation result of the combination of the first and second signal energy or 2.) a demodulation result of the first signal energy or 3.) a demodulation result of the second signal energy is to be used at the receiving station.

11. A method for operating a receiving station that has a first diversity antenna and a second diversity antenna, said method comprising:

ascertaining a first attribute associated with a combination of a first signal energy detected at the first diversity antenna and a second signal energy detected at the second diversity antenna; and

selecting which of 1) a diversity demodulation result of a combination of the first and second signal energy or 2) a demodulation result of the first signal energy or 3) a demodulation result of the second signal energy is to be used at the receiving station based upon a first indication of the first attribute.

12. The method of claim 11 wherein the first signal energy and the second signal energy comprise frame-formatted data and wherein said operations of ascertaining; and selecting are iteratively made upon selected successive ones of frames of the frame-formatted data.

13. The method of claim 11 wherein said operation of ascertaining comprises ascertaining an individual quality metric associated with at least one of the first signal energy and the second signal energy and ascertaining a combined quality metric associated with a combination of the first and second signal energy.

14. The method of claim 13 wherein selection made during said operation of selecting further comprises determining which quality metric is of a most appropriate quality.

15. The method of claim 11 further comprising the operation of demodulating subsequent to said operation of selecting.
16. The method of claim 11 further comprising:
ascertaining a second attribute associated with the combination of the first signal energy and the second signal energy; and
the selecting operation is based upon the first indication of the first attribute and a second indication of the second attribute.
17. The method of claim 15 wherein said selecting further comprises reselecting which of: 1.) the diversity demodulation result of the combination of the first and second signal energy or 2.) a demodulation result of the first signal energy or 3.) a demodulation result of the second signal energy is to be used at the receiving station.
18. An apparatus for selecting demodulated data from a plurality of demodulators comprising:
a first demodulator adapted to demodulate a first signal detected at a first antenna resulting in a first demodulated signal;
a second demodulator adapted to demodulate a second signal detected at a second antenna resulting in a second demodulated signal;
a third demodulator adapted to demodulate a third signal, the third signal is a combination of the first signal and the second signal resulting a third demodulated signal;
a quality metric calculator connected with the first, second and third demodulators, the quality metric calculator adapted to calculate a first quality metric for the first demodulated signal, a second quality metric for the second demodulated signal, and a third quality metric for the third demodulated signal; and
a signal quality evaluation module connected with the quality metric calculator, the signal quality evaluation module adapted to receive the first, second and third quality

metrics and to select a demodulated signal from one of the three demodulated signals based upon the first, second and third quality metrics.

19. The apparatus of claim 18 wherein the quality metric is selected from a group consisting of: BER (Bit Error Rate), a BLER (Block Error Rate), an FER (Frame Error Rate), an SNR (Signal-to-Noise) ratio, a C/I (Carrier to Interference Ratio), a SINR (Signal-to-Interference plus Noise ratio), an associated E_b/N_0 .

20. A method for selecting demodulated data from a plurality of demodulators comprising:

demodulating a first signal detected at a first antenna resulting in a first demodulated signal;

demodulating a second signal detected at a second antenna resulting in a second demodulated signal;

demodulating a third signal, the third signal is a combination of the first and second signal, resulting in a third demodulated signal;

calculating a first quality metric for the first demodulated signal, a second quality metric for the second demodulated signal, and a third quality metric for the third demodulated signal; and

selecting a demodulated signal from one of the three demodulated signals based upon the first, second and third quality metrics.

21. The method of claim 20, wherein the quality metric is selected from a group consisting of: BER (Bit Error Rate), a BLER (Block Error Rate), an FER (Frame Error Rate), an SNR (Signal-to-Noise) ratio, a C/I (Carrier to Interference Ratio), a SINR (Signal-to-Interference plus Noise ratio), an associated E_b/N_0 .

1/3

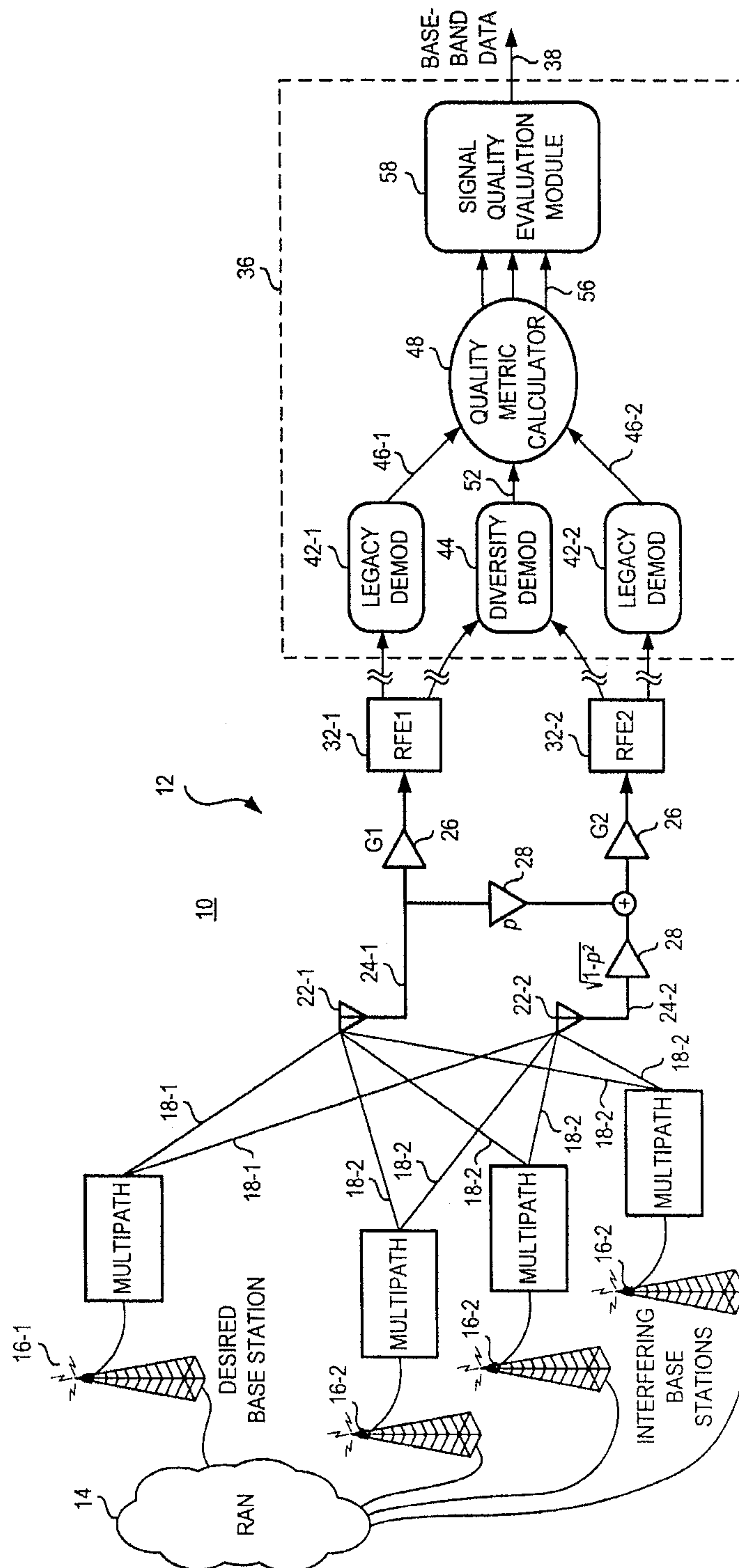


FIG. 1

2/3

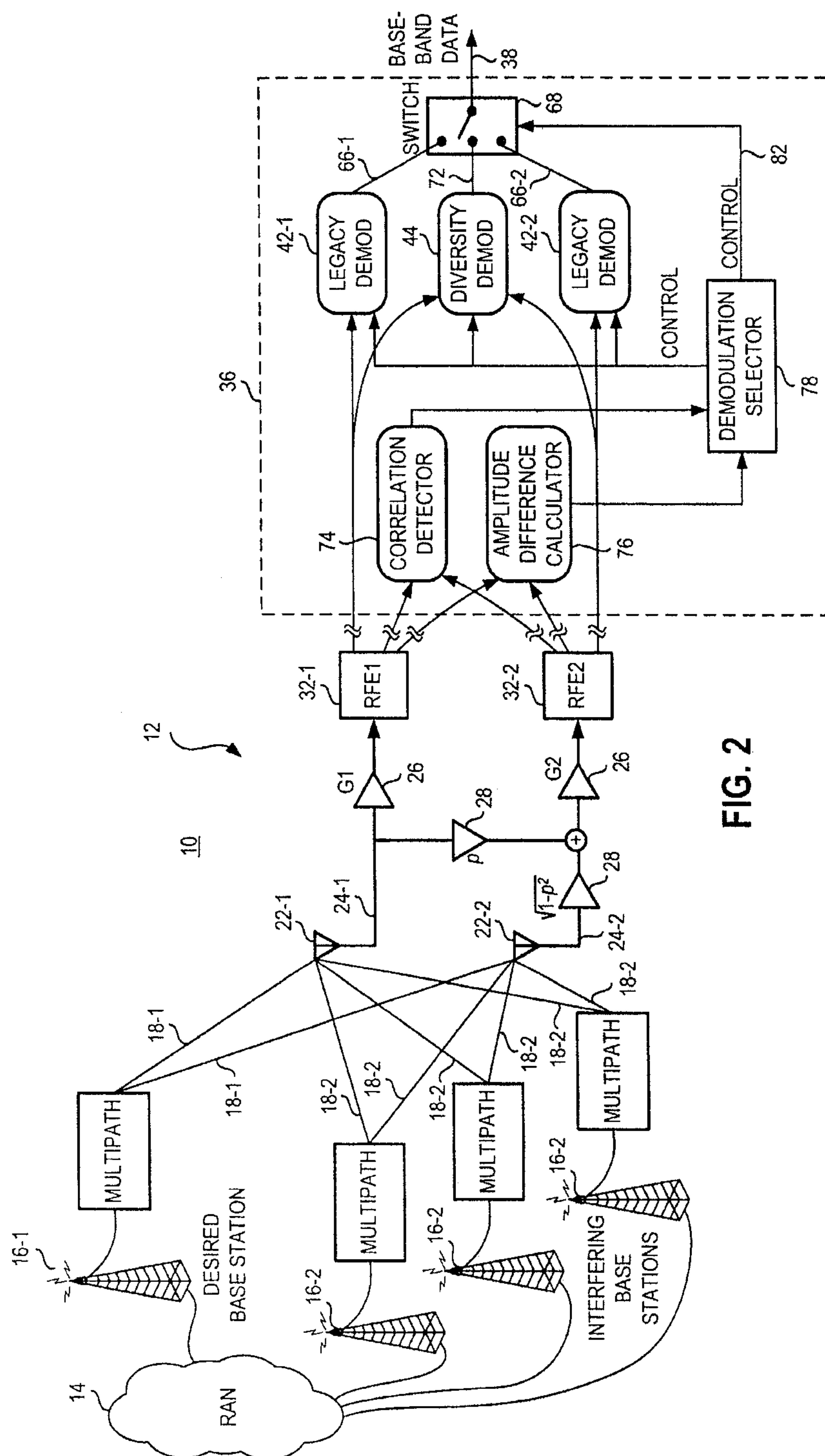


FIG. 2

3/3

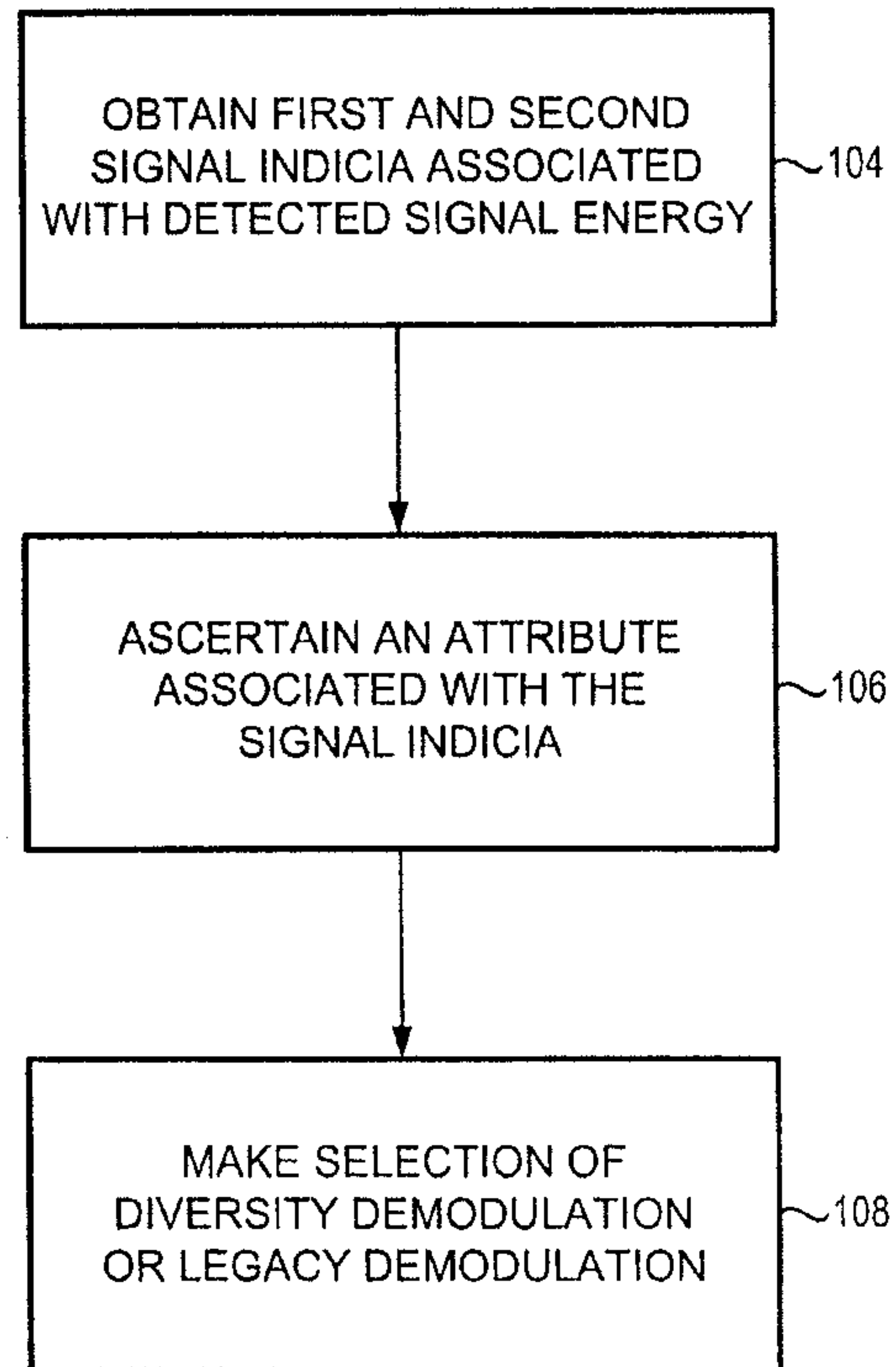
102

FIG. 3

