SYSTEM FOR DIVERSE PATH ANTENNA SELECTION

BACKGROUND

I. FIELD

[0001] The present invention relates generally to the operation of communication devices, and more particularly, to a system for diverse path antenna selection to receive signals in a communication device.

II. DESCRIPTION OF THE RELATED ART

[0002] Wireless communication networks are currently in widespread use to allow mobile terminal users to wirelessly communicate with each other and other network entities. Increasingly, mobile terminals are being used to receive both voice communications and data services. However, during operation, mobile terminals may experience the effects of Rayleigh signal fading and/or other transmission distortions that reduce performance. For example, Rayleigh signal fading can occur when multiple out-of-phase versions of the same signal arrive at the receiving antenna. The out-of-phase versions tend to cancel each other and yield a degraded received signal.

[0003] One technique used to reduce the effects of signal fading utilizes multiple antennas coupled to primary and diverse receiving paths, respectively, at the receiving device. The antennas are physically space apart from each other, and the primary receive path processes signals received by the first antenna while the diverse receive path processes signals received by the second antenna. By combining the signals on the two receive paths, the effects of signal fading can be reduced. Typically, the second antenna may be incorporated into the housing of the device so as to be less visible. Furthermore, the second antenna and its associated diverse receive path electronics may be constructed using less expensive components and offer lower performance (i.e., less sensitivity) than the first antenna and the primary receive path.

[0004] As the availability of wireless services have increased, it would be desirable to be able to receive and process multiple information signals at one time. For example, it is possible for a mobile terminal to receive voice calls, paging messages, data and multimedia services, and positioning signals, such as global positioning signals (GPS). Unfortunately, typical terminals having a

static diverse receive path and generally utilize that path only to process signals to reduce transmission effects, such as signal fading. Furthermore, due to cost constraints, the second antenna may not offer the performance of the primary antenna. Thus, current devices are generally limited to processing only one information signal at a time. As a result, the capabilities and functionality of mobile terminals having diverse path processing may be unnecessarily limited and/or underutilized.

[0005] Therefore, it would be desirable to have a system that utilizes the diverse receive path in a communication device to provide additional functionality and/or flexibility. For example, it would be desirable to process one or more information signals at the same time in a mobile device.

SUMMARY

[0006] In one or more embodiments, a system for diverse path antenna selection is provided that operates to select between primary and diverse receive paths in a communication device. For example, the system is suitable for use in a mobile terminal to allow the terminal to receive and process multiple signals at the same time, thereby providing additional functionality and/or flexibility to the device.

[0007] In one embodiment, the system operates to provide several operating modes so that a communication device may fully utilize its diverse receive path processing. For example, in one operating mode, referred to as "optimized signal" mode, the system operates to select between primary and secondary antennas to receive a desired signal with a selected quality level. Thus, the system operates to flexibly utilized diverse receive path processing in the communication device, so that it is not limited to simply reducing transmission effects, such as signal fading, as in conventional systems.

[0008] In one embodiment, a method is provided for receiving a signal in a communication device having first and second antennas. The method comprises receiving a first version of the signal using the first antenna, and receiving a second version of the signal using the second antenna. The method also comprises determining a first quality indicator and a second quality indicator associated with the first and second versions of the signal, respectively, and selecting one of the first and second versions of the signal to process based on the first and second quality indicators.

[0009] In another embodiment, apparatus is provided for receiving a signal in a device having first and second antennas, wherein the first antenna receives

the signal and produces a first version of the signal, and the second antenna receives the signal and produces a second version of the signal. The apparatus comprises a switch coupled to receive the first and second versions of the signal and a control signal, wherein the switch operates to selectively couple one of the first and second versions of the signal to receiving logic based on the control signal. The apparatus also comprises control logic that operates to output the control signal based one or more signal quality indicators associated with the first and second versions of the signal.

[0010] In still another embodiment, apparatus is provided for receiving a signal in a communication device having first and second antennas. The apparatus comprises means for receiving a first version of the signal using the first antenna, and means for receiving a second version of the signal using the second antenna. The apparatus also comprises means for determining a first quality indicator and a second quality indicator associated with the first and second versions of the signal, respectively, and means for selecting one of the first and second versions of the signal to process based on the first and second quality indicators.

[0011] In still another embodiment, a signal-bearing medium is provided that tangibly embodies a program of machine-readable instructions executable by a digital processing apparatus to perform a method for receiving a signal in a communication device having first and second antennas. The method comprising operations of receiving a first version of the signal using the first antenna, and receiving a second version of the signal using the second antenna. The method also comprises operations of determining a first quality indicator and a second quality indicator associated with the first and second versions of the signal, respectively, and selecting one of the first and second versions of the signal to process based on the first and second quality indicators.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The foregoing aspects and the attendant advantages of the embodiments described herein will become more readily apparent by reference to the following detailed description when taken in conjunction with the accompanying drawings wherein:

[0013] **FIG. 1** shows a device in a communication network that includes one embodiment of a diverse path selection system;

[0014] **FIG. 2** shows a diagram of one embodiment of a diverse path

selection system;

[0015] **FIG. 3** shows one embodiment of a method for providing diverse path selection in a communication device; and

[0016] **FIG. 4** shows one embodiment of a method for providing diverse path selection in a communication device.

DETAILED DESCRIPTION

[0017] The following detailed description describes one or more embodiments of a diverse path selection system for use in a communication device. For example, the system is suitable for use in wireless communication devices that operate to receive voice and data services.

[0018] **FIG. 1** shows a communication device **104** in a communication network **100** that includes one embodiment of a diverse path selection system **106**. The network **100** comprises a data network **102** that communicates with the device **104** over a wireless communication link **108**. The communication link **108** may comprise forward communication channels, reverse communication channels, control channels, paging channels, and/or any other type of data or voice communication channel. The communication network may comprise any type or combination of wired and/or wireless networks that may communicate over a wireless communication link. The device **104** may comprise virtually any type of device capable of receiving wireless transmissions, such as a mobile telephone, pager, PDA, notebook computer, desktop computer, or radio.

[0019] The device **104** comprises a first antenna **110** that operates to receive signals transmitted from the data network **102** over the wireless link **108**. The device **104** also comprises a second antenna **112** that operates to receive signals transmitted from the data network **102** over the wireless link **108**. In this embodiment, the antennas **110** and **112** both receive signals transmitted by the network **102**, however, in other embodiments, the antennas **110** and **112** operate to receive signal transmitted from different sources. For example, the antennas may receive positioning signals, radio signals, or any other type of transmitted signal.

[0020] In one embodiment, the first antenna **110** is located outside the housing of the device **104** to provide optimal signal reception. The second antenna **112** is located within the housing of the device **104**, and because of this, may offer lower performance than the first antenna **110**. The first and second antennas **110**, **112** comprise any suitable type, size, shape, or quality of

antenna and/or antenna technology.

[0021] In one embodiment, the device **104** comprises diverse path selection logic **106** that operates to receive and process signals received by the antennas **110**, **112**. The diverse path selection logic **106** comprises a primary receive path to receive and process signals from the first antenna **110**. The primary receive path comprises splitter **114** and primary receiver logic **116**. The diverse path selection logic **106** also comprises a diverse or secondary receive path to receive and process signals from the second antenna **112**. The diverse receive path comprises switch **118** and diverse receiver logic **120**.

[0022] The splitter **114** comprises any suitable signal splitting logic and operates to receive a signal from the first antenna **110** and split that signal into two signals that are input to the primary receiver logic **116** and the switch **118**. The switch **118** comprises any suitable switch logic and operates to receive a signal from the second antenna **112** and a signal from the splitter **114**, and direct one or those signals to a switch output that is input to the diverse path receiving logic **120**. Either of the two signals input to the switch **118** may be output from the switch output based on a control signal (Ctl). The primary path receiving logic **116** and the diverse path receiving logic **120** comprise any suitable type of receiving logic to receive and process signals received by the first and second antennas **110**, **112**.

[0023] During operation, the diverse path selection logic **106** allows the device **104** to operate in a variety of modes to process and receive transmitted signals. For example, in one embodiment, the device **104** may operate to process two information signals at the same time. For example, the device **104** may process a voice call and a GPS signal simultaneously. In another case, the device **104** may receive a multimedia signal and a paging signal. Thus, the operating modes provided by the diverse path selection logic **106** allow the device **104** to operate with enhanced functionality and flexibility. It should be noted that the following processing modes are illustrative and that other processing modes are possible within the scope of the embodiments.

Diverse Path Mode

[0024] In diverse path mode, the selection logic **106** operates to allow the device **104** to receive and process two versions of the same signal. For example, the transmitted signal may be associated with a voice call being processed by the device **104**. The diverse path mode allows the receiver to overcome the effects of fading or other adverse transmission conditions by

processing two versions of the voice call signal so that acceptable signal quality can be achieved. In this mode, the first antenna **110** receives the transmitted signal and inputs it to the splitter **114** of the primary receive path. The signal then flows to the primary receive logic **116** and on to be further processed by other logic at the device **104**. The second antenna **112** also receives the signal, however, the signal is out of phase from the signal received at the first antenna **110**. The second antenna **112** inputs the signal to the switch **118**. The control signal (Ctl) controls the switch **118** to output the signal from the second antenna **112** to the diverse path receiver **120**. The diverse path receiver **120** processes this signal and forwards the signal to be processed by baseband processing logic at the device **104**. Thus, the two antennas **110, 112** allow two versions of the same signal to be processed to reduce the effects of fading and/or other adverse transmission effects so that the voice call can be conducted with an acceptable quality level.

Multiple Signal Mode

[0025] In multiple signal mode, the selection logic **106** allows the device **104** to receive multiple signals for processing. For example, a first signal may be received that is associated with a voice call, and a second signal may be received that is associated with a GPS signal. In one embodiment, the switch **118** is controlled so that signals received by the second antenna **112** are routed to the diverse path receiving logic **120**. As a result, the primary receiving logic **116** operates to process the first signal received from the first antenna **110**, and the diverse receiving logic **120** operates to process the second signal from the second antenna **112**. Thus, the device **104** is able to receive and process two different information signals.

Optimized Signal Mode

[0026] In the optimized signal mode, the switch **118** is set to provide an optimal version of a signal to be processed by the diverse receiving logic **120**. For example, a desired signal, such as a GPS signal, may be received on both the first and second antennas **110, 112**. In one embodiment, the switch **118** is set so that the optimal version of the signal is routed to the diverse receiving logic **120**. For example, in one case the second antenna may receive the signal with the better quality, and as a result, the switch **118** routes the signal from the second antenna to the diverse receiving logic **120**. In another case, the first antenna **110** may receive the signal with the better quality, and as a result, the

switch **118** routes the signal from the first antenna **110** to the diverse receiving logic **120**. It should be noted that the processing of the signal by the diverse path occurs while the primary path processes the same or a different signal.

[0027] Therefore, the diverse path selection logic **106** allows a communication device to operate in a number of modes to provide the most efficient processing of one or more received information signals, thereby providing flexibility and performance not available in conventional devices.

[0028] **FIG. 2** shows a diagram of one embodiment of diverse path selection logic **200** for use in a communication device. For example, the selection logic **200** is suitable for use as the diverse path selection logic **106** shown in **FIG. 1**. The selection logic **200** comprises a primary receive path, shown generally at **202**, and a diverse receive path, shown generally at **204**.

[0029] In one embodiment, the primary receive path **202** comprises a duplexer **206**, transmit and receive amplifiers (**208**, **210**), signal splitter **212**, amplifier **236**, filter **214** and primary receive logic **216**. The diverse receive path **204** comprises filter **218**, receive amplifier **220**, filter **222**, switch **224**, and diverse receive logic **226**. It will be assumed that the primary receive path **202** is coupled to a first antenna **228**, and that the diverse receive path **204** is coupled to a second antenna **230**. In one embodiment, the first antenna **228** is located outside the housing of the communication device and the second antenna is located within the housing of the communication device. As a result, the first antenna **228** and the primary receive path **202** operate to provide superior performance over the second antenna **230** and the diverse receive path **204**.

[0030] Signals received at the first antenna **228** flow through the duplexer **206** and receive amplifier **210** to the splitter **214**. The splitter **214** comprises any suitable logic, circuitry or other technology that operates to split an input signal into two output signals. The splitter **212** operates to split the signal at it input into signals that are input to the amplifier **236** and a first terminal of the switch **224**.

[0031] Signals received at the second antenna **230** flow through the filter **218**, receive amplifier **220**, and filter **222** to a second terminal of the switch **224**. The switch **224** comprises any suitable switch technology and may include logic, discrete components, and/or solid-state circuitry that meet desirable linearity requirements. The switch **224** operates to switch one of the signals at its inputs to a switch output, so that the selected signal flows to the diverse receive logic **226**. In one embodiment, the switch **224** operates to select

one of the signals at its inputs based on a control signal **232**. In one embodiment, control logic **234** at the device provides the control signal **232**. However, the control signal **232** may also be provided by the primary receive logic **216**, the diverse receive logic **226**, or any other logic operating at the device.

[0032] During operation, the diverse path selection logic **200** operates to determine how signals received at the antennas **228**, **230** are routed to the diverse path receive logic **226**. For example, in one embodiment, the selection logic **200** selects how signals are routed to the diverse receive logic **226** based on the operating mode of the device. For example, if the operating mode is set to diverse path mode, then the control logic **234** controls the switch **224** to route the signals received on the antenna **230** to the diverse receive logic **226**. If the mode is set to multiple signal mode, then the control logic **234** controls the switch **224** to route the signals received on the antenna **230** to the diverse receive logic **226**. If the mode is set to optimized signal mode, then the control logic **234** controls the switch **224** so that an optimal version of a signal received on both antennas **228**, **230** is routed to the diverse path receiving logic **226**. For example, if a selected signal is received on both antennas **228**, **230**, then the control logic **234** will control the switch **224** so that the higher quality version of the signal is routed to the diverse receiving logic **226**.

[0033] In one embodiment, the diverse path selection logic **200** comprises a signal-bearing medium tangibly embodying a program of machine-readable instructions executable by a digital processing apparatus to perform the functions described herein. For example, instructions may be loaded into the selection logic **200** from a computer-readable media, such as a floppy disk, CDROM, memory card, FLASH memory device, RAM, ROM, or any other type of memory device or computer-readable media that interfaces to the selection logic **200**. In another embodiment, the instructions may be downloaded into the selection logic **200** from a network resource. The instructions, when executed by the selection logic **200**, provide one or more embodiments of a diverse path selection system as described herein.

[0034] It should be understood that the elements of the selection logic **200** shown in **FIG. 2** represent just one embodiment, and that implementation of the selection logic **200** could be achieved in one of any number of ways using greater or fewer functional elements. For example, some or all of the function elements shown could be implemented in hardware or in a computer program executed by one or more processors.

[0035] **FIG. 3** shows one embodiment of a method **300** for operating a diverse path receiving system for use in a communication device. The method **300** operates to allow device to process received signals in either diverse path mode or multiple signal mode. The method **300** is suitable for use by one or more embodiments of the diverse path receiving logic **200** shown in **FIG. 2**.

[0036] At block **302**, a first signal is received by the device using a primary receive path. For example, the first signal may be a voice call signal that is received via the first antenna **228** and processed by the primary receiver **216**.

[0037] At block **304**, an operating mode for the device is selected. For example, logic at the device selects an operating mode to provide selected functionality to the terminal user. One of two modes are selected, namely; diverse path mode or multiple signal mode. It should be noted that other modes are possible within the scope of the embodiments.

[0038] At block **306**, the diverse path mode is selected. For example, the diverse path mode is selected to allow the device to receive two versions of the same signal so that the versions may be processed together to counter the effects of fading and/or other degrading transmission effects.

[0039] At block **308**, signals from a second antenna are routed to a diverse path receiver. For example, the switch **224** is set to position 2 to operate in diverse path mode. For example, the control logic **234** sets the control signal **232** to control the switch **224** to select position 2. This allows signals received by the second antenna to be routed to the diverse receive logic **226**.

[0040] At block **310**, signals received by the second antenna are routed to the diverse receive logic **226**. This allows the terminal to perform diverse path processing because the diverse receive logic **226** receives a version of the same signal that is receive by the primary receive logic **216**. The method then proceeds to block **312** where the received signals are processed accordingly.

[0041] At block **314**, multiple signal mode is selected. For example, the terminal may operate to process a voice call and a GPS signal. The multiple signal mode is selected to allow the terminal to receive two different signals for processing.

[0042] At block **316**, the switch is set to position 2 to operate in multiple signal mode. For example, the control logic **234** sets the control signal **232** to control the switch **224** to select position 2. This allows signals received by the second antenna **230** to be routed to the diverse receive logic **226**.

[0043] At block **308**, signals received by the second antenna are routed to the diverse receive logic **226**. This allows the terminal to perform multiple

signal processing because the diverse receive logic **226** receives a different signal than the primary receive logic **216**. The method then proceeds to block **312**.

[0044] At block **312**, the signals are processed by the device based on the selected operating mode. It should be noted that the method **300** is just one embodiment and that changes, additions, deletions, or rearrangements of the method **300** are within the scope of the described embodiments.

[0045] **FIG. 4** shows one embodiment of a method **400** for operating a diverse path receiving system for use in a communication device. The method **400** operates to allow a communication device to process received signals in optimized signal mode. The method **400** is suitable for use by one or more embodiments of the diverse path selection logic **200** shown in **FIG. 2**.

[0046] At block **402**, a first signal is received by the device using a primary receive path. For example, the first signal may be a voice call signal that is received via the first antenna **228** and processed by the primary receiver **216**.

[0047] At block **404**, the optimized signal mode is selected. For example, the device may be operating to process a voice call and a paging message. The optimized signal mode is selected to allow the device to receive two different signals so that second signal is received with the best quality possible. For example, the second signal may be received on either of the two antennas, and the optimized signal mode allows the signal to be received on the antenna that provides the better quality.

[0048] At block **406**, a switch is set to select the first antenna to receive the desired second signal. For example, the control logic **234** sets the control signal **232** to control the switch **224** to select switch position 1. This causes signals received by the first antenna to be routed to the diverse receive logic **226**.

[0049] At block **408**, the desired second signal is received by the first antenna and routed to the diverse receive logic **226**.

[0050] At block **410**, a first quality indicator is determined. The diverse receive logic **226** operates to determine a first quality indicator associated with the received second signal. In one embodiment, the quality indicator is a signal strength indicator, however, any suitable quality indicator may be determined.

[0051] At block **412**, a switch is set to select the second antenna to receive the desired second signal. For example, the control logic **234** sets the control signal **232** to control the switch **224** to select switch position 2. This causes signals received by the second antenna to be routed to the diverse receive logic **226**.

[0052] At block **414**, the desired second signal is received by the second antenna and routed to the diverse receive logic **226**.

[0053] At block **416**, a second quality indicator is determined. The diverse receive logic **226** operates to determine a second quality indicator associated with the received second signal. In one embodiment, the quality indicator is a signal strength indicator, however, any suitable quality indicator may be determined.

[0054] At block **418**, a test is performed to determine which antenna has received the desired second signal with the better quality. For example, the diverse receive logic **226** operates to compare the first and second quality indicators to determine which antenna is receiving the desired second signal with better quality. In another embodiment, receiving logic in the device, such as baseband processing logic, operates to determine and compare the signal quality indicators. For example, any number of indicators or parameters may be used to determine which received signal has the better quality. For example, the logic may look at in-band power based on signal magnitude. Thus, any suitable signal quality indicators may be used to determine which antenna is providing the desired signal with the better quality. If it is determined that the first antenna is receiving the desired second signal with better quality, the method proceeds to block **422**. If it is determined that the second antenna is receiving the desired second signal with better quality, the method proceeds to block **420**.

[0055] At block **420**, the second antenna is selected to receive the desired second signal. For example, the diverse receiving logic **226** indicates the desired switch setting to the control logic **234** via the signal at **238**. The control logic **234** then sets the control signal **232** to control the switch **224** to select switch position 2. The method then proceeds to block **424**.

[0056] At block **422**, the first antenna is selected to receive the desired second signal. For example, the diverse receiving logic **226** indicates the desired switch setting the control logic **234** via the signal at **238**. The control logic **234** then sets the control signal **232** to control the switch **224** to select switch position 1. The method then proceeds to block **424**.

[0057] At block **424**, the desired second signal is received with the best signal quality and routed to the diverse path receive logic **226**. At block **428**, the device processes the received first and second signals as desired.

[0058] It should be noted that the method **400** is just one embodiment and that changes, additions, deletions, or rearrangements of the method **400** are within the scope of the described embodiments. For example, the method **400** may be combined with one or more functions of the method **300** within the scope of the described embodiments.

[0059] In another embodiment, the method **400** is adjusted so that the primary antenna **228** is always selected to provide its received signal to the diverse receive logic **226**. For example, the switch **224** is set to position 1 whenever the optimized signal mode is activated.

[0060] A diverse path antenna selection system for selecting signals to be processed by a diverse path in a communication device has been presented. Accordingly, while one or more embodiments of the diverse path selection system have been illustrated and described herein, it will be appreciated that various changes can be made to the embodiments without departing from their spirit or essential characteristics. Therefore, the disclosures and descriptions herein are intended to be illustrative, but not limiting, of the scope of the invention, which is set forth in the following claims.

I CLAIM:

CLAIMS

1. A method for receiving a signal in a communication device having first and second antennas, the method comprising:

receiving a first version of the signal using the first antenna;

receiving a second version of the signal using the second antenna;

determining a first quality indicator and a second quality indicator associated with the first and second versions of the signal, respectively;

selecting one of the first and second versions of the signal to process based on the first and second quality indicators.

2. The method of claim **1**, wherein the step of determining comprises switching the first and second versions of the signal to receiving logic that operates to measure the first and second quality indicators.

3. The method of claim **1**, wherein the step of receiving the first version of the signal comprises splitting the first version of the signal from a receive path associated with the first antenna.

4. The method of claim **1**, wherein the step of determining comprises determining the first quality indicator and the second quality indicator associated with the first and second versions of the signal, respectively, wherein the first quality indicator is a first signal strength indicator and the second quality indicator is a second signal strength indicator.

5. Apparatus for receiving a signal in a device having first and second antennas, wherein the first antenna receives the signal and produces a first version of the signal, and the second antenna receives the signal and produces a second version of the signal, the apparatus comprising:

a switch coupled to receive the first and second versions of the signal and a control signal, wherein the switch operates to selectively couple one of the first and second versions of the signal to receiving logic based on the control signal;

control logic that operates to output the control signal based one or more signal quality indicators associated with the first and second versions of the signal.

6. The apparatus of claim **5**, further comprising a splitter coupled between the first antenna and the switch.

7. The apparatus of claim **5**, wherein the one or more signal quality indicators comprise a signal strength indicator.

8. The apparatus of claim **5**, wherein the receiving logic operates to determine the one or more signal quality indicators.

9. Apparatus for receiving a signal in a communication device having first and second antennas, the apparatus comprising:

means for receiving a first version of the signal using the first antenna;

means for receiving a second version of the signal using the second antenna;

means for determining a first quality indicator and a second quality indicator associated with the first and second versions of the signal, respectively;

means for selecting one of the first and second versions of the signal to process based on the first and second quality indicators.

10. The apparatus of claim **9**, wherein the means for determining comprises means for switching the first and second versions of the signal to receiving logic that operates to measure the first and second quality indicators.

11. The apparatus of claim **9**, wherein the means for receiving the first version of the signal comprises means for splitting the first version of the signal from a receive path associated with the first antenna.

12. The apparatus of claim **9**, wherein the means for determining comprises means for determining the first quality indicator and the second quality indicator associated with the first and second versions of the signal, respectively, wherein the first quality indicator is a first signal strength indicator and the second quality indicator is a second signal strength indicator.

13. A signal-bearing medium tangibly embodying a program of machine-readable instructions executable by a digital processing apparatus to perform a method for receiving a signal in a communication device having first and second antennas, said method comprising operations of:

receiving a first version of the signal using the first antenna;

receiving a second version of the signal using the second antenna;

determining a first quality indicator and a second quality indicator associated with the first and second versions of the signal, respectively;

selecting one of the first and second versions of the signal to process based on the first and second quality indicators.

14. The signal-bearing medium of claim **21**, wherein the operation of determining comprises switching the first and second versions of the signal to receiving logic that operates to measure the first and second quality indicators.

15. The signal-bearing medium of claim **21**, wherein the operation of receiving the first version of the signal comprises splitting the first version of the signal from a receive path associated with the first antenna.

16. The signal-bearing medium of claim **21**, wherein the operation of determining comprises determining the first quality indicator and the second quality indicator associated with the first and second versions of the signal, respectively, wherein the first quality indicator is a first signal strength indicator and the second quality indicator is a second signal strength indicator.