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(54) **METHODS AND COMMUNICATION SYSTEMS HAVING ADAPTIVE MODE SELECTION**

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(51) **Int. Cl.**
H04B 1/38 (2006.01)

(52) **U.S. Cl.**
USPC **375/219**; 375/295; 375/260

(58) **Field of Classification Search**
USPC 375/219, 295, 260
See application file for complete search history.

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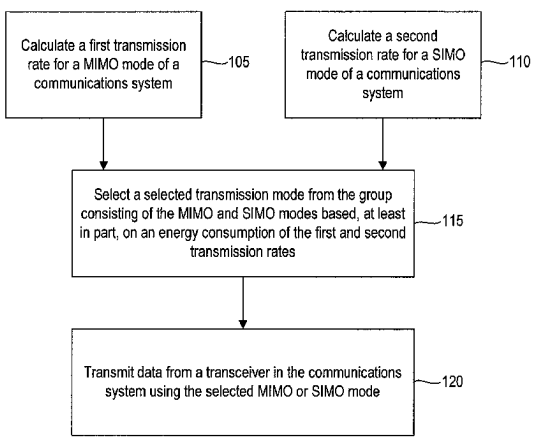
(57) **ABSTRACT**

Examples are generally described that include methods for selecting a transmit mode in a communications system. An example method may include calculating a first transmission rate for data in a multiple-input multiple-output mode of the communications system and calculating a second transmission rate for the data in a single-input multiple-output mode of the communications system. A mode may be selected from the group consisting of the multiple-input multiple-output mode and the single-input multiple-output mode based, at least in part, on an energy consumption of the first and second transmission rates. Data may be transmitted from a transceiver in the communications system using the selected mode.

29 Claims, 4 Drawing Sheets



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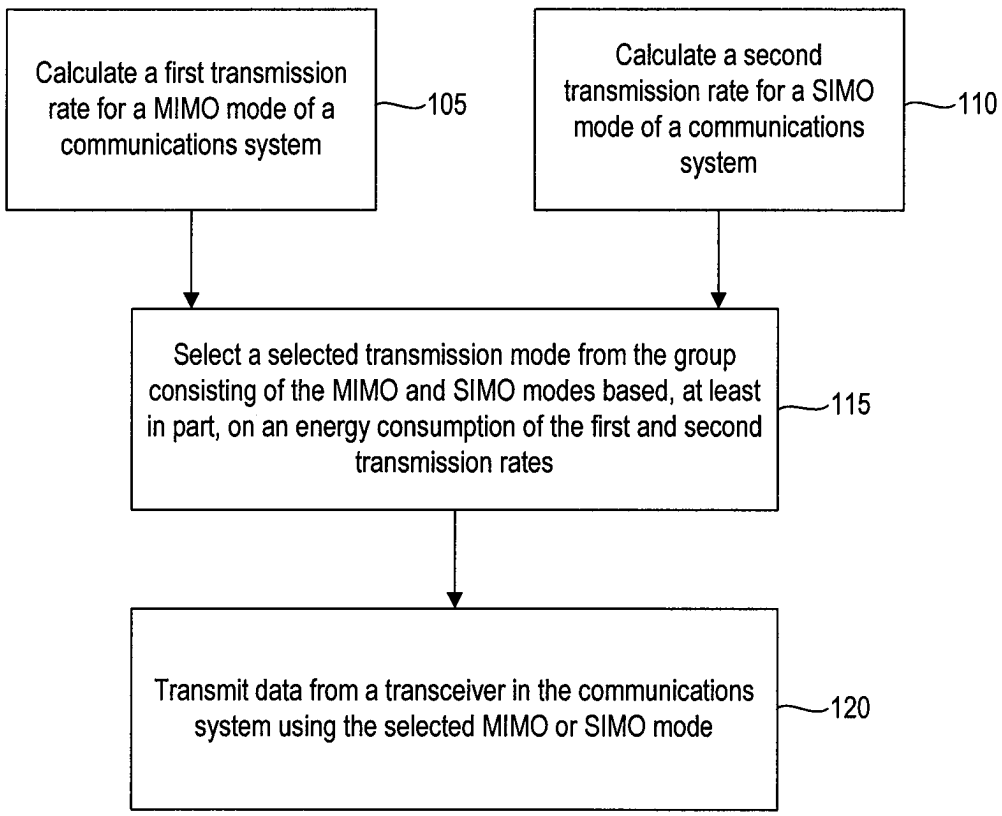
Calculate a first transmission rate for a MIMO mode of a communications system
105
Calculate a second transmission rate for a SIMO mode of a communications system
110
Select a selected transmission mode from the group consisting of the MIMO and SIMO modes based, at least in part, on an energy consumption of the first and second transmission rates
115
Transmit data from a transceiver in the communications system using the selected MIMO or SIMO mode
120

Figure 1

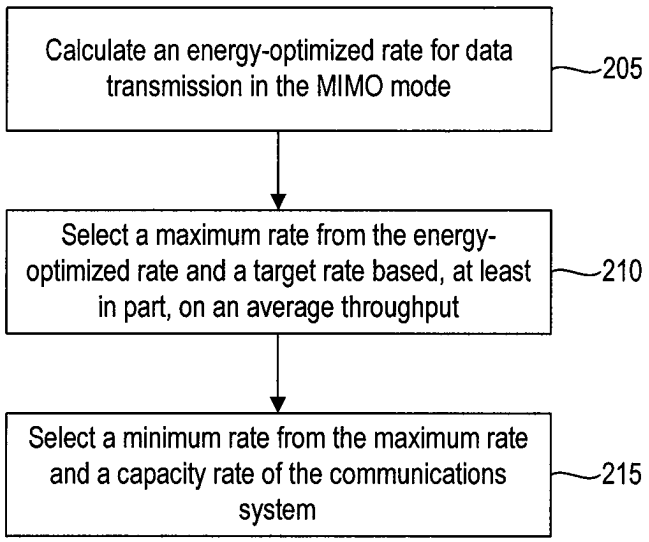

Figure 2

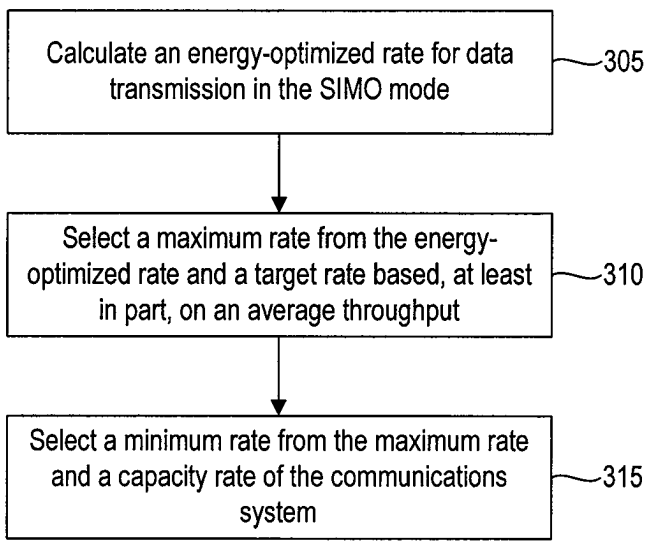

Figure 3

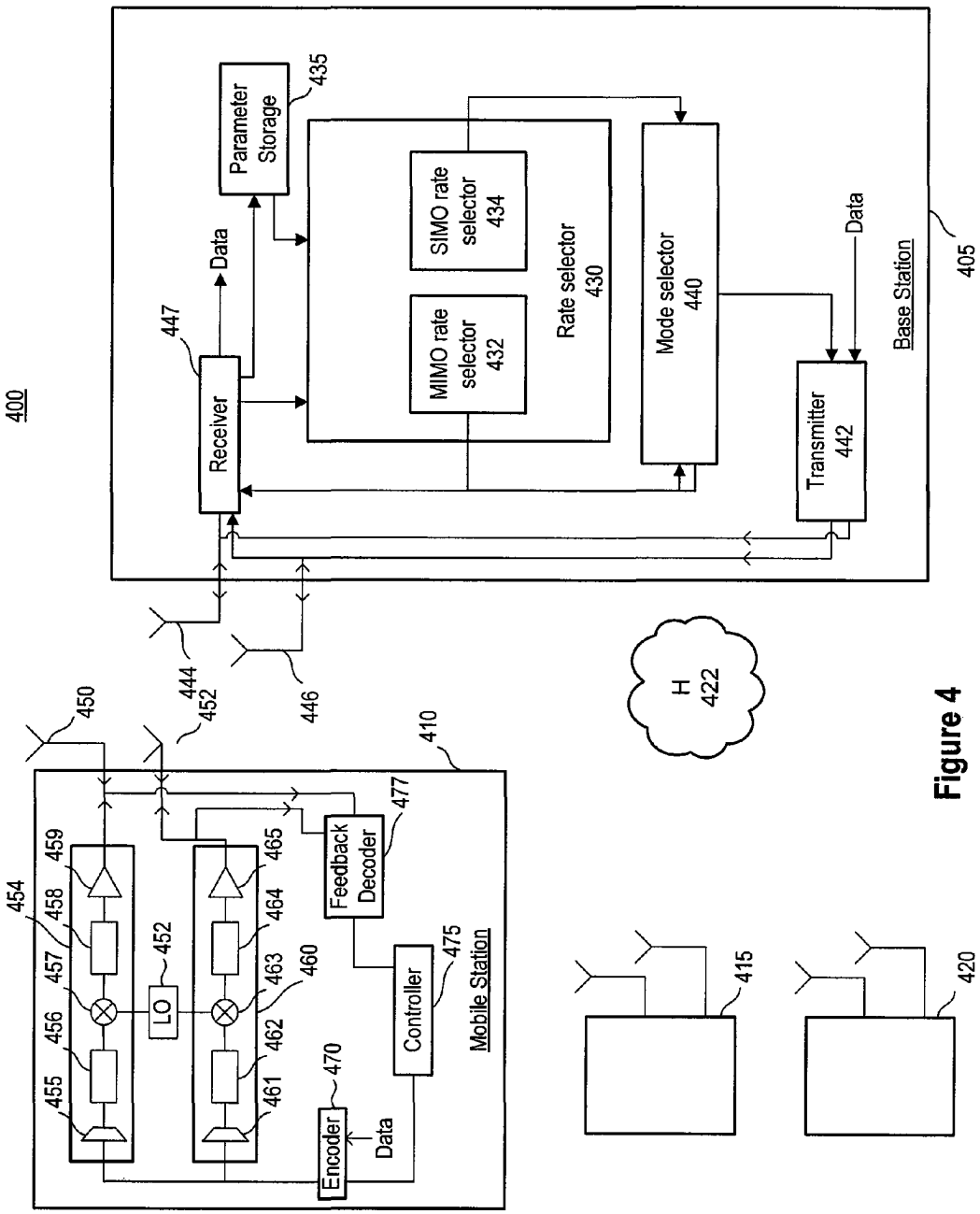
400
Parameter Storage
435
Data
447
Receiver
SIMO rate selector 434
MIMO rate selector 432
Rate selector 430
Mode selector 440
Data
Transmitter 442
Base Station
405
444
446
450
452
410
454
459
458
457
456
455
452
LO
465
464
463
460
462
461
Feedback Decoder
477
Controller
475
Mobile Station
Encoder
470
Data
H 422
415
420

Figure 4

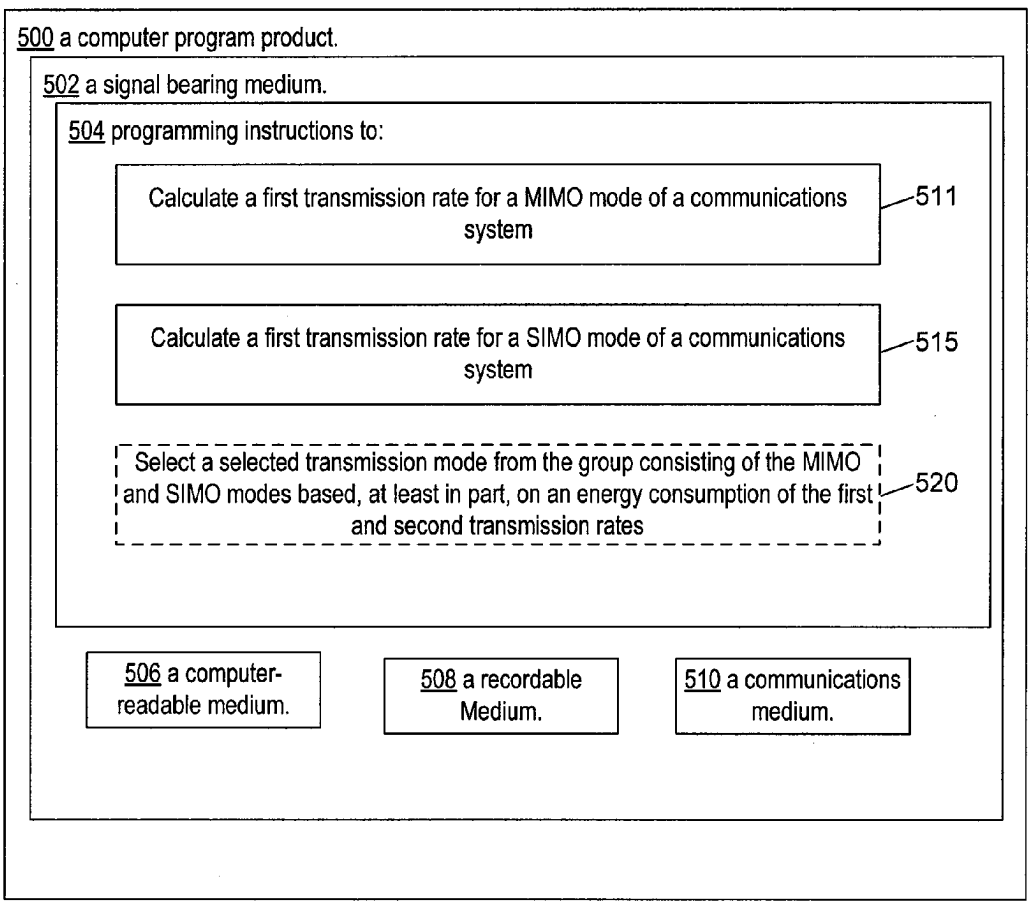
500 a computer program product.
502 a signal bearing medium.
504 programming instructions to:
Calculate a first transmission rate for a MIMO mode of a communications system
511
Calculate a first transmission rate for a SIMO mode of a communications system
515
Select a selected transmission mode from the group consisting of the MIMO and SIMO modes based, at least in part, on an energy consumption of the first and second transmission rates
520
506 a computer-readable medium.
508 a recordable Medium.
510 a communications medium.

Figure 5

METHODS AND COMMUNICATION SYSTEMS HAVING ADAPTIVE MODE SELECTION

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of the filing date of U.S. Provisional Application Ser. No. 61/161,166, filed Mar. 18, 2009, which application is hereby incorporated by reference in its entirety for any purpose.

BACKGROUND

Unless otherwise indicated herein, the materials described in this section are not prior art to the claims in this application, and are not admitted to be prior art by inclusion in this section.

Multiple-input multiple-output (MIMO) communication systems employ multiple transmit antennas and multiple receive antennas to communicate data symbols over a communications channel. MIMO communication systems may allow a plurality of receivers to be serviced utilizing a same frequency band. In this manner, MIMO communication systems may advantageously increase an amount of data the communication systems are able to send to users.

Single-input multiple-output (SIMO) communication systems may employ a single transmit antenna and multiple receive antennas to communicate data symbols over a communications channel.

MIMO and SIMO systems may find use in a variety of applications including, but not limited to, wireless networks, cellular systems including 3G and 4G systems, such as 3GPP LTE-Advanced, local and wide area networks, and wireless broadband systems (such as WiMAX or WiMAX2).

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other features of the present disclosure will become more fully apparent from the following description and appended claims, taken in conjunction with the accompanying drawings. Understanding that these drawings depict only several examples in accordance with the disclosure and are, therefore, not to be considered limiting of its scope, the disclosure will be described with additional specificity and detail through use of the accompanying drawings, in which:

In the drawings:

FIG. **1** is a flow diagram illustrating a method for selecting a transmit mode in a communications system;

FIG. **2** is a flow diagram illustrating a method for calculating the first transmission rate for a MIMO mode of a communications;

FIG. **3** is a flow diagram illustrating a method for calculating the second transmission rate for a SIMO mode of a communications;

FIG. **4** is a schematic illustration of a communications system, all arranged in accordance with at least some examples of the present disclosure; and

FIG. **5** is a block diagram illustrating an example computer program product **500** that is arranged to store instructions for selecting a transmission rate and selecting a transmission mode in accordance with at least some examples of the present disclosure.

DETAILED DESCRIPTION

In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the

drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative examples described in the detailed description, drawings, and claims are not meant to be limiting. Other examples may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the Figures, can be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are implicitly contemplated herein.

This disclosure is drawn, inter alia, to methods, systems, devices, and/or apparatus generally related to selecting a transmit mode in a communications system. An example method may include calculating a first transmission rate for data in a multiple-input multiple-output mode of the communications system and calculating a second transmission rate for the data in a single-input multiple-output mode of the communications system. A mode may be selected from the group consisting of the multiple-input multiple-output mode and the single-input multiple-output mode based, at least in part, on an energy consumption of the first and second transmission rates. Data may be transmitted from a transceiver in the communications system using the selected mode.

FIG. **1** is a flow diagram illustrating some example methods for selecting a transmit mode in a communications system arranged in accordance with at least some examples of the present disclosure. Example methods illustrated by FIG. **1** may include one or more functions, operations or actions as are illustrated by block **105**, **110**, **115** and/or **120**. Processing may begin at block **105** and/or block **110**.

In block **105**, a first transmission rate for a multiple-input multiple-output (MIMO) mode of a communications system may be calculated. In block **110**, a second transmission rate for a single-input multiple-output (SIMO) mode of a communications system may be calculated. Block **115** may follow the conclusion of the calculations of blocks **105** and/or **110**. In block **115**, a selected mode may be selected from the group consisting of the MIMO and SIMO modes. The selection may be based, at least in part, on an energy consumption of the first and second transmission rates. Block **115** may be followed by block **120**. In block **120**, data may be transmitted from a transceiver in the communications system using the selected MIMO or SIMO mode. In this manner, as will be described further below, MIMO or SIMO mode operation may be adaptively selected during operation of the communications system.

In block **105**, a first transmission rate for a MIMO mode of the communications system may be calculated. The first transmission rate may be calculated based, at least in part, on an energy-optimized rate for data in the MIMO mode. The energy-optimized rate may be based, at least in part, on power consumption of circuitry coupled to a plurality of antennas at the transceiver which are configured to transmit in the MIMO mode. That is, the power consumed by the circuitry used to process signals for antennas used to transmit in the MIMO mode may be included in the calculation of the energy-optimized rate. The energy-optimized rate may also or instead be based, at least in part, on a power consumption of the transceiver during an idle time. The idle time is a time during which the transceiver may be waiting to send data over the communications channel. The transceiver may, for example, be waiting for a scheduled start time for the transceiver to use the communications channel. Generally, greater power is needed to transmit at higher rates in the communications system. Accordingly, power may be saved by reducing the transmission rate in the MIMO mode when a lower transmis-

sion rate is acceptable for a particular application, to achieve a particular average throughput in some examples. However, if the transmission rate is too slow, a greater number of transceivers may become idle, waiting to send transmissions over the communications channel. Even if the idling transceivers turn off their transmission chains, some idle power may be consumed due to leakage current or other effects. The idle power spent at a lower transmission rate may accordingly make the lower transmission rate less desirable in some examples.

The energy-optimized rate may be expressed mathematically in the following equation:

$$e_{i,z}(t) = \underset{r}{\operatorname{argmin}}(\upsilon_i(t) f_{i,z}(r/\upsilon_i(t)) + (1-\upsilon_i(t))p_{idle})\frac{1}{r};$$

where $e_{i,z}(t)$ is the energy-optimized rate for a user i, the index z designates the MIMO mode, and r designates rate. $\upsilon_i(t)$ is a fraction of time the user i is transmitting, and $1-\upsilon_i(t)$ is a fraction of time the user i is idle. In some examples, where temporally fair scheduling may be used, $\upsilon_i(t)$ may be equal to 1/n(t) where n(t) is a number of users of the communications system. $f_{i,z}(r/\upsilon_i(t)$ is a function for an amount of power consumed by user i during transmission.

Any of a variety of power models may be used to calculate the amount of power consumed by user i during transmission in the MIMO mode. The power consumption expression may vary with the type of receiver used, such as a zero forcing receiver, maximum-likelihood receiver, or MMSE receiver in some examples. In one example, the transmission power equation f(r) may be expressed mathematically as:

$$f(r) = \frac{2N_0}{\eta\phi_1\phi_2}\left(\sqrt{\left(\frac{\phi_1+\phi_2}{2}\right)^2 + \phi_1\phi_2(2^{r/w}-1)} - \frac{\phi_1+\phi_2}{2}\right) + p_{dc,m};$$

where N_0 is the noise power, η is an efficiency of a power amplifier used to power one or more transmit antennas; ϕ_1 and ϕ_2 are eigenvalues of H*H, where H is a channel matrix representing an operation of a channel on a transmitted data symbol, and H* is the complex conjugate of H; r is the transmission rate, w is the spectral bandwidth, and $p_{dc,m}$ is a power consumption of circuitry coupled to the multiple antennas configured to transmit in the MIMO mode. The power consumption of the circuitry may include any of a variety of circuit components, including power consumption of one or more digital-to-analog converters, mixers, filters, and frequency synthesizers.

The first transmission rate may be equal to the energy-optimized rate, or may be based on the energy-optimized rate. The calculation of the first transmission rate may also take into account a target rate and a capacity rate in some examples, which will be described further below.

Referring again to FIG. **1**, in block **110** a second transmission rate for a SIMO mode of the communications system may be calculated. The order of execution of the blocks **105** and **110** may vary in examples of the invention. All or a portion of the calculations in blocks **105** and **110** may occur in parallel in some examples. In other examples, the calculation of the first transmission rate may occur before the calculation of the second transmission rate, and in other examples, the calculation of the second transmission rate may occur before the calculation of the first transmission rate.

Recall the energy-optimized rate may be mathematically expressed as written above:

$$e_{i,z}(t) = \underset{r}{\operatorname{argmin}}(\upsilon_i(t) f_{i,z}(r/\upsilon_i(t)) + (1-\upsilon_i(t))p_{idle})\frac{1}{r};$$

in block **110**, the z index refers to the SIMO mode. Any of a variety of power models may be used to calculate the amount of power consumed by user i during transmission in the SIMO mode. The power consumption expression may vary with the type of receiver used, such as a zero forcing receiver, maximum-likelihood receiver, or MMSE receiver in some examples. In one example, the transmission power equation f(r) may be expressed mathematically as:

$$f(r) = \frac{1}{\eta}\frac{2^{r/w}-1}{\sum_{l=1}^{N_r}|h_{l,k}|^2}N_0 + p_{dc,s};$$

where N_0 is the noise power, η is an efficiency of a power amplifier used to power one or more transmit antennas; l is an index of a number of antennas, N_r is a number of receive antennas, and h_k is the kth column vector of the channel matrix H; r is the transmission rate, w is the spectral bandwidth, and $p_{dc,s}$ is a power consumption of circuitry coupled to the multiple antennas configured to transmit in the SIMO mode. The power consumption of the circuitry may include any of a variety of circuit components, including power consumption of one or more digital-to-analog converters, mixers, filters, and frequency synthesizers. Note that in SIMO mode, only one set of circuitry coupled to the single transmit antenna may contribute substantially to the $p_{dc,s}$ term. Accordingly, SIMO mode may consume less power in circuitry for the transmit antennas than MIMO mode at some rates.

While examples of the calculation of first and second transmission rates involving an energy-optimized rate have been described above, in some examples the first and second transmission rates may be specified by the communications system, and may be equal to one another.

Referring again to FIG. **1**, in block **115** a selected mode may be selected from the group consisting of the MIMO mode and the SIMO mode based, at least in part, on an energy consumption of the first and second transmission rates. That is, either the MIMO mode or the SIMO mode may be selected based, at least in part, on which mode provides a lower energy per bit for transmission in the communications system. Mathematically, the selection may be described as evaluation of the function for each user i where the selected mode z is given as:

$$\hat{z} = \underset{z\in\{m,s\}}{\operatorname{argmin}}\frac{f_{i,z}(n(t)r_{i,z}(t))}{r_{i,z}(t)},$$

where $f_{i,z}$ is a transmit power function, examples of which were described above, and $r_{i,z}$ represents the first and second transmission rates for the respective modes z.

A crossover point for when SIMO consumes less power than MIMO, or vice versa, may be considered a function of any of a variety of variables including, but not limited to, the power consumed by circuitry processing signals for the receive antennas, a number of receive antennas, and channel correlations. The power consumed by circuitry and number of

receive antennas effect the power consumed during transmission, as described above, and accordingly may affect the crossover point. Correlations in the communications channel of the communications system may further effect the crossover point by reducing an available capacity of the MIMO mode, making a SIMO mode more energy efficient in some examples.

The transmission mode may be selected periodically in block **115** in some examples. In some examples, the transmission mode may be selected once for each data frame. In this manner, the transmission mode may be adaptively changed during operation of a communications system.

In block **120**, data may be transmitted from a transceiver in the communications system using the selected MIMO or SIMO mode. In some examples, the selection of the MIMO or SIMO mode may be made in a base station of the communications system. The transmission mode may then be communicated to a mobile station, which may then encode data for transmission in accordance with the indicated MIMO or SIMO mode. If SIMO mode is selected, a particular antenna may also be specified for use in transmission. In one example, the antenna selected is one in which the product $h_k^*h_k$ is largest, where h_k is the k-th column vector of the channel matrix H.

FIG. **2** is a flow diagram illustrating some example methods for calculating the first transmission rate for a MIMO mode of a communications system arranged in accordance with at least some examples of the present disclosure. Example methods illustrated by FIG. **2** may include one or more functions, operations or actions as are illustrated by blocks **205**, **210**, and/or **215**. Processing for the illustrated methods may begin at block **205**.

In block **205**, an energy-optimized rate for data transmission in the MIMO mode may be calculated, for example, by a base station in a communications system. Block **205** may be followed by block **210**. In block **210**, a maximum rate may be selected, for example, by a base station in a communications system, from the energy-optimized rate and a target rate based, at least in part, on an average throughput. Block **210** may be followed by block **215**. In block **215**, a minimum rate may be selected, for example, by a base station in a communications system, from the maximum rate and a capacity rate of the communications system. The minimum rate selected in the block **215** may then be utilized as the first transmission rate described with reference to FIG. **1**.

In block **205**, an energy-optimized rate for data transmission in the MIMO mode may be calculated, by a device such as a base station in a communications system. Examples of the calculation of the energy-optimized rate have been described above. In some examples, the energy-optimized rate may be used as the first transmission rate used to select the mode. However, in other examples, a different rate may be used, as described further now with reference to FIG. **2**.

In block **210**, a maximum rate may be selected, by a device such as a base station in a communications system, from the energy-optimized rate and a target rate based, at least in part, on an average throughput. One or more receivers or transmitters in the communications system may specify an average throughput for data. In some examples, the average throughput itself may be equivalent to the target rate. In other examples, the target rate may be reduced relative to the average throughput if the data to be transmitted is fault tolerant, such as in examples where data files are transmitted in the communications system. Accordingly, the target rate represents a rate required by a user, transmitter, or receiver, of the communications system. If the energy-optimized rate is less than the target rate, the target rate may instead be used as the first transmission rate in FIG. **1**. If the energy-optimized rate is greater than the target rate, the energy-optimized rate may be used as the first transmission rate in FIG. **1**.

Referring again to FIG. **2**, in block **215**, a minimum rate may be selected, by a device such as a base station in a communications system, from the maximum rate selected in block **210** and a capacity rate of the communications system. The capacity rate may represent a maximum feasible transmission rate of the communications system. Accordingly, if the rate selected in the block **210** is greater than the capacity rate, the capacity rate may be used as the first transmission rate in FIG. **1**. If the rate selected in the block **210** is less than the capacity rate, the rate selected in the block **210** may be used as the first transmission rate in FIG. **1**. The capacity rate may be calculated based on parameters of the communications system, including an available power supply, for example.

FIG. **3** is a flow diagram illustrating some methods for calculating the second transmission rate for a SIMO mode of a communications system arranged in accordance with at least some examples of the present disclosure. Example methods illustrated by FIG. **3** may include one or more functions, operations or actions as are illustrated by blocks **305**, **310**, and/or **315**. Processing for the illustrated methods may begin at block **305**.

In block **305**, an energy-optimized rate for data transmission in the SIMO mode may be calculated, for example, by a base station in a communications system. Block **305** may be followed by block **310**. In block **310**, a maximum rate may be selected, for example, by a base station in a communications system, from the energy-optimized rate and a target rate based, at least in part, on an average throughput. Block **310** may be followed by block **315**. In block **315**, a minimum rate may be selected, for example, by a base station in a communications system, from the maximum rate and a capacity rate of the communications system. The minimum rate selected in the block **315** may then be utilized as the second transmission rate described with reference to FIG. **1**.

In block **305**, an energy-optimized rate for data transmission in the SIMO mode may be calculated, for example, by a base station in a communications system. Examples of the calculation of the energy-optimized rate have been described above. In some examples, the energy-optimized rate may be used as the first transmission rate used to select the mode. However, in other examples, a different rate may be used, as described further now with reference to FIG. **3**.

In block **310**, a maximum rate may be selected, for example, by a base station in a communications system, from the energy-optimized rate and a target rate based, at least in part, on an average throughput. The target rate has been described above. If the energy-optimized rate for the SIMO mode calculated in the block **305** is less than the target rate, the target rate may instead be used as the first transmission rate in FIG. **1**. If the energy-optimized rate is greater than the target rate, the energy-optimized rate may be used as the second transmission rate in FIG. **1**.

Referring again to FIG. **3**, in block **315**, a minimum rate may be selected, for example, by a base station in a communications system, from the maximum rate selected in block **310** and a capacity rate of the communications system. The capacity rate has been described above with reference to FIG. **2**. If the rate selected in the block **310** is greater than the capacity rate, the capacity rate may be used as the second transmission rate in FIG. **1**. If the rate selected in the block **310** is less than the capacity rate, the rate selected in the block **310** may be used as the second transmission rate in FIG. **1**.

FIG. **4** is a schematic illustration of some example communications systems arranged in accordance with at least some examples of the present disclosure. The example communications system **400** includes a base station **405** and three mobile stations **410**, **415**, and **420**. The base station **405** is configured to communicate with the mobile stations **410**, **415**, and **420** over a communications channel **422** represented by a channel matrix H. The base station **405** includes a rate selector **430**, which may include a MIMO rate selector **432** and SIMO rate selector **434**. Parameter storage **435** may be coupled to the rate selector **430**. A mode selector **440** may be coupled to the rate selector **435** and a transmitter **442**. The base station **405** may include two antennas **444** and **446** configured to transmit and/or receive over the communications channel **422**. A decoder **447** may be coupled to the antennas **444** and **446** and the transmitter **442**, and may be further coupled to the parameter storage **435**. The mobile station **410** may include two antennas **450** and **452**. First circuitry **454** is coupled to the antenna **450** and configured to process signals for transmission by the antenna **450**. The first circuitry may include a digital-to-analog converter **455**, a filter **456**, a mixer **457**, a filter **458**, and a power amplifier **459**. Second circuitry **460** may be coupled to the antenna **452** and configured to process signals for transmission by the antenna **452**. The second circuitry **460** may also include a digital-to-analog converter **461**, a filter **462**, a mixer **463**, a filter **464**, and a power amplifier **465**. A local oscillator **452** may be coupled to the first circuitry **454** and the second circuitry **460** at the respective mixers **457** and **463**. An encoder **470** may be coupled to the first and second circuitry. A controller **475** may be coupled to the encoder **470** and configured to provide a signal to the encoder **470** to operate in a MIMO mode or a SIMO mode. A feedback decoder **477** may be coupled to the controller **475** and one or more of the antennas **450** and **452** and configured to decode received data and provide a signal to the controller **475** corresponding to a selected mode. The mobile stations **415** and **420** may have analogous components to the mobile station **410**, which are not shown in FIG. **4**. Further, blocks used to encode and modulate data for transmission over the communications channel **422** and decode and demodulate data received over the communications channel **422** have not necessarily been shown in FIG. **4** to avoid obscuring the components shown and described below.

The base station **405** may be configured to communicate with any number of mobile stations, including the mobile stations **410**, **415**, and **420** shown in FIG. **4**. The base station **405** may be configured to transmit data symbols over the communications channel **422** to the base stations **410**, **415**, and **420**. Examples of components of the base station **405** are described further below, however, not all components of the base station **405** may be described. In particular, the base station **405** may include any of a variety of components useful for encoding, decoding, transmitting, and/or receiving over the communications channel including for example encoders, decoders, modulators, demodulators, analog-to-digital converters, digital-to-analog converters, etc.

Any number of antennas may be included at the base station **405**, including the antennas **444** and **446**. The antennas may be configured to transmit data symbols over the communications channel **422**, and receive data symbols over the communications channel. Multiple antennas may be configured to allow for spatial multiplexing, as is generally described above.

The rate selector **430** may be configured to generate a first signal corresponding to a first transmission rate for data in a multiple-input multiple-output mode of the communications system **400** and a second signal corresponding to a second transmission rate for data in a single-input multiple-output mode of the communications system **400**. Accordingly, the rate selector **430** may implement examples of the methods for calculating the first and second transmission rates as described above. The rate selector **430** may be implemented in hardware, software, or combinations thereof, and one or more processing units used to implement the rate selector **430** may, in some examples, be shared with other components of the base station **405** described herein. Although shown in the base station **405**, the rate selector **430** may in some embodiments be provided at one or more of the mobile stations **410**, **415**, and **420**. That is, in some examples, when the mobile station may be configured to calculate one or more transmission rates as described above. Generally, when the mobile station is configured to calculate the transmission rates, the mobile station may be provided with information suitable for making the calculation, including, for example, information about the channel **422**.

The rate selector **430** may include a MIMO rate selector **432** and a SIMO rate selector **434**. Although illustrated separately in FIG. **4**, the MIMO and SIMO rate selectors may be implemented in some examples using all or portions of the same hardware, software, or combinations thereof. The MIMO rate selector **432** may be configured to calculate the first transmission rate based, at least in part, on an energy-optimized rate for data in the multiple-input-multiple-output mode. The MIMO rate selector **432** may be further configured to calculate the energy-optimized rate.

The SIMO rate selector **434** may be configured to calculate the second transmission rate based, at least in part, on an energy-optimized rate for data in the single-input-multiple-output mode. The SIMO rate selector **434** may be further configured to calculate the energy-optimized rate.

The MIMO and SIMO rate selectors **432** and **434** may accordingly make use of one or multiple parameters of the communications system **400** in calculating the first and second transmission rates, as generally described above, including, but not limited to, idle power consumption of one or more mobile stations, transmission circuitry power consumption of one or more mobile stations, number of users of the communications system, number of receive antennas at the base station or one or more mobile stations, and variations in the communications channel **422**. These parameters may be provided to the rate selector **430**, including the MIMO and SIMO rate selectors **432** and **434**, in any of a variety of ways, examples of which are described further below.

One or more of the parameters used by the rate selector **430** may be stored in the parameters storage **435**. Any type of storage device may be used to implement the parameter storage **435**, including any type of electronic memory, which may be integral to or in communication with the base station **405**.

Various data or other information associated with a power consumption of the mobile station **410** during an idle time, or other mobile stations in the communications system **400** may be stored in the parameter storage **435**. Recall the idle time may include times during which the mobile station **410** is waiting to send data over the communications channel, such as waiting for a scheduled time to begin transmission. Alternatively or in addition to storing information related to the power consumption of the mobile station **410** during an idle time, a signal indicative of the power consumption during an idle time may be provided to the rate selector **430**, without necessarily storing the parameter. In some examples, a default value may be stored and may be updated by a communication from the mobile station **410**, or other mobile stations, over the communications channel **422**. A feedback control channel may be used to carry the updated power consumption infor-

mation, and it may be received and decoded by the receiver **447**, and stored in the parameter storage **435**.

Various information associated with power consumption of the circuitry **454** and **460** may be stored in the parameter storage **435**. The information may include a rate of power consumption of the circuitry **454** or **460** during the transmission of data over the communications channel. Alternatively or in addition to storing information related to the power consumption of the circuitry **454** or **460**, a signal indicative of the power consumption of the circuitry **454** or **460** may be provided to the rate selector **430**, without necessarily storing the information. In some examples, a default value may be stored and may be updated by a communication from the mobile station **410**, or other mobile stations, over the communications channel **422**. A feedback control channel may be used to carry the updated circuitry power consumption information, and it may be received and decoded by the receiver **447**, and stored in the parameter storage **435**.

Various data or other information indicating a number of users of the communications system **400** may be stored in the parameter storage **435**, and a signal indicative of the number of users may be provided to the rate selector **430**. In some examples, the signal may not be provided by the parameter storage **435**, and may be provided by another component of the base station **405** (not necessarily shown in FIG. **4**) that has access to the number of users, such as a component of the base station **405** involved in scheduling user transmission.

A number of receive antennas at the base station is known to the base station, and a signal indicative of the number of antennas may be used by the rate selector **430** in calculating the first and second transmission rates for MIMO and SIMO modes, respectively. A number of antennas at one or more of the mobile stations **410**, **415**, **420**, may communicated to the base station **405** and provided to the rate selector **430**. Alternatively or in addition, the number of antennas may be stored in the parameter storage **435**.

Channel variations or other channel information used by the rate selector **430** may be stored in the parameter storage **435** in some examples, and may be provided to the rate selector **430** by other components of the base station **405** (not necessarily shown in FIG. **4**), such as components involved in the generation or analysis of channel state information.

The mode selector **440** may be coupled to the rate selector. The mode selector **440** may be configured to receive the first and second signals indicative of the first and second transmission rates. The mode selector **440** may be configured to select a selected mode from the group consisting of the multiple-input multiple-output mode and the single-input multiple-output mode based, at least in part, on an energy consumption of the first and second transmission rates. The mode selector **440** may be implemented in hardware, software, or combinations thereof, and one or more processing units used to implement the mode selector **440** in some examples may be shared with other components of the base station **440** described herein. Although the mode selector **440** is shown in FIG. **4** in the base station **405**, in other examples the mode selector **440** may be implemented in one or more mobile stations, such as the mobile station **410**, **415**, or **420**. The mode selector **440** may be configured to implement examples of methods described above for selecting between the MIMO and SIMO mode. In making the selection, the mode selector **440** may also be provided with one or more signals indicative of parameters of the communications system **400**, as generally described above with reference to the rate selector **430**. The mode selector **440** may also be configured to identify one of a plurality of transmit antennas at a mobile station to use when SIMO mode is selected. The mode selector **440** may also provide a signal corresponding to the selected mode to the receiver **447**.

The transmitter **442** may be coupled to the mode selector **440** and configured to transmit a signal corresponding to the selected mode to one or more of the mobile stations, such as the mobile station **410**. In some examples, the transmitter **442** may also be configured to encode data to be transmitted over the communications channel. In some examples, the signal corresponding to the selected mode may be implemented as a bit that may be included in one or more data frames. As mentioned above, the transmission mode may be changed periodically. In some examples, the transmission mode may be selected once for each data frame. In this manner, the transmission mode may be adaptively changed during operation of a communications system.

The transmitter **442** may also be configured to transmit a signal indicative of which of a plurality of transmit antennas at the mobile station to use when the mode is SIMO. For example, the transmitter **442** may be configured to transmit an indication that the antenna **450** at the mobile station **410** should be used to transmit when SIMO mode is selected.

The receiver **447** may be configured to receive and decode data from the communications channel **422**. The receiver **447** may be provided with a signal indicative of the selected mode from the mode selector **440**. Responsive to the signal, the receiver **447** may change the manner in which received data is decoded. The receiver **447** may thus be dynamically configured to decode received data in a different manner based on whether the SIMO mode is selected or the MIMO mode is selected. Any suitable strategy for SIMO or MIMO decoding may be implemented by the receiver **447**. In some examples, multiple decoders may be included in the base station **405**, including one for SIMO decoding and one for MIMO decoding. While in some examples the receiver **447** may implement a decoding method based on a selected mode provided by the mode selector **440**, in other examples the receiver **447** may implement a decoding method based on mode information received from one or more mobile stations, such as the mobile station **410**. In some examples as will be discussed further below, the mobile station **410** may be configured to override a mode selection received from the mode selector **440**, and a different mode may be used to transmit. The receiver **447** may accordingly be dynamically configured to decode data in accordance with a mode indicator received from one or more mobile stations. The receiver **447** may also decode feedback information received from one or more mobile stations, and provide signals to one or more of the parameter storage **435** and/or the rate selector **430**.

Any number of mobile stations may generally be configured for communication with the base station **405**. Three mobile stations **410**, **415**, and **420** are shown in FIG. **4**. Any of a variety of devices may be used as a mobile station, including but not limited to, cellular telephones, laptop computers, desktop computers, and personal digital assistants or other similar computing devices that are configured for MIMO/SIMO communications. A device need not be mobile to be used as a mobile station. Components of all mobile stations are not shown in FIG. **4**. The mobile station **410** will be described as an example, and the mobile stations **415** and **420** may also include components analogous to those described with reference to the mobile station **410**.

The mobile station **410** may be configured to communicate data symbols over the communications channel **422** and receive data symbols over the communications channel **422**. While a single communications channel **422** is shown in FIG. **4**, multiple communications channels may be utilized by the

communications system **400**. Not all components of the mobile station **410** are shown in FIG. **4**, and any of a variety of components useful for the sending and receiving of data symbols may be included in the mobile station **410** including, but not limited to, encoders, decoders, modulators, demodulators, analog-to-digital converters, and digital-to-analog converters.

Circuitry **454** and **460** may be coupled to the antennas **450** and **452**, respectively. The circuitry **454** and **460** may be configured to process signals for transmission by the antennas **450** and **452**. The circuitry **454** may include a digital-to-analog converter **455**, filter **456**, mixer **457**, filter **458**, and power amplifier **459**. The circuitry **460** may include a digital-to-analog converter **461**, filter **462**, mixer **463**, filter **464**, and power amplifier **465**. A local oscillator **466** may be coupled to both the circuitry **454** and **460** at the respective mixers **457** and **463**. The power consumption of the circuitry **454** and **460** may be used to calculate the MIMO and SIMO transmission rates, as generally described above. Accordingly, a signal indicative of the power consumption of the circuitry **454** and **460** may in some examples be communicated to the base station **405**. In other examples, the base station **405** may determine an approximation of the power consumption of the circuitry **454** and **460**.

A feedback decoder **477** may be coupled to the antennas **450** and **452** and configured to decode feedback signals received from the base station **405**. The feedback signals may include control signals corresponding to a selected mode, selected rate, selected antenna for use in SIMO mode, or combinations of those, as generally described above. A feedback control channel may be used to communicate the feedback information, and generally any type of feedback control channel may be used, including for example a dedicated or an optional feedback control channel.

A controller **475** may be coupled to the feedback decoder **477** and an encoder **470**. The controller **475** may be provided with a signal indicative of the selected mode, selected rate, selected antenna, or combinations thereof. Based on the received signals, the controller may configure the encoder **470** to encode data using the selected mode, selected rate, selected antenna, or combinations thereof. That is, as described above, the base station **405** may be configured to communicate a selected mode of MIMO or SIMO mode to the mobile station **410**. If the selected mode is a MIMO mode, the controller **475** may provide a control signal to the encoder **470** to configure the encoder **470** for MIMO operation using both the antennas **450** and **452**. If the selected mode is SIMO mode, the controller **475** may provide a control signal to the encoder **470** to configure the encoder **470** for SIMO operation using either the antenna **450** or **452**. In some examples, the controller **475** may not configure the encoder **470** in accordance with the mode selected by the base station **405**, but may override that selection based on some other criteria. For example, if a battery power at the mobile station **410** is too low to implement a mode selection made by the base station **405**, the controller **475** may implement a different mode. The controller may be implemented in hardware, software, or combinations thereof, and one or more processing units used to implement the controller **475** in some examples may be shared with other components of the mobile station **410**.

The encoder **470** may be coupled to the circuitry **454** and **460** and configured to encode data for transmission over the communications channel **422** in accordance with a control signal provided by the controller **475**. In particular, the encoder may be dynamically configured to encode data in either a MIMO mode or a SIMO mode. While one encoder is shown in FIG. **4**, any number may be used, including one for MIMO mode and one for SIMO mode. The encoder **470** may be implemented in hardware, software, or combinations thereof, and one or more processing units used to implement the encoder **470** may be shared with other components of the mobile station **410**. FIG. **5** is a block diagram illustrating an example computer program product **500** that is arranged to store instructions for selecting a transmission rate and selecting a transmission mode in accordance with at least some examples of the present disclosure. The signal bearing medium **502** which may be implemented as or include a computer-readable medium **506**, a recordable medium **508**, a communications medium **510**, or combinations thereof, stores instructions **504** that may configure one or more processing units to perform all or some of the processes previously described. These instructions may include, for example, one or more executable instructions **511** causing one or more processing units to calculate **511** a first transmission rate for a MIMO mode of a communications system, calculate **515** a second transmission rate for a MIMO mode of a communications system, and select **520** a selected transmission mode from the group consisting of the MIMO and SIMO modes based, at least in part, on an energy consumption of the first and second transmission rates. The computer program product **500** may be stored at least partially in a base station of the communications system in some examples, and the base station may also execute the programming instructions shown in FIG. **5** in some examples.

The present disclosure is not to be limited in terms of the particular examples described in this application, which are intended as illustrations of various aspects. Many modifications and examples can may be made without departing from its spirit and scope, as will be apparent to those skilled in the art. Functionally equivalent methods and apparatuses within the scope of the disclosure, in addition to those enumerated herein, will be apparent to those skilled in the art from the foregoing descriptions. Such modifications and examples are intended to fall within the scope of the appended claims. The present disclosure is to be limited only by the terms of the appended claims, along with the full scope of equivalents to which such claims are entitled. It is to be understood that this disclosure is not limited to particular methods, reagents, compounds compositions or biological systems, which can, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular examples only, and is not intended to be limiting.

With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as "open" terms (e.g., the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.).

It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation

by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to examples containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should be interpreted to mean at least the recited number (e.g., the bare recitation of "two recitations," without other modifiers, means at least two recitations, or two or more recitations).

Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention analogous to "at least one of A, B, or C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B."

In addition, where features or aspects of the disclosure are described in terms of Markush groups, those skilled in the art will recognize that the disclosure is also thereby described in terms of any individual member or subgroup of members of the Markush group.

As will be understood by one skilled in the art, for any and all purposes, such as in terms of providing a written description, all ranges disclosed herein also encompass any and all possible subranges and combinations of subranges thereof. Any listed range can be easily recognized as sufficiently describing and enabling the same range being broken down into at least equal halves, thirds, quarters, fifths, tenths, etc. As a non-limiting example, each range discussed herein can be readily broken down into a lower third, middle third and upper third, etc. As will also be understood by one skilled in the art all language such as "up to," "at least," "greater than," "less than," and the like include the number recited and refer to ranges which can be subsequently broken down into subranges as discussed above. Finally, as will be understood by one skilled in the art, a range includes each individual member. Thus, for example, a group having 1-3 items refers to groups having 1, 2, or 3 items. Similarly, a group having 1-5 items refers to groups having 1, 2, 3, 4, or 5 items, and so forth.

While the foregoing detailed description has set forth various examples of the devices and/or processes via the use of block diagrams, flowcharts, and/or examples, such block diagrams, flowcharts, and/or examples contain one or more functions and/or operations, it will be understood by those within the art that each function and/or operation within such block diagrams, flowcharts, or examples can be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, or virtually any combination thereof. In one example, several portions of the subject matter described herein may be implemented via Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs), digital signal processors (DSPs), or other integrated formats. However, those skilled in the art will recognize that some aspects of the examples disclosed herein, in whole or in part, can be equivalently implemented in integrated circuits, as one or more computer programs running on one or more computers (e.g., as one or more programs running on one or more computer systems), as one or more programs running on one or more processors (e.g., as one or more programs running on one or more microprocessors), as firmware, or as virtually any combination thereof, and that designing the circuitry and/or writing the code for the software and or firmware would be well within the skill of one of skill in the art in light of this disclosure. For example, if a user determines that speed and accuracy are paramount, the user may opt for a mainly hardware and/or firmware vehicle; if flexibility is paramount, the user may opt for a mainly software implementation; or, yet again alternatively, the user may opt for some combination of hardware, software, and/or firmware.

In addition, those skilled in the art will appreciate that the mechanisms of the subject matter described herein are capable of being distributed as a program product in a variety of forms, and that an illustrative example of the subject matter described herein applies regardless of the particular type of signal bearing medium used to actually carry out the distribution. Examples of a signal bearing medium include, but are not limited to, the following: a recordable type medium such as a floppy disk, a hard disk drive, a Compact Disc (CD), a Digital Video Disk (DVD), a digital tape, a computer memory, etc.; and a transmission type medium such as a digital and/or an analog communication medium (e.g., a fiber optic cable, a waveguide, a wired communications link, a wireless communication link, etc.).

Those skilled in the art will recognize that it is common within the art to describe devices and/or processes in the fashion set forth herein, and thereafter use engineering practices to integrate such described devices and/or processes into data processing systems. That is, at least a portion of the devices and/or processes described herein can be integrated into a data processing system via a reasonable amount of experimentation. Those having skill in the art will recognize that a typical data processing system generally includes one or more of a system unit housing, a video display device, a memory such as volatile and non-volatile memory, processors such as microprocessors and digital signal processors, computational entities such as operating systems, drivers, graphical user interfaces, and applications programs, one or more interaction devices, such as a touch pad or screen, and/or control systems including feedback loops and control motors (e.g., feedback for sensing position and/or velocity; control motors for moving and/or adjusting components and/or quantities). A typical data processing system may be implemented utilizing any suitable commercially available components, such as those typically found in data computing/communication and/or network computing/communication systems.

The herein described subject matter sometimes illustrates different components contained within, or connected with, different other components. It is to be understood that such depicted architectures are merely examples, and that in fact many other architectures can be implemented which achieve the same functionality. In a conceptual sense, any arrange-

ment of components to achieve the same functionality is effectively "associated" such that the desired functionality is achieved. Hence, any two components herein combined to achieve a particular functionality can be seen as "associated with" each other such that the desired functionality is achieved, irrespective of architectures or intermedial components. Likewise, any two components so associated can also be viewed as being "operably connected", or "operably coupled", to each other to achieve the desired functionality, and any two components capable of being so associated can also be viewed as being "operably couplable", to each other to achieve the desired functionality. Specific examples of operably couplable include but are not limited to physically mateable and/or physically interacting components and/or wirelessly interactable and/or wirelessly interacting components and/or logically interacting and/or logically interactable components.

While various aspects and examples have been disclosed herein, other aspects and examples will be apparent to those skilled in the art. The various aspects and examples disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

What is claimed is:

1. A method for selecting a transmission mode for a transceiver in a communications system, the method comprising:

calculating a first transmission rate for data in a multiple-input multiple-output (MIMO) mode of the communications system;

calculating a second transmission rate for the data in a single-input multiple-output (SIMO) mode of the communications system; and

selecting the transmission mode based, at least in part, on an energy consumption of the transceiver associated with the first and second transmission rates, wherein selecting the transmission mode is further based at least in part, on a number of users of the communications system, and wherein the selected transmission mode corresponds to either the MIMO mode or the SIMO mode.

2. The method of claim **1**, further comprising: transmitting data from the transceiver in the communications system using the selected transmission mode.

3. The method of claim **1**, wherein calculating the first transmission rate comprises calculating the first transmission rate based, at least in part, on an energy-optimized rate for data in the MIMO mode.

4. The method of claim **3**, wherein the energy-optimized rate is based, at least in part, on a power consumption of circuitry coupled to a plurality of antennas at the transceiver when the communications system is configured to transmit in the MIMO mode.

5. The method of claim **1**, wherein calculating the second transmission rate comprises calculating the second transmission rate based, at least in part, on an energy-optimized rate for data in the SIMO mode.

6. The method of claim **5**, wherein the energy-optimized rate is based, at least in part, on a power consumption associated with circuitry coupled to a single antenna configured to transmit in the SIMO mode.

7. The method of claim **1**, wherein the communications system is configured for communication over a communications channel, and wherein selecting the transmission mode is further based, at least in part, on a correlation in the communications channel.

8. The method of claim **1**, wherein selecting the transmission mode is further based, at least in part, on a number of receive antennas in the communications system.

9. The method of claim **1**, wherein calculating the first and second transmission rates are performed by a base station.

10. A method for selecting a transmission mode for a transceiver in a communications system, the method comprising:

calculating a first transmission rate for data in a multiple-input multiple-output (MIMO) mode of the communications system based, at least in part, on an energy-optimized rate for data in the MIMO mode, wherein the energy-optimized rate is based, at least in part, on a power consumption of circuitry coupled to a plurality of antennas at the transceiver when the communications system is configured to transmit in the MIMO mode, wherein the energy-optimized rate is further based, at least in part, on a power consumption of the transceiver during an idle time;

calculating a second transmission rate for the data in a single-input multiple-output (SIMO) mode of the communications system; and

selecting the transmission mode based, at least in part, on an energy consumption of the transceiver associated with the first and second transmission rates, wherein the selected transmission mode corresponds to either the MIMO mode or the SIMO mode.

11. A method for selecting a transmission mode for a transceiver in a communications system, the method comprising:

calculating a first transmission rate for data in a multiple-input multiple-output (MIMO) mode of the communications system based, at least in part, on an energy-optimized rate for data in the MIMO mode, wherein the energy-optimized rate is based, at least in part, on a power consumption of circuitry coupled to a plurality of antennas at the transceiver when the communications system is configured to transmit in the MIMO mode, wherein calculating the first transmission rate comprises selecting a maximum rate from the energy-optimized rate and a target rate, wherein the target rate is based, at least in part, on an average throughput for the communications system;

calculating a second transmission rate for the data in a single-input multiple-output (SIMO) mode of the communications system; and

selecting the transmission mode based, at least in part, on an energy consumption of the transceiver associated with the first and second transmission rates, wherein the selected transmission mode corresponds to either the MIMO mode or the SIMO mode.

12. The method of claim **11**, wherein calculating the first transmission rate comprises selecting a minimum rate from the selected maximum rate and a capacity rate for the communications system, wherein the capacity rate is based, at least in part, on a configuration of the communications system.

13. A method for selecting a transmission mode for a transceiver in a communications system, the method comprising:

calculating a first transmission rate for data in a multiple-input multiple-output (MIMO) mode of the communications system;

calculating a second transmission rate for the data in a single-input multiple-output (SIMO) mode of the communications system, wherein calculating the second transmission rate comprises calculating the second

transmission rate based, at least in part, on an energy-optimized rate for data in the SIMO mode, wherein calculating the second transmission rate comprises selecting a maximum rate from the energy-optimized rate and a target rate, wherein the target rate is based, at least in part, on an average throughput for the communications systems; and

selecting the transmission mode based, at least in part, on an energy consumption of the transceiver associated with the first and second transmission rates, wherein the selected transmission mode corresponds to either the MIMO mode or the SIMO mode.

14. The method of claim **13**, wherein calculating the second transmission rate comprises selecting a minimum rate from the selected maximum rate and a capacity rate for the communications system, wherein the capacity rate is based, at least in part, on a configuration of the communications system.

15. A method for selecting a transmission mode for a transceiver in a communications system, the method comprising:

calculating a first transmission rate for data in a multiple-input multiple-output (MIMO) mode of the communications system;

calculating a second transmission rate for the data in a single-input multiple-output (SIMO) mode of the communications system;

selecting the transmission mode based, at least in part, on an energy consumption of the transceiver associated with the first and second transmission rates, wherein the transmission mode corresponds to either the MIMO mode or the SIMO mode; and

selecting an identity of a single antenna at the transceiver for use in the SIMO mode when the selected transmission mode corresponds to the SIMO mode.

16. A base station for use in communicating over a communications channel, the base station comprising:

a rate selector configured to generate a first signal corresponding to a first transmission rate for data in a multiple-input multiple-output (MIMO) mode of the communications system, wherein the rate selector is further configured to generate a second signal corresponding to a second transmission rate for data in a single-input multiple-output (SIMO) mode of the communications system;

a mode selector coupled to the rate selector, wherein the mode selector is configured to receive the first and second signals, and select a transmission mode based, at least in part, on an energy consumption of a transmitter associated with the first and second transmission rates, wherein the transmission mode corresponds to either the MIMO mode or the SIMO mode; and

the transmitter coupled to the mode selector, wherein the transmitter is configured to transmit a third signal to a transceiver in the communications system, wherein the third signal identifies the selected transmission mode for the transceiver, wherein, when the selected mode is the SIMO mode, the transmitter is further configured to transmit a fourth signal corresponding to an identity of a single antenna for use in the SIMO mode.

17. The base station of claim **16**, wherein the rate selector comprises a MIMO rate selector configured to calculate the first transmission rate based, at least in part, on an energy-optimized rate for data in the MIMO mode.

18. The base station of claim **17**, wherein the MIMO rate selector is configured to receive a signal indicative of a power consumption of circuitry coupled to a plurality of antennas at the transceiver, and wherein the energy-optimized rate is based, at least in part, on the power consumption of circuitry coupled to the plurality of antennas at the transceiver configured to transmit in the MIMO mode.

19. The base station of claim **16**, wherein the rate selector comprises a SIMO rate selector configured to calculate the second transmission rate based, at least in part, on an energy-optimized rate for data in the SIMO mode.

20. The base station of claim **19**, wherein the SIMO rate selector is further configured to receive a signal indicative of a power consumption of circuitry coupled to a single antenna at the transceiver, and wherein the energy-optimized rate is based, at least in part, on the power consumption of the circuitry coupled to the single antenna at the transceiver configured to transmit in the SIMO mode.

21. The base station of claim **16**, wherein the mode selector is further configured to receive a signal indicative of a number of users of the communications system, and wherein the selected mode is further based, at least in part, on the number of users.

22. The base station of claim **16**, wherein the communications system is configured for communication over a communications channel, and wherein the mode selector is further configured to select the mode is based, at least in part, on a correlation in the communications channel.

23. The base station of claim **16**, wherein the mode selector is further configured to select the selected transmission mode based, at least in part, on a number of receive antennas at the transceiver.

24. A base station for use in communicating over a communications channel, the base station comprising:

a rate selector configured to generate a first signal corresponding to a first transmission rate for data in a multiple-input multiple-output (MIMO) mode of the communications system, wherein the rate selector is further configured to generate a second signal corresponding to a second transmission rate for data in a single-input multiple-output (SIMO) mode of the communications system, wherein the rate selector comprises a MIMO rate selector configured to calculate the first transmission rate based, at least in part, on an energy-optimized rate for data in the MIMO mode wherein the MIMO rate selector is configured to receive a signal indicative of a power consumption of circuitry coupled to a plurality of antennas at the transceiver, and wherein the MIMO rate selector is further configured to receive a signal indicative of a power consumption of the transceiver during an idle time;

a mode selector coupled to the rate selector, wherein the mode selector is configured to receive the first and second signals, and select a transmission mode based, at least in part, on an energy consumption of a transmitter associated with the first and second transmission rates, wherein the transmission mode corresponds to either the MIMO mode or the SIMO mode, wherein the energy-optimized rate is based, at least in part, on the power consumption of circuitry coupled to the plurality of antennas at the transceiver configured to transmit in the MIMO mode, and wherein the energy-optimized rate is further based, at least in part, on the power consumption of the transceiver during the idle time; and

the transmitter coupled to the mode selector, wherein the transmitter is configured to transmit a third signal to a transceiver in the communications system, wherein the third signal identifies the selected transmission mode for the transceiver.

25. A mobile station for use in a communications system comprising:

a first antenna and a second antenna;

first circuitry coupled to the first antenna and configured to process signals for transmission by the first antenna;

second circuitry coupled to the second antenna and configured to process signals for transmission by the second antenna; and

a controller coupled to the first and second circuitry, wherein the controller is configured to receive a control signal and, in accordance with the control signal, to select between a multiple-input multiple-output (MIMO) mode wherein both the first and second antennas transmit data over a communications channel and a single-input multiple-output (SIMO) mode wherein only one of the first and second antennas transmit data over a communications channel, wherein the control signal is based, at least in part, on a power consumption of the first and second circuitry, wherein the control signal is based, at least in part, on an idle power consumption of the mobile station.

26. The mobile station of claim **25**, wherein the control signal is based, at least in part, on a correlation in the communications channel.

27. The mobile station of claim **25**, wherein the control signal is based, at least in part, on energy optimized rates for the MIMO mode and the SIMO mode.

28. The mobile station of claim **25**, wherein the control signal is transmitted to the mobile station by a base station.

29. A mobile station for use in a communications system comprising:

a first antenna and a second antenna;

first circuitry coupled to the first antenna and configured to process signals for transmission by the first antenna;

second circuitry coupled to the second antenna and configured to process signals for transmission by the second antenna; and

a controller coupled to the first and second circuitry, wherein the controller is configured to receive a control signal and, in accordance with the control signal, to select between a multiple-input multiple-output (MIMO) mode wherein both the first and second antennas transmit data over a communications channel and a single-input multiple-output (SIMO) mode wherein only one of the first and second antennas transmit data over a communications channel, wherein the control signal is based, at least in part, on a power consumption of the first and second circuitry, wherein the control signal is based, at least in part, on a number of users of the communications system.

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