

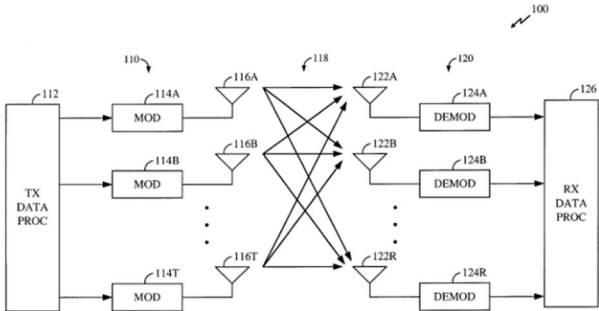
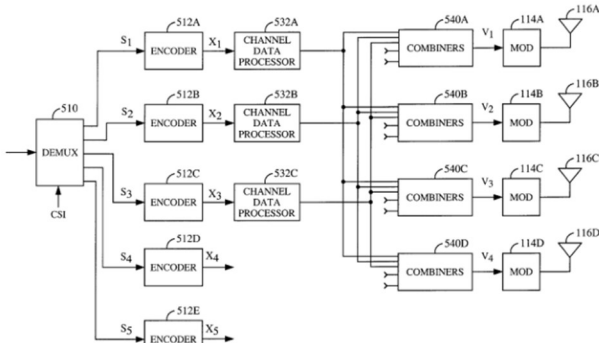
DEFENDANTS' INVALIDITY CONTENTIONS FOR U.S. PAT. 8,891,347

EXHIBIT A6: U.S. Patent No. 6,473,467 ("Wallace '467")

As demonstrated in the claim charts below, the claims of U.S. Patent No. 8,891,347 ("the '347 patent") are invalid (a) under one or more sections of 35 U.S.C. § 102 as anticipated by Wallace '467 and (b) under 35 U.S.C. § 103(a) as obvious over Wallace '467 standing alone and as set forth herein, and/or combined with the knowledge of a person of ordinary skill in the art, Applicant's Admitted Prior Art, and/or the additional prior art references identified in Defendant's Preliminary and Supplemental Invalidity Contentions, the contents of which are hereby incorporated by reference into this chart. One of ordinary skill in the art, as of the priority date of the '347 patent, would have known to combine the prior art elements disclosed by the foregoing references using known methods, and to use these elements according to their established functions in order to achieve a known and predictable result.

Defendant has conducted the invalidity analysis herein based at least in part and in some instance entirely upon Plaintiff's apparent application of the claims of the '347 patent. By charting the prior art against the claims and elements herein, Defendant is not admitting or agreeing to Plaintiff's application of the claims at issue in this case, and these charts should not be interpreted as an admission or concession by Defendant that any particular construction or application of any claim element by Plaintiff is correct or proper. Additionally, these charts provide representative examples of portions of the charted references that disclose the indicated elements of the claims; additional portions of these references other than the representative examples provided herein may also disclose the indicated element(s). For example, where a particular figure is cited, the citation should be understood to encompass the caption and description of the figure as well as any text relating to or describing the figure. Conversely, where particular text referring to a figure is cited, the citation should be understood to include the figure as well.

Claim Element	Exemplary Citations to Wallace '467
19[pre] A wireless device for performing wireless communication with a base station with a transmitter via a plurality of propagation paths, the wireless device comprising:	By providing this disclosure, Defendant does not take a position on whether the preamble is a claim limitation. Wallace '467 discloses or renders obvious "[a] wireless device for performing wireless communication with a base station with a transmitter via a plurality of propagation paths." For example: Wallace '467 at Abstract Channel state information (CSI) can be used by a communications system to precondition transmissions between transmitter units and receiver units. In one aspect of the invention, disjoint sub-channel sets are assigned to transmit antennas located at a transmitter unit. Pilot symbols are generated and transmitted on a subset of the disjoint sub-channels. Upon receipt of the transmitted pilot symbols, the receiver units determine the CSI for the disjoint sub-channels that carried pilot symbols. These CSI values are reported to the transmitter unit, which will use these CSI values to generate CSI estimates for the disjoint sub-channels that did not carry pilot symbols. The amount of information necessary to report CSI on the reverse link can be further minimized through compression techniques and resource allocation techniques.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at Wallace-467 at Fig. 1A  FIG. 1A Wallace '467 at Wallace-467 at Fig. 5A  FIG. 5A Wallace '467 at 1:57-2:8 Given the ever-growing demand for wireless communication, a higher efficiency, higher performance wireless communications system is desirable. One type of higher performance wireless communications system is a Multiple Input/Multiple Output (MIMO) system that employs multiple transmit antennas to transmit over a propagation channel to multiple receive antennas. As in lower performance systems, the propagation channel in a MIMO system is subject to the deleterious effects of multipath, as well as interference from adjacent antennas. Multipath occurs when a transmitted signal arrives at a receiver unit through multiple propagation paths with differing delays. When signals arrive from multiple propagation paths, components of the signals can combine destructively, which is referred to as “fading.” In order to improve the efficiency and decrease the complexity of the MIMO system, information as to the characteristics of the propagation channel can be transmitted back to the transmitter unit in order to

Claim Element	Exemplary Citations to Wallace '467
	precondition the signal before transmission. Wallace '467 at 2:25–48 The present invention is directed to a method and apparatus for the measuring and reporting of channel state information in a high efficiency, high performance communications system, comprising the steps of: generating a plurality of pilot signals; transmitting the plurality of pilot signals over a propagation channel between a transmitter unit and a plurality of receiver units, wherein the transmitter unit comprises at least one transmit antenna, each of the plurality of receiver units comprises at least one receive antenna, and the propagation channel comprises a plurality of sub-channels between the transmitter unit and the plurality of receiver units; receiving at least one of the plurality of pilot signals at each of the plurality of receiver units; determining a set of transmission characteristics for at least one of the plurality of sub-channels, wherein the step of determining the set of transmission characteristics uses at least one of the plurality of pilot signals received at each of the plurality of receiver units; reporting an information signal from each of the plurality of receiver units to the transmitter unit, wherein the information signal carries the set of transmission characteristics for at least one of the plurality of sub-channels; and optimizing a set of transmission parameters at the transmitter unit, based on the information signal. Wallace '467 at 2:49–62 In one aspect of the invention, pilot symbols are transmitted on a plurality of disjoint OFDM sub-channel sets. When the pilot symbols are transmitted on disjoint OFDM sub-channels, the characteristics of the propagation channel can be determined through a set of K sub-channels carrying the pilot symbols, wherein K is less than the number of OFDM sub-channels in the system. In addition to transmitting pilot symbols on disjoint sub-channels, the system can transmit a time-domain pilot sequence that can be used to determine characteristics of the propagation channel. Along with the generation and transmission of pilot symbols, an aspect of the invention is the compression of the amount of information necessary to reconstruct the characteristics of the propagation channel. Wallace '467 at 3:34–54 FIG. 1A is a diagram of a Multiple Input/Multiple Output (MIMO) communications system 100 capable of implementing some embodiments of the invention. Communications system 100 can be operative to provide a combination of antenna, frequency, and temporal diversity to increase spectral efficiency, improve performance, and enhance flexibility. Increased spectral efficiency is characterized by the ability to transmit more bits per second per Hertz (bps/Hz) when and where possible to better utilize the available

Claim Element	Exemplary Citations to Wallace '467
	system bandwidth. Techniques to obtain higher spectral efficiency are described in further detail below. Improved performance may be quantified, for example, by a lower bit-error-rate (BER) or frame-error-rate (FER) for a given link carrier-to-noise-plus-interference ratio (C/I). And enhanced flexibility is characterized by the ability to accommodate multiple users having different and typically disparate requirements. These goals may be achieved, in part, by employing multi-carrier modulation, time division multiplexing (TDM), multiple transmit and/or receive antennas, and other techniques. The features, aspects, and advantages of the invention are described in further detail below. Wallace '467 at 3:55–67 As shown in FIG. 1A, communications system 100 includes a first system 110 in communication with a second system 120. System 110 includes a (transmit) data processor 112 that (1) receives or generates data, (2) processes the data to provide antenna, frequency, or temporal diversity, or a combination thereof, and (3) provides processed modulation symbols to a number of modulators (MOD) 114a through 114t. Each modulator 114 further processes the modulation symbols and generates an RF modulated signal suitable for transmission. The RF modulated signals from modulators 114a through 114t are then transmitted from respective antennas 116a through 116t over communications links 118 to system 120. Wallace '467 at 4:1–17 In FIG. 1A, system 120 includes a number of receive antennas 122a through 122r that receive the transmitted signals and provide the received signals to respective demodulators (DEMOD) 124a through 124r. As shown in FIG. 1A, each receive antenna 122 may receive signals from one or more transmit antennas 116 depending on a number of factors such as, for example, the operating mode used at system 110, the directivity of the transmit and receive antennas, the characteristics of the communications links, and others. Each demodulator 124 demodulates the respective received signal using a demodulation scheme that is complementary to the modulation scheme used at the transmitter. The demodulated symbols from demodulators 124a through 124r are then provided to a (receive) data processor 126 that further processes the symbols to provide the output data. The data processing at the transmitter and receiver units is described in further detail below. Wallace '467 at 4:18–27 FIG. 1A shows only the forward link transmission from system 110 to system 120. This configuration may be used for data broadcast and other one-way data transmission applications. In a bidirectional communications system, a reverse link from system 120 to system 110 is also provided, although not

Claim Element	Exemplary Citations to Wallace '467
	shown in FIG. 1A for simplicity. For the bidirectional communications system, each of systems 110 and 120 may operate as a transmitter unit or a receiver unit, or both concurrently, depending on whether data is being transmitted from, or received at, the unit. Wallace '467 at 4:28–34 For simplicity, communications system 100 is shown to include one transmitter unit (i.e., system 110) and one receiver unit (i.e., system 120). However, in general, multiple transmit antennas and multiple receive antennas are present on each transmitter unit and each receiver unit. The communications system of the invention may include any number of transmitter units and receiver units. Wallace '467 at 4:36–47 Each transmitter unit may include a single transmit antenna or a number of transmit antennas, such as that shown in FIG. 1A. Similarly, each receiver unit may include a single receive antenna or a number of receive antennas, again such as that shown in FIG. 1A. For example, the communications system may include a central system (i.e., similar to a base station in the IS-95 CDMA system) having a number of antennas that transmit data to, and receive data from, a number of remote systems (i.e., subscriber units, similar to remote stations in the CDMA system), some of which may include one antenna and others of which may include multiple antennas. Wallace '467 at 4:48–63 As used herein, an antenna refers to a collection of one or more antenna elements that are distributed in space. The antenna elements may be physically located at a single site or distributed over multiple sites. Antenna elements physically co-located at a single site may be operated as an antenna array (e.g., such as for a CDMA base station). An antenna network consists of a collection of antenna arrays or elements that are physically separated (e.g., several CDMA base stations). An antenna array or an antenna network may be designed with the ability to form beams and to transmit multiple beams from the antenna array or network. For example, a CDMA base station may be designed with the capability to transmit up to three beams to three different sections of a coverage area (or sectors) from the same antenna array. Thus, the three beams may be viewed as three transmissions from three antennas. Wallace '467 at 4:64–5:4 The communications system of the invention can be designed to provide a multi-user, multiple access

Claim Element	Exemplary Citations to Wallace '467
	communications scheme capable of supporting subscriber units having different requirements as well as capabilities. The scheme allows the system's total operating bandwidth, W, (e.g., 1.2288 MHz) to be efficiently shared among different types of services that may have highly disparate data rate, delay, and quality of service (QOS) requirements. Wallace '467 at 5:47–53 The communications system of the invention provides the above-described features and advantages, and is capable of supporting different types of services having disparate requirements. The features are achieved by employing antenna, frequency, or temporal diversity, or a combination thereof. Antenna, frequency, or temporal diversity can be independently achieved and dynamically selected. Wallace '467 at 5:54–67 As used herein, antenna diversity refers to the transmission and/or reception of data over more than one antenna, frequency diversity refers to the transmission of data over more than one sub-band, and temporal diversity refers to the transmission of data over more than one time period. Antenna, frequency, and temporal diversity may include subcategories. For example, transmit diversity refers to the use of more than one transmit antenna in a manner to improve the reliability of the communications link, receive diversity refers to the use of more than one receive antenna in a manner to improve the reliability of the communications link, and spatial diversity refers to the use of multiple transmit and receive antennas to improve the reliability and/or increase the capacity of the communications link. Wallace '467 at 6:6–14 Frequency diversity can be provided by use of a multi-carrier modulation scheme such as orthogonal frequency division multiplexing (OFDM), which allows for transmission of data over various sub-bands of the operating bandwidth. Temporal diversity is achieved by transmitting the data over different times, which can be more easily accomplished with the use of time-division multiplexing (TDM). These various aspects of the communications system of the invention are described in further detail below. Wallace '467 at 6:15–32 In accordance with an aspect of the invention, antenna diversity is achieved by employing a number of (N_T) transmit antennas at the transmitter unit or a number of (N_R) receive antennas at the receiver unit, or multiple antennas at both the transmitter and receiver units. In a terrestrial communications system (e.g., a

Claim Element	Exemplary Citations to Wallace '467
	cellular system, a broadcast system, an MMDS system, and others), an RF modulated signal from a transmitter unit may reach the receiver unit via a number of transmission paths. The characteristics of the transmission paths typically vary over time based on a number of factors. If more than one transmit or receive antenna is used, and if the transmission paths between the transmit and receive antennas are independent (i.e., uncorrelated), which is generally true to at least an extent, then the likelihood of correctly receiving the transmitted signal increases as the number of antennas increases. Generally, as the number of transmit and receive antennas increases, diversity increases and performance improves. Wallace '467 at 6:33–52 Antenna diversity is dynamically provided based on the characteristics of the communications link to provide the required performance. For example, a higher degree of antenna diversity can be provided for some types of communication (e.g., signaling), for some types of services (e.g., voice), for some communications link characteristics (e.g., low C/I), or for some other conditions or considerations. As used herein, antenna diversity includes transmit diversity and receive diversity. For transmit diversity, data is transmitted over multiple transmit antennas. Typically, additional processing is performed on the data transmitted from the transmit antennas to achieve the desired diversity. For example, the data transmitted from different transmit antennas may be delayed or reordered in time, or coded and interleaved across the available transmit antennas. Also, frequency and temporal diversity may be used in conjunction with the different transmit antennas. For receive diversity, modulated signals are received on multiple receive antennas, and diversity is achieved by simply receiving the signals via different transmission paths. Wallace '467 at 6:53–7:14 In accordance with another aspect of the invention, frequency diversity can be achieved by employing a multi-carrier modulation scheme. One such scheme that has numerous advantages is OFDM. With OFDM modulation, the overall transmission channel is essentially divided into a number of (L) parallel sub-channels that are used to transmit the same or different data. The overall transmission channel occupies the total operating bandwidth of W, and each of the sub-channels occupies a sub-band having a bandwidth of W/L and centered at a different center frequency. Each sub-channel has a bandwidth that is a portion of the total operating bandwidth. Each of the sub-channels may also be considered an independent data transmission channel that may be associated with a particular (and possibly unique) processing, coding, and modulation scheme, as described below. The data may be partitioned and transmitted over any defined set of two or more sub-bands to provide frequency diversity. For example, the transmission to a particular subscriber unit may occur over sub-

Claim Element	Exemplary Citations to Wallace '467
	channel 1 at time slot 1, sub-channel 5 at time slot 2, sub-channel 2 at time slot 3, and so on. As another example, data for a particular subscriber unit may be transmitted over sub-channels 1 and 2 at time slot 1 (e.g., with the same data being transmitted on both sub-channels), sub-channels 4 and 6 at time slot 2, only sub-channel 2 at time slot 3, and so on. Transmission of data over different sub-channels over time can improve the performance of a communications system experiencing frequency selective fading and channel distortion. Other benefits of OFDM modulation are described below. Wallace '467 at 7:15–31 In accordance with yet another aspect of the invention, temporal diversity is achieved by transmitting data at different times, which can be more easily accomplished using time division multiplexing (TDM). For data services (and possibly for voice services), data transmission occurs over time slots that may be selected to provide immunity to time dependent degradation in the communications link. Temporal diversity may also be achieved through the use of interleaving. For example, the transmission to a particular subscriber unit may occur over time slots 1 through x, or on a subset of the possible time slots from 1 through x (e.g., time slots 1, 5, 8, and so on). The amount of data transmitted at each time slot may be variable or fixed. Transmission over multiple time slots improves the likelihood of correct data reception due to, for example, impulse noise and interference. Wallace '467 at 7:33–8:3 The combination of antenna, frequency, and temporal diversity allows the communications system of the invention to provide robust performance. Antenna, frequency, and/or temporal diversity improves the likelihood of correct reception of at least some of the transmitted data, which may then be used (e.g., through decoding) to correct for some errors that may have occurred in the other transmissions. The combination of antenna, frequency, and temporal diversity also allows the communications system to concurrently accommodate different types of services having disparate data rate, processing delay, and quality of service requirements. The communications system of the invention can be designed and operated in a number of different communications modes, with each communications mode employing antenna, frequency, or temporal diversity, or a combination thereof. The communications modes include, for example, a diversity communications mode and a MIMO communications mode. Various combinations of the diversity and MIMO communications modes can also be supported by the communications system. Also, other communications modes can be implemented and are within the scope of the present invention. The diversity communications mode employs transmit and/or receive diversity, frequency, or temporal diversity, or a combination thereof, and is generally used to improve the reliability of the communications link. In one implementation of the diversity communications mode, the transmitter unit selects a

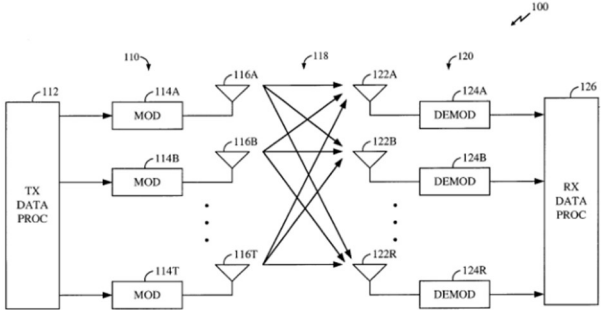
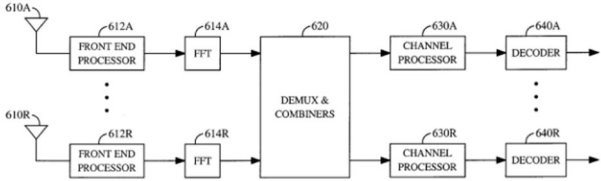
Claim Element	Exemplary Citations to Wallace '467
	modulation and coding scheme (i.e., configuration) from a finite set of possible configurations, which are known to the receiver units. For example, each overhead and common channel may be associated with a particular configuration that is known to all receiver units. When using the diversity communications mode for a specific user (e.g., for a voice call or a data transmission), the mode and/or configuration may be known a priori (e.g., from a previous set up) or negotiated (e.g., via a common channel) by the receiver unit. Wallace '467 at 8:16–52 The MIMO communications mode employs antenna diversity at both ends of the communication link and is generally used to improve both the reliability and increase the capacity of the communications link. The MIMO communications mode may further employ frequency and/or temporal diversity in combination with the antenna diversity. The MIMO communications mode, which may also be referred to herein as the spatial communications mode, employs one or more processing modes to be described below. The diversity communications mode generally has lower spectral efficiency than the MIMO communications mode, especially at high C/I levels. However, at low to moderate C/I values, the diversity communications mode achieves comparable efficiency and can be simpler to implement. In general, the use of the MIMO communications mode provides greater spectral efficiency when used, particularly at moderate to high C/I values. The MIMO communications mode may thus be advantageously used when the data rate requirements are moderate to high. The communications system can be designed to concurrently support both diversity and MIMO communications modes. The communications modes can be applied in various manners and, for increased flexibility, may be applied independently on a sub-channel basis. The MIMO communications mode is typically applied to specific users. However, each communications mode may be applied on each sub-channel independently, across a subset of sub-channels, across all sub-channels, or on some other basis. For example, the use of the MIMO communications mode may be applied to a specific user (e.g., a data user) and, concurrently, the use of the diversity communications mode may be applied to another specific user (e.g., a voice user) on a different sub-channel. The diversity communications mode may also be applied, for example, on sub-channels experiencing higher path loss. Wallace '467 at 8:53–9:3 The communications system of the invention can also be designed to support a number of processing modes. When the transmitter unit is provided with information indicative of the conditions (i.e., the “state”) of the communications links, additional processing can be performed at the transmitter unit to further improve performance and increase efficiency. Full channel state information (CSI) or partial CSI may be available to the transmitter unit. Full CSI includes sufficient characterization of the propagation

Claim Element	Exemplary Citations to Wallace '467
	path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-band. Full CSI also includes the C/I per sub-band. The full CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. Partial CSI may include, for example, the C/I of the sub-band . With full CSI or partial CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 9:4–15 The transmitter unit can precondition the signals presented to the transmit antennas in a way that is unique to a specific receiver unit (e.g., the pre-conditioning is performed for each sub-band assigned to that receiver unit). As long as the channel does not change appreciably from the time it is measured by the receiver unit and subsequently sent back to the transmitter and used to precondition the transmission, the intended receiver unit can demodulate the transmission. In this implementation, a full-CSI based MIMO communication can only be demodulated by the receiver unit associated with the CSI used to precondition the transmitted signals. Wallace '467 at 9:29–48 As an example, assume that the MIMO communications mode is applied to a channel data stream that is transmitted on one particular sub-channel from four transmit antennas. The channel data stream is demultiplexed into four data sub-streams, one data sub-stream for each transmit antenna. Each data sub-stream is then modulated using a particular modulation scheme (e.g., M-PSK, M-QAM, or other) selected based on the CSI for that sub-band and for that transmit antenna. Four modulation sub-streams are thus generated for the four data sub-streams, with each modulation sub-streams including a stream of modulation symbols. The four modulation sub-streams are then pre-conditioned using the eigenvector matrix, as expressed below in equation (1), to generate pre-conditioned modulation symbols. The four streams of pre-conditioned modulation symbols are respectively provided to the four combiners of the four transmit antennas. Each combiner combines the received pre-conditioned modulation symbols with the modulation symbols for the other sub-channels to generate a modulation symbol vector stream for the associated transmit antenna. Wallace '467 at 9:64–10:4 In instances where full CSI is not available, less descriptive information on the transmission path (or partial CSI) may be available and can be used to pre-condition the data prior to transmission. For

Claim Element	Exemplary Citations to Wallace '467
	example, the C/I of each of the sub-channels may be available. The C/I information can then be used to control the transmission from various transmit antennas to provide the required performance in the sub-channels of interest and increase system capacity. Wallace '467 at 13:3–21 Given the complexity of a system using multiple transmit antennas and multiple receive antennas, with the associated dispersive channel effects, the preferred modulation technique is OFDM, which effectively decomposes the channel into a set of non-interfering narrowband channels, or sub-channels. With proper OFDM signal design, a signal transmitted on one subchannel sees “flat fading”, i.e., the channel response is effectively constant over the subchannel bandwidth. The channel state information or CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-channel. CSI also includes the information of the relative levels of interference and noise in each sub-channel, that is known as C/I information. The CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. With CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 14:56–15:2 Multiple antennas at a receiver unit 145 receive signals at step 146. At step 147, the received signals undergo a Discrete Fourier Transform (DFT) operation to channelize the received signals. At step 148, the data from each subchannel over all of the receive antennas is processed. At this processing step, information regarding channel characteristics is extracted from the data, and converted into a more compressed format. One compression technique is the use of the conjugate channel response and the eigenmode matrix to reduce the amount of information needed to describe channel characteristics. At step 149, a message containing the compressed channel state information is transmitted from the receiver unit 145 to the transmitter unit 140, which will then be used to precondition further transmissions. Wallace '467 at 15:3–7 To facilitate the derivation of the CSI, the transmit waveform is made up of known pilot symbols for an initial preamble. The pilot waveforms for different transmit antennas comprise disjoint sets of OFDM subchannels as illustrated for the case when $N_t=4$ in FIG. 1C.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 18:5–32 The embodiments of the invention discussed herein have been directed to the design and transmission of pilot signals that will allow a person skilled in the art to derive characteristics of the propagation channel and to report such characteristics to the transmission site. However, the full CSI is a large amount of information and also highly redundant. Many methods are available for compressing the amount of CSI information to be transmitted. One method discussed previously is the use of the Hermitian matrix H^*H, wherein H is the channel response as determined at the receiver unit. The Hermitian matrix H^*H can be reported to the transmitter unit and be used to precondition transmissions. Due to the properties of Hermitian matrices, only half of the matrix elements need to be transmitted, such as the complex lower triangular portion of the matrix H^*H, and the real-valued diagonal. Additional efficiencies are realized if the number of receive antennas is larger than the number of transmit antennas. Another method to reduce the amount of information transmitted to the transmitter unit on the reverse link is to report only a subset of the channel response matrices H_i to the transmitter unit, from which the unreported channel response matrices can be determined through interpolation schemes. In another method, a functional representation of the channel response across the sub-channels may be derived for each transmit/receive antenna pair, e.g., a polynomial function representative of the channel response can be generated. The coefficients of the polynomial function are then transmitted to the transmitter unit. Wallace '467 at 18:33–44 As an alternative to these methods for compressing CSI information, one embodiment of the invention is directed to the transmission of a time-domain representation of the channel response, which is the channel impulse response. If a time-domain representation of the channel response is simple, as in cases where there are only two or three multipath components, an inverse FFT can be performed upon the set of channel frequency responses. The inverse FFT operation can be performed for each link between a transmit/receive antenna pair. The resulting channel impulse responses are then translated into a set of amplitudes and delays that are reported to the transmitter. Wallace '467 at 28:58–29:4 As shown above, the transmitter unit and receiver unit are each implemented with various processing units that include various types of data processor, encoders, IFFTs, FFTs, demultiplexers, combiners, and so on. These processing units can be implemented in various manners such as an application specific integrated circuit (ASIC), a digital signal processor, a microcontroller, a microprocessor, or other electronic circuits designed to perform the functions described herein. Also, the processing units can be

Claim Element	Exemplary Citations to Wallace '467
	implemented with a general-purpose processor or a specially designed processor operated to execute instruction codes that achieve the functions described herein. Thus, the processing units described herein can be implemented using hardware, software, or a combination thereof. Wallace '467 at 29:16–38 1. A method for measuring and reporting transmission characteristics of a multiple input/multiple output communication system, comprising: assigning a first subset of sub-channels of a plurality of sub-channels to a first transmit antenna of a plurality of transmit antennas of a first transmitter unit, wherein the sub-channels of the first subset of sub-channels are noncontiguous; transmitting, by the first transmit antenna, a first pilot symbol over the sub-channels of the first subset of sub-channels; receiving, by a first receive antenna of a first receiver unit, the first pilot symbol; determining, from the received first pilot symbol, the transmission characteristics of the sub-channels of the first subset of sub-channels; reporting, by the first receiver unit to the first transmitter unit, an information signal that carries the determined transmission characteristics for the sub-channels of the first subset of sub-channels; and optimizing a set of transmission parameters at the first transmitter unit, based on the information signal. Wallace '467 at 31:8–32 19. A method for measuring and reporting channel state information (CSI) in a multiple input/multiple output (MIMO) system, comprising: assigning a plurality of sub-channel subsets to a plurality of transmit antennas of at least one transmitter unit, wherein the sub-channels of each of the sub-channel subsets are noncontiguous; transmitting a plurality of Orthogonal Frequency Division Multiplexed (OFDM) pilot waveforms from the at least one transmitter unit to at least one receiver unit, wherein each of the plurality of OFDM pilot waveforms is transmitted over a separate one of the plurality of sub-channel subsets; receiving, by the at least one receiver unit, the plurality of OFDM pilot waveforms; demodulating the received plurality of OFDM pilot waveforms; determining the CSI of the sub-channels corresponding to each of the plurality of sub-channel subsets from the demodulated plurality of OFDM pilot waveforms; transmitting the determined CSI to the at least one transmitter unit, and preconditioning a transmission symbol according to the determined CSI.

Claim Element	Exemplary Citations to Wallace '467
	To the extent this element is not disclosed by Wallace '467, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Wallace '467, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
[19.a] a receiver;	Wallace '467 discloses or renders obvious “a receiver.” For example: Wallace '467 at Abstract Channel state information (CSI) can be used by a communications system to precondition transmissions between transmitter units and receiver units. In one aspect of the invention, disjoint sub-channel sets are assigned to transmit antennas located at a transmitter unit. Pilot symbols are generated and transmitted on a subset of the disjoint sub-channels. Upon receipt of the transmitted pilot symbols, the receiver units determine the CSI for the disjoint sub-channels that carried pilot symbols. These CSI values are reported to the transmitter unit, which will use these CSI values to generate CSI estimates for the disjoint sub-channels that did not carry pilot symbols. The amount of information necessary to report CSI on the reverse link can be further minimized through compression techniques and resource allocation techniques. Wallace '467 at Wallace-467 at Fig. 1A  FIG. 1A Wallace '467 at Wallace-467 at Fig. 6  FIG. 6

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 1:57–2:8 Given the ever-growing demand for wireless communication, a higher efficiency, higher performance wireless communications system is desirable. One type of higher performance wireless communications system is a Multiple Input/Multiple Output (MIMO) system that employs multiple transmit antennas to transmit over a propagation channel to multiple receive antennas. As in lower performance systems, the propagation channel in a MIMO system is subject to the deleterious effects of multipath, as well as interference from adjacent antennas. Multipath occurs when a transmitted signal arrives at a receiver unit through multiple propagation paths with differing delays. When signals arrive from multiple propagation paths, components of the signals can combine destructively, which is referred to as “fading.” In order to improve the efficiency and decrease the complexity of the MIMO system, information as to the characteristics of the propagation channel can be transmitted back to the transmitter unit in order to precondition the signal before transmission. Wallace '467 at 2:25–48 The present invention is directed to a method and apparatus for the measuring and reporting of channel state information in a high efficiency, high performance communications system, comprising the steps of: generating a plurality of pilot signals; transmitting the plurality of pilot signals over a propagation channel between a transmitter unit and a plurality of receiver units, wherein the transmitter unit comprises at least one transmit antenna, each of the plurality of receiver units comprises at least one receive antenna, and the propagation channel comprises a plurality of sub-channels between the transmitter unit and the plurality of receiver units; receiving at least one of the plurality of pilot signals at each of the plurality of receiver units; determining a set of transmission characteristics for at least one of the plurality of sub-channels, wherein the step of determining the set of transmission characteristics uses at least one of the plurality of pilot signals received at each of the plurality of receiver units; reporting an information signal from each of the plurality of receiver units to the transmitter unit, wherein the information signal carries the set of transmission characteristics for at least one of the plurality of sub-channels; and optimizing a set of transmission parameters at the transmitter unit, based on the information signal. Wallace '467 at 2:49–62 In one aspect of the invention, pilot symbols are transmitted on a plurality of disjoint OFDM sub-channel sets. When the pilot symbols are transmitted on disjoint OFDM sub-channels, the characteristics of the propagation channel can be determined through a set of K sub-channels carrying the pilot symbols, wherein K is less than the number of OFDM sub-channels in the system. In addition to transmitting pilot

Claim Element	Exemplary Citations to Wallace '467
	symbols on disjoint sub-channels, the system can transmit a time-domain pilot sequence that can be used to determine characteristics of the propagation channel. Along with the generation and transmission of pilot symbols, an aspect of the invention is the compression of the amount of information necessary to reconstruct the characteristics of the propagation channel. Wallace '467 at 3:34–54 FIG. 1A is a diagram of a Multiple Input/Multiple Output (MIMO) communications system 100 capable of implementing some embodiments of the invention. Communications system 100 can be operative to provide a combination of antenna, frequency, and temporal diversity to increase spectral efficiency, improve performance, and enhance flexibility. Increased spectral efficiency is characterized by the ability to transmit more bits per second per Hertz (bps/Hz) when and where possible to better utilize the available system bandwidth. Techniques to obtain higher spectral efficiency are described in further detail below. Improved performance may be quantified, for example, by a lower bit-error-rate (BER) or frame-error-rate (FER) for a given link carrier-to-noise-plus-interference ratio (C/I). And enhanced flexibility is characterized by the ability to accommodate multiple users having different and typically disparate requirements. These goals may be achieved, in part, by employing multi-carrier modulation, time division multiplexing (TDM), multiple transmit and/or receive antennas, and other techniques. The features, aspects, and advantages of the invention are described in further detail below. Wallace '467 at 3:55–67 As shown in FIG. 1A, communications system 100 includes a first system 110 in communication with a second system 120. System 110 includes a (transmit) data processor 112 that (1) receives or generates data, (2) processes the data to provide antenna, frequency, or temporal diversity, or a combination thereof, and (3) provides processed modulation symbols to a number of modulators (MOD) 114a through 114t. Each modulator 114 further processes the modulation symbols and generates an RF modulated signal suitable for transmission. The RF modulated signals from modulators 114a through 114t are then transmitted from respective antennas 116a through 116t over communications links 118 to system 120. Wallace '467 at 4:1–17 In FIG. 1A, system 120 includes a number of receive antennas 122a through 122r that receive the transmitted signals and provide the received signals to respective demodulators (DEMOD) 124a through 124r. As shown in FIG. 1A, each receive antenna 122 may receive signals from one or more transmit antennas 116 depending on a number of factors such as, for example, the operating mode used at system

Claim Element	Exemplary Citations to Wallace '467
	110, the directivity of the transmit and receive antennas, the characteristics of the communications links, and others. Each demodulator 124 demodulates the respective received signal using a demodulation scheme that is complementary to the modulation scheme used at the transmitter. The demodulated symbols from demodulators 124a through 124r are then provided to a (receive) data processor 126 that further processes the symbols to provide the output data. The data processing at the transmitter and receiver units is described in further detail below. Wallace '467 at 4:18–27 FIG. 1A shows only the forward link transmission from system 110 to system 120. This configuration may be used for data broadcast and other one-way data transmission applications. In a bidirectional communications system, a reverse link from system 120 to system 110 is also provided, although not shown in FIG. 1A for simplicity. For the bidirectional communications system, each of systems 110 and 120 may operate as a transmitter unit or a receiver unit, or both concurrently, depending on whether data is being transmitted from, or received at, the unit. Wallace '467 at 4:28–34 For simplicity, communications system 100 is shown to include one transmitter unit (i.e., system 110) and one receiver unit (i.e., system 120). However, in general, multiple transmit antennas and multiple receive antennas are present on each transmitter unit and each receiver unit. The communications system of the invention may include any number of transmitter units and receiver units. Wallace '467 at 4:36–47 Each transmitter unit may include a single transmit antenna or a number of transmit antennas, such as that shown in FIG. 1A. Similarly, each receiver unit may include a single receive antenna or a number of receive antennas, again such as that shown in FIG. 1A. For example, the communications system may include a central system (i.e., similar to a base station in the IS-95 CDMA system) having a number of antennas that transmit data to, and receive data from, a number of remote systems (i.e., subscriber units, similar to remote stations in the CDMA system), some of which may include one antenna and others of which may include multiple antennas. Wallace '467 at 4:48–63 As used herein, an antenna refers to a collection of one or more antenna elements that are distributed in

Claim Element	Exemplary Citations to Wallace '467
	space. The antenna elements may be physically located at a single site or distributed over multiple sites. Antenna elements physically co-located at a single site may be operated as an antenna array (e.g., such as for a CDMA base station). An antenna network consists of a collection of antenna arrays or elements that are physically separated (e.g., several CDMA base stations). An antenna array or an antenna network may be designed with the ability to form beams and to transmit multiple beams from the antenna array or network. For example, a CDMA base station may be designed with the capability to transmit up to three beams to three different sections of a coverage area (or sectors) from the same antenna array. Thus, the three beams may be viewed as three transmissions from three antennas. Wallace '467 at 4:64–5:4 The communications system of the invention can be designed to provide a multi-user, multiple access communications scheme capable of supporting subscriber units having different requirements as well as capabilities. The scheme allows the system's total operating bandwidth, W, (e.g., 1.2288 MHz) to be efficiently shared among different types of services that may have highly disparate data rate, delay, and quality of service (QOS) requirements. Wallace '467 at 5:54–67 As used herein, antenna diversity refers to the transmission and/or reception of data over more than one antenna, frequency diversity refers to the transmission of data over more than one sub-band, and temporal diversity refers to the transmission of data over more than one time period. Antenna, frequency, and temporal diversity may include subcategories. For example, transmit diversity refers to the use of more than one transmit antenna in a manner to improve the reliability of the communications link, receive diversity refers to the use of more than one receive antenna in a manner to improve the reliability of the communications link, and spatial diversity refers to the use of multiple transmit and receive antennas to improve the reliability and/or increase the capacity of the communications link. Wallace '467 at 6:6–14 Frequency diversity can be provided by use of a multi-carrier modulation scheme such as orthogonal frequency division multiplexing (OFDM), which allows for transmission of data over various sub-bands of the operating bandwidth. Temporal diversity is achieved by transmitting the data over different times, which can be more easily accomplished with the use of time-division multiplexing (TDM). These various

Claim Element	Exemplary Citations to Wallace '467
	aspects of the communications system of the invention are described in further detail below. Wallace '467 at 6:15–32 In accordance with an aspect of the invention, antenna diversity is achieved by employing a number of (N_T) transmit antennas at the transmitter unit or a number of (N_R) receive antennas at the receiver unit, or multiple antennas at both the transmitter and receiver units. In a terrestrial communications system (e.g., a cellular system, a broadcast system, an MMDS system, and others), an RF modulated signal from a transmitter unit may reach the receiver unit via a number of transmission paths. The characteristics of the transmission paths typically vary over time based on a number of factors. If more than one transmit or receive antenna is used, and if the transmission paths between the transmit and receive antennas are independent (i.e., uncorrelated), which is generally true to at least an extent, then the likelihood of correctly receiving the transmitted signal increases as the number of antennas increases. Generally, as the number of transmit and receive antennas increases, diversity increases and performance improves. Wallace '467 at 6:33–52 Antenna diversity is dynamically provided based on the characteristics of the communications link to provide the required performance. For example, a higher degree of antenna diversity can be provided for some types of communication (e.g., signaling), for some types of services (e.g., voice), for some communications link characteristics (e.g., low C/I), or for some other conditions or considerations. As used herein, antenna diversity includes transmit diversity and receive diversity. For transmit diversity, data is transmitted over multiple transmit antennas. Typically, additional processing is performed on the data transmitted from the transmit antennas to achieve the desired diversity. For example, the data transmitted from different transmit antennas may be delayed or reordered in time, or coded and interleaved across the available transmit antennas. Also, frequency and temporal diversity may be used in conjunction with the different transmit antennas. For receive diversity, modulated signals are received on multiple receive antennas, and diversity is achieved by simply receiving the signals via different transmission paths. Wallace '467 at 6:53–7:14 In accordance with another aspect of the invention, frequency diversity can be achieved by employing a multi-carrier modulation scheme. One such scheme that has numerous advantages is OFDM. With OFDM modulation, the overall transmission channel is essentially divided into a number of (L) parallel sub-channels that are used to transmit the same or different data. The overall transmission channel occupies the total operating bandwidth of W, and each of the sub-channels occupies a sub-band having a bandwidth

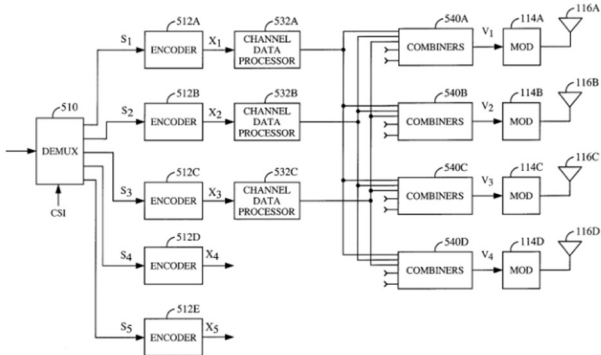
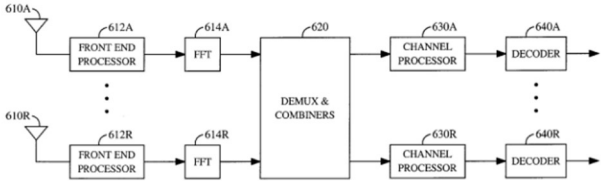
Claim Element	Exemplary Citations to Wallace '467
	of W/L and centered at a different center frequency. Each sub-channel has a bandwidth that is a portion of the total operating bandwidth. Each of the sub-channels may also be considered an independent data transmission channel that may be associated with a particular (and possibly unique) processing, coding, and modulation scheme, as described below. The data may be partitioned and transmitted over any defined set of two or more sub-bands to provide frequency diversity. For example, the transmission to a particular subscriber unit may occur over sub-channel 1 at time slot 1, sub-channel 5 at time slot 2, sub-channel 2 at time slot 3, and so on. As another example, data for a particular subscriber unit may be transmitted over sub-channels 1 and 2 at time slot 1 (e.g., with the same data being transmitted on both sub-channels), sub-channels 4 and 6 at time slot 2, only sub-channel 2 at time slot 3, and so on. Transmission of data over different sub-channels over time can improve the performance of a communications system experiencing frequency selective fading and channel distortion. Other benefits of OFDM modulation are described below. Wallace '467 at 7:15–31 In accordance with yet another aspect of the invention, temporal diversity is achieved by transmitting data at different times, which can be more easily accomplished using time division multiplexing (TDM). For data services (and possibly for voice services), data transmission occurs over time slots that may be selected to provide immunity to time dependent degradation in the communications link. Temporal diversity may also be achieved through the use of interleaving. For example, the transmission to a particular subscriber unit may occur over time slots 1 through x, or on a subset of the possible time slots from 1 through x (e.g., time slots 1, 5, 8, and so on). The amount of data transmitted at each time slot may be variable or fixed. Transmission over multiple time slots improves the likelihood of correct data reception due to, for example, impulse noise and interference. Wallace '467 at 7:33–8:3 The combination of antenna, frequency, and temporal diversity allows the communications system of the invention to provide robust performance. Antenna, frequency, and/or temporal diversity improves the likelihood of correct reception of at least some of the transmitted data, which may then be used (e.g., through decoding) to correct for some errors that may have occurred in the other transmissions. The combination of antenna, frequency, and temporal diversity also allows the communications system to concurrently accommodate different types of services having disparate data rate, processing delay, and quality of service requirements. The communications system of the invention can be designed and operated in a number of different communications modes, with each communications mode employing antenna, frequency, or temporal diversity, or a combination thereof. The communications modes include, for example, a diversity

Claim Element	Exemplary Citations to Wallace '467
	communications mode and a MIMO communications mode. Various combinations of the diversity and MIMO communications modes can also be supported by the communications system. Also, other communications modes can be implemented and are within the scope of the present invention. The diversity communications mode employs transmit and/or receive diversity, frequency, or temporal diversity, or a combination thereof, and is generally used to improve the reliability of the communications link. In one implementation of the diversity communications mode, the transmitter unit selects a modulation and coding scheme (i.e., configuration) from a finite set of possible configurations, which are known to the receiver units. For example, each overhead and common channel may be associated with a particular configuration that is known to all receiver units. When using the diversity communications mode for a specific user (e.g., for a voice call or a data transmission), the mode and/or configuration may be known a priori (e.g., from a previous set up) or negotiated (e.g., via a common channel) by the receiver unit. Wallace '467 at 8:16–52 The MIMO communications mode employs antenna diversity at both ends of the communication link and is generally used to improve both the reliability and increase the capacity of the communications link. The MIMO communications mode may further employ frequency and/or temporal diversity in combination with the antenna diversity. The MIMO communications mode, which may also be referred to herein as the spatial communications mode, employs one or more processing modes to be described below. The diversity communications mode generally has lower spectral efficiency than the MIMO communications mode, especially at high C/I levels. However, at low to moderate C/I values, the diversity communications mode achieves comparable efficiency and can be simpler to implement. In general, the use of the MIMO communications mode provides greater spectral efficiency when used, particularly at moderate to high C/I values. The MIMO communications mode may thus be advantageously used when the data rate requirements are moderate to high. The communications system can be designed to concurrently support both diversity and MIMO communications modes. The communications modes can be applied in various manners and, for increased flexibility, may be applied independently on a sub-channel basis. The MIMO communications mode is typically applied to specific users. However, each communications mode may be applied on each sub-channel independently, across a subset of sub-channels, across all sub-channels, or on some other basis. For example, the use of the MIMO communications mode may be applied to a specific user (e.g., a data user) and, concurrently, the use of the diversity communications mode may be applied to another specific user (e.g., a voice user) on a different sub-channel. The diversity communications mode may also be applied, for example, on sub-channels experiencing higher path loss.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 8:53–9:3 The communications system of the invention can also be designed to support a number of processing modes. When the transmitter unit is provided with information indicative of the conditions (i.e., the “state”) of the communications links, additional processing can be performed at the transmitter unit to further improve performance and increase efficiency. Full channel state information (CSI) or partial CSI may be available to the transmitter unit. Full CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-band. Full CSI also includes the C/I per sub-band. The full CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. Partial CSI may include, for example, the C/I of the sub-band . With full CSI or partial CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 9:4–15 The transmitter unit can precondition the signals presented to the transmit antennas in a way that is unique to a specific receiver unit (e.g., the pre-conditioning is performed for each sub-band assigned to that receiver unit). As long as the channel does not change appreciably from the time it is measured by the receiver unit and subsequently sent back to the transmitter and used to precondition the transmission, the intended receiver unit can demodulate the transmission. In this implementation, a full-CSI based MIMO communication can only be demodulated by the receiver unit associated with the CSI used to precondition the transmitted signals. Wallace '467 at 9:29–48 As an example, assume that the MIMO communications mode is applied to a channel data stream that is transmitted on one particular sub-channel from four transmit antennas. The channel data stream is demultiplexed into four data sub-streams, one data sub-stream for each transmit antenna. Each data sub-stream is then modulated using a particular modulation scheme (e.g., M-PSK, M-QAM, or other) selected based on the CSI for that sub-band and for that transmit antenna. Four modulation sub-streams are thus generated for the four data sub-streams, with each modulation sub-streams including a stream of modulation symbols. The four modulation sub-streams are then pre-conditioned using the eigenvector matrix, as expressed below in equation (1), to generate pre-conditioned modulation symbols. The four streams of pre-conditioned modulation symbols are respectively provided to the four combiners of the four transmit antennas. Each combiner combines the received pre-conditioned modulation symbols with

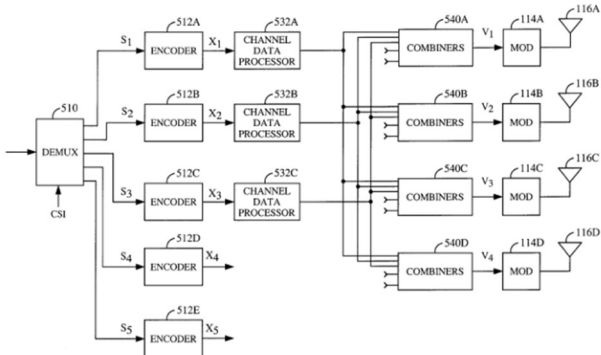
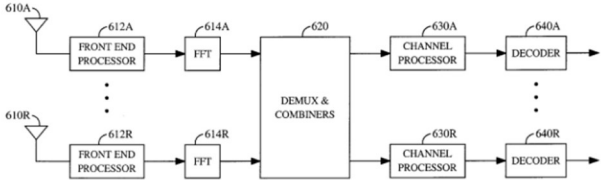
Claim Element	Exemplary Citations to Wallace '467
	the modulation symbols for the other sub-channels to generate a modulation symbol vector stream for the associated transmit antenna. Wallace '467 at 9:64–10:4 In instances where full CSI is not available, less descriptive information on the transmission path (or partial CSI) may be available and can be used to pre-condition the data prior to transmission. For example, the C/I of each of the sub-channels may be available. The C/I information can then be used to control the transmission from various transmit antennas to provide the required performance in the sub-channels of interest and increase system capacity. Wallace '467 at 13:3–21 Given the complexity of a system using multiple transmit antennas and multiple receive antennas, with the associated dispersive channel effects, the preferred modulation technique is OFDM, which effectively decomposes the channel into a set of non-interfering narrowband channels, or sub-channels. With proper OFDM signal design, a signal transmitted on one subchannel sees “flat fading”, i.e., the channel response is effectively constant over the subchannel bandwidth. The channel state information or CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-channel. CSI also includes the information of the relative levels of interference and noise in each sub-channel, that is known as C/I information. The CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. With CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 14:56–15:2 Multiple antennas at a receiver unit 145 receive signals at step 146. At step 147, the received signals undergo a Discrete Fourier Transform (DFT) operation to channelize the received signals. At step 148, the data from each subchannel over all of the receive antennas is processed. At this processing step, information regarding channel characteristics is extracted from the data, and converted into a more compressed format. One compression technique is the use of the conjugate channel response and the eigenmode matrix to reduce the amount of information needed to describe channel characteristics. At step 149, a message containing the compressed channel state information is transmitted from the receiver unit

Claim Element	Exemplary Citations to Wallace '467
	145 to the transmitter unit 140, which will then be used to precondition further transmissions. Wallace '467 at 29:16–38 1. A method for measuring and reporting transmission characteristics of a multiple input/multiple output communication system, comprising: assigning a first subset of sub-channels of a plurality of sub-channels to a first transmit antenna of a plurality of transmit antennas of a first transmitter unit, wherein the sub-channels of the first subset of sub-channels are noncontiguous; transmitting, by the first transmit antenna, a first pilot symbol over the sub-channels of the first subset of sub-channels; receiving, by a first receive antenna of a first receiver unit, the first pilot symbol; determining, from the received first pilot symbol, the transmission characteristics of the sub-channels of the first subset of sub-channels; reporting, by the first receiver unit to the first transmitter unit, an information signal that carries the determined transmission characteristics for the sub-channels of the first subset of sub-channels; and optimizing a set of transmission parameters at the first transmitter unit, based on the information signal. Wallace '467 at 31:8–32 19. A method for measuring and reporting channel state information (CSI) in a multiple input/multiple output (MIMO) system, comprising: assigning a plurality of sub-channel subsets to a plurality of transmit antennas of at least one transmitter unit, wherein the sub-channels of each of the sub-channel subsets are noncontiguous; transmitting a plurality of Orthogonal Frequency Division Multiplexed (OFDM) pilot waveforms from the at least one transmitter unit to at least one receiver unit, wherein each of the plurality of OFDM pilot waveforms is transmitted over a separate one of the plurality of sub-channel subsets; receiving, by the at least one receiver unit, the plurality of OFDM pilot waveforms; demodulating the received plurality of OFDM pilot waveforms; determining the CSI of the sub-channels corresponding to each of the plurality of sub-channel subsets from the demodulated plurality of OFDM pilot waveforms; transmitting the determined CSI to the at least one transmitter unit, and preconditioning a transmission symbol according to the determined CSI. To the extent this element is not disclosed by Wallace '467, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Wallace '467, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.

Claim Element	Exemplary Citations to Wallace '467
[19b] a computing device; and	Wallace '467 discloses or renders obvious “a computing device.” For example: Wallace '467 at Wallace-467 at Fig. 5A  FIG. 5A Wallace '467 at Wallace-467 at Fig. 6  FIG. 6 Wallace '467 at 2:25–48 The present invention is directed to a method and apparatus for the measuring and reporting of channel state information in a high efficiency, high performance communications system, comprising the steps of: generating a plurality of pilot signals; transmitting the plurality of pilot signals over a propagation channel between a transmitter unit and a plurality of receiver units, wherein the transmitter unit comprises at least one transmit antenna, each of the plurality of receiver units comprises at least one receive antenna, and the propagation channel comprises a plurality of sub-channels between the transmitter unit and the plurality of receiver units; receiving at least one of the plurality of pilot signals at each of the plurality of receiver units; determining a set of transmission characteristics for at least one of the plurality of sub-channels, wherein the step of determining the set of transmission characteristics uses at least one of the plurality of pilot signals received at each of the plurality of receiver units; reporting an information signal from each of the plurality of receiver units to the transmitter unit, wherein the information signal carries the set of transmission characteristics for at least one of the plurality of sub-channels; and optimizing a set of

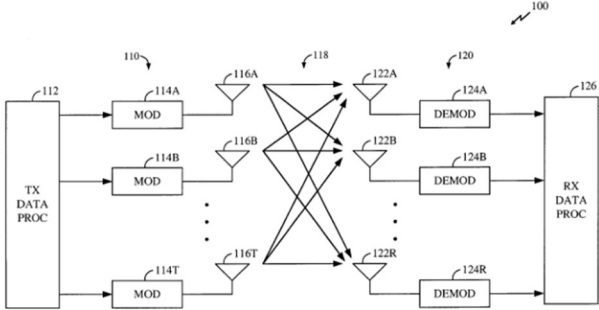
Claim Element	Exemplary Citations to Wallace '467
	transmission parameters at the transmitter unit, based on the information signal. Wallace '467 at 3:34–54 FIG. 1A is a diagram of a Multiple Input/Multiple Output (MIMO) communications system 100 capable of implementing some embodiments of the invention. Communications system 100 can be operative to provide a combination of antenna, frequency, and temporal diversity to increase spectral efficiency, improve performance, and enhance flexibility. Increased spectral efficiency is characterized by the ability to transmit more bits per second per Hertz (bps/Hz) when and where possible to better utilize the available system bandwidth. Techniques to obtain higher spectral efficiency are described in further detail below. Improved performance may be quantified, for example, by a lower bit-error-rate (BER) or frame-error-rate (FER) for a given link carrier-to-noise-plus-interference ratio (C/I). And enhanced flexibility is characterized by the ability to accommodate multiple users having different and typically disparate requirements. These goals may be achieved, in part, by employing multi-carrier modulation, time division multiplexing (TDM), multiple transmit and/or receive antennas, and other techniques. The features, aspects, and advantages of the invention are described in further detail below. Wallace '467 at 3:55–67 As shown in FIG. 1A, communications system 100 includes a first system 110 in communication with a second system 120. System 110 includes a (transmit) data processor 112 that (1) receives or generates data, (2) processes the data to provide antenna, frequency, or temporal diversity, or a combination thereof, and (3) provides processed modulation symbols to a number of modulators (MOD) 114a through 114t. Each modulator 114 further processes the modulation symbols and generates an RF modulated signal suitable for transmission. The RF modulated signals from modulators 114a through 114t are then transmitted from respective antennas 116a through 116t over communications links 118 to system 120. Wallace '467 at 4:36–47 Each transmitter unit may include a single transmit antenna or a number of transmit antennas, such as that shown in FIG. 1A. Similarly, each receiver unit may include a single receive antenna or a number of receive antennas, again such as that shown in FIG. 1A. For example, the communications system may include a central system (i.e., similar to a base station in the IS-95 CDMA system) having a number of antennas that transmit data to, and receive data from, a number of remote systems (i.e., subscriber units, similar to remote stations in the CDMA system), some of which may include one antenna and others of

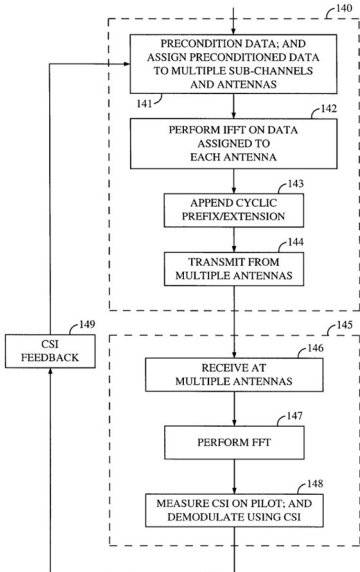
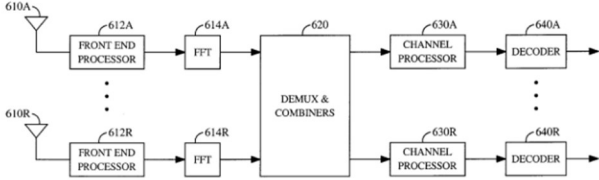
Claim Element	Exemplary Citations to Wallace '467
	which may include multiple antennas. Wallace '467 at 4:48–63 As used herein, an antenna refers to a collection of one or more antenna elements that are distributed in space. The antenna elements may be physically located at a single site or distributed over multiple sites. Antenna elements physically co-located at a single site may be operated as an antenna array (e.g., such as for a CDMA base station). An antenna network consists of a collection of antenna arrays or elements that are physically separated (e.g., several CDMA base stations). An antenna array or an antenna network may be designed with the ability to form beams and to transmit multiple beams from the antenna array or network. For example, a CDMA base station may be designed with the capability to transmit up to three beams to three different sections of a coverage area (or sectors) from the same antenna array. Thus, the three beams may be viewed as three transmissions from three antennas. Wallace '467 at 28:58–29:4 As shown above, the transmitter unit and receiver unit are each implemented with various processing units that include various types of data processor, encoders, IFFTs, FFTs, demultiplexers, combiners, and so on. These processing units can be implemented in various manners such as an application specific integrated circuit (ASIC), a digital signal processor, a microcontroller, a microprocessor, or other electronic circuits designed to perform the functions described herein. Also, the processing units can be implemented with a general-purpose processor or a specially designed processor operated to execute instruction codes that achieve the functions described herein. Thus, the processing units described herein can be implemented using hardware, software, or a combination thereof. To the extent this element is not disclosed by Wallace '467, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Wallace '467, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
[19c] a computer-readable storage medium having computer-executable instructions stored thereon that are executable by the computing device to perform operations comprising:	Wallace '467 discloses or renders obvious “a computer-readable storage medium having computer-executable instructions stored thereon that are executable by the computing device to perform operations.” For example:

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at Wallace-467 at Fig. 5A  FIG. 5A Wallace '467 at Wallace-467 at Fig. 6  FIG. 6 Wallace '467 at 2:25-48 The present invention is directed to a method and apparatus for the measuring and reporting of channel state information in a high efficiency, high performance communications system, comprising the steps of: generating a plurality of pilot signals; transmitting the plurality of pilot signals over a propagation channel between a transmitter unit and a plurality of receiver units, wherein the transmitter unit comprises at least one transmit antenna, each of the plurality of receiver units comprises at least one receive antenna, and the propagation channel comprises a plurality of sub-channels between the transmitter unit and the plurality of receiver units; receiving at least one of the plurality of pilot signals at each of the plurality of receiver units; determining a set of transmission characteristics for at least one of the plurality of sub-channels, wherein the step of determining the set of transmission characteristics uses at least one of the plurality of pilot signals received at each of the plurality of receiver units; reporting an information signal from each of the plurality of receiver units to the transmitter unit, wherein the information signal carries the set of transmission characteristics for at least one of the plurality of sub-channels; and optimizing a set of

Claim Element	Exemplary Citations to Wallace '467
	transmission parameters at the transmitter unit, based on the information signal. Wallace '467 at 3:34–54 FIG. 1A is a diagram of a Multiple Input/Multiple Output (MIMO) communications system 100 capable of implementing some embodiments of the invention. Communications system 100 can be operative to provide a combination of antenna, frequency, and temporal diversity to increase spectral efficiency, improve performance, and enhance flexibility. Increased spectral efficiency is characterized by the ability to transmit more bits per second per Hertz (bps/Hz) when and where possible to better utilize the available system bandwidth. Techniques to obtain higher spectral efficiency are described in further detail below. Improved performance may be quantified, for example, by a lower bit-error-rate (BER) or frame-error-rate (FER) for a given link carrier-to-noise-plus-interference ratio (C/I). And enhanced flexibility is characterized by the ability to accommodate multiple users having different and typically disparate requirements. These goals may be achieved, in part, by employing multi-carrier modulation, time division multiplexing (TDM), multiple transmit and/or receive antennas, and other techniques. The features, aspects, and advantages of the invention are described in further detail below. Wallace '467 at 3:55–67 As shown in FIG. 1A, communications system 100 includes a first system 110 in communication with a second system 120. System 110 includes a (transmit) data processor 112 that (1) receives or generates data, (2) processes the data to provide antenna, frequency, or temporal diversity, or a combination thereof, and (3) provides processed modulation symbols to a number of modulators (MOD) 114a through 114t. Each modulator 114 further processes the modulation symbols and generates an RF modulated signal suitable for transmission. The RF modulated signals from modulators 114a through 114t are then transmitted from respective antennas 116a through 116t over communications links 118 to system 120. Wallace '467 at 4:36–47 Each transmitter unit may include a single transmit antenna or a number of transmit antennas, such as that shown in FIG. 1A. Similarly, each receiver unit may include a single receive antenna or a number of receive antennas, again such as that shown in FIG. 1A. For example, the communications system may include a central system (i.e., similar to a base station in the IS-95 CDMA system) having a number of antennas that transmit data to, and receive data from, a number of remote systems (i.e., subscriber units, similar to remote stations in the CDMA system), some of which may include one antenna and others of

Claim Element	Exemplary Citations to Wallace '467
	which may include multiple antennas. Wallace '467 at 4:48–63 As used herein, an antenna refers to a collection of one or more antenna elements that are distributed in space. The antenna elements may be physically located at a single site or distributed over multiple sites. Antenna elements physically co-located at a single site may be operated as an antenna array (e.g., such as for a CDMA base station). An antenna network consists of a collection of antenna arrays or elements that are physically separated (e.g., several CDMA base stations). An antenna array or an antenna network may be designed with the ability to form beams and to transmit multiple beams from the antenna array or network. For example, a CDMA base station may be designed with the capability to transmit up to three beams to three different sections of a coverage area (or sectors) from the same antenna array. Thus, the three beams may be viewed as three transmissions from three antennas. Wallace '467 at 28:58–29:4 As shown above, the transmitter unit and receiver unit are each implemented with various processing units that include various types of data processor, encoders, IFFTs, FFTs, demultiplexers, combiners, and so on. These processing units can be implemented in various manners such as an application specific integrated circuit (ASIC), a digital signal processor, a microcontroller, a microprocessor, or other electronic circuits designed to perform the functions described herein. Also, the processing units can be implemented with a general-purpose processor or a specially designed processor operated to execute instruction codes that achieve the functions described herein. Thus, the processing units described herein can be implemented using hardware, software, or a combination thereof. To the extent this element is not disclosed by Wallace '467, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Wallace '467, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
[19d] receiving a first signal at the receiver via a first propagation path of the plurality of propagation paths;	Wallace '467 discloses or renders obvious “receiving a first signal at the receiver via a first propagation path of the plurality of propagation paths.” For example: Wallace '467 at Abstract Channel state information (CSI) can be used by a communications system to precondition transmissions between transmitter units and receiver units. In one aspect of the invention, disjoint sub-channel sets are assigned to transmit antennas located at a transmitter unit. Pilot symbols are generated and transmitted on

Claim Element	Exemplary Citations to Wallace '467
	a subset of the disjoint sub-channels. Upon receipt of the transmitted pilot symbols, the receiver units determine the CSI for the disjoint sub-channels that carried pilot symbols. These CSI values are reported to the transmitter unit, which will use these CSI values to generate CSI estimates for the disjoint sub-channels that did not carry pilot symbols. The amount of information necessary to report CSI on the reverse link can be further minimized through compression techniques and resource allocation techniques. Wallace '467 at Wallace-467 at Fig. 1A  FIG. 1A

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at Wallace-467 at Fig. 1B  <pre> graph TD subgraph 140 [] 141[PRECONDITION DATA, AND ASSIGN PRECONDITIONED DATA TO MULTIPLE SUB-CHANNELS AND ANTENNAS] --> 142[PERFORM IFFT ON DATA ASSIGNED TO EACH ANTENNA] 142 --> 143[APPEND CYCLIC PREFIX/EXTENSION] 143 --> 144[TRANSMIT FROM MULTIPLE ANTENNAS] end 144 --> 145 subgraph 145 [] 146[RECEIVE AT MULTIPLE ANTENNAS] --> 147[PERFORM FFT] 147 --> 148[MEASURE CSI ON PILOT; AND DEMODULATE USING CSI] end 148 --> 149[CSI FEEDBACK] 149 --> 141 </pre> FIG. 1B Wallace '467 at Wallace-467 at Fig. 6  <pre> graph LR 610A[610A] --> 612A[612A FRONT END PROCESSOR] 610R[610R] --> 612R[612R FRONT END PROCESSOR] 612A --> 614A[614A FFT] 612R --> 614R[614R FFT] 614A --> 620[620 DEMUX & COMBINERS] 614R --> 620 620 --> 630A[630A CHANNEL PROCESSOR] 620 --> 630R[630R CHANNEL PROCESSOR] 630A --> 640A[640A DECODER] 630R --> 640R[640R DECODER] </pre> FIG. 6 Wallace '467 at 1:57-2:8 Given the ever-growing demand for wireless communication, a higher efficiency, higher performance wireless communications system is desirable. One type of higher performance wireless communications system is a Multiple Input/Multiple Output (MIMO) system that employs multiple transmit antennas to transmit over a propagation channel to multiple receive antennas. As in lower performance systems, the propagation channel in a MIMO system is subject to the deleterious effects of multipath, as well as interference from adjacent antennas. Multipath occurs when a transmitted signal arrives at a receiver unit through multiple propagation paths with differing delays. When signals arrive from multiple propagation

Claim Element	Exemplary Citations to Wallace '467
	paths, components of the signals can combine destructively, which is referred to as “fading.” In order to improve the efficiency and decrease the complexity of the MIMO system, information as to the characteristics of the propagation channel can be transmitted back to the transmitter unit in order to precondition the signal before transmission. Wallace '467 at 2:25–48 The present invention is directed to a method and apparatus for the measuring and reporting of channel state information in a high efficiency, high performance communications system, comprising the steps of: generating a plurality of pilot signals; transmitting the plurality of pilot signals over a propagation channel between a transmitter unit and a plurality of receiver units, wherein the transmitter unit comprises at least one transmit antenna, each of the plurality of receiver units comprises at least one receive antenna, and the propagation channel comprises a plurality of sub-channels between the transmitter unit and the plurality of receiver units; receiving at least one of the plurality of pilot signals at each of the plurality of receiver units; determining a set of transmission characteristics for at least one of the plurality of sub-channels, wherein the step of determining the set of transmission characteristics uses at least one of the plurality of pilot signals received at each of the plurality of receiver units; reporting an information signal from each of the plurality of receiver units to the transmitter unit, wherein the information signal carries the set of transmission characteristics for at least one of the plurality of sub-channels; and optimizing a set of transmission parameters at the transmitter unit, based on the information signal. Wallace '467 at 2:49–62 In one aspect of the invention, pilot symbols are transmitted on a plurality of disjoint OFDM sub-channel sets. When the pilot symbols are transmitted on disjoint OFDM sub-channels, the characteristics of the propagation channel can be determined through a set of K sub-channels carrying the pilot symbols, wherein K is less than the number of OFDM sub-channels in the system. In addition to transmitting pilot symbols on disjoint sub-channels, the system can transmit a time-domain pilot sequence that can be used to determine characteristics of the propagation channel. Along with the generation and transmission of pilot symbols, an aspect of the invention is the compression of the amount of information necessary to reconstruct the characteristics of the propagation channel. Wallace '467 at 3:34–54 FIG. 1A is a diagram of a Multiple Input/Multiple Output (MIMO) communications system 100 capable of implementing some embodiments of the invention. Communications system 100 can be operative to

Claim Element	Exemplary Citations to Wallace '467
	provide a combination of antenna, frequency, and temporal diversity to increase spectral efficiency, improve performance, and enhance flexibility. Increased spectral efficiency is characterized by the ability to transmit more bits per second per Hertz (bps/Hz) when and where possible to better utilize the available system bandwidth. Techniques to obtain higher spectral efficiency are described in further detail below. Improved performance may be quantified, for example, by a lower bit-error-rate (BER) or frame-error-rate (FER) for a given link carrier-to-noise-plus-interference ratio (C/I). And enhanced flexibility is characterized by the ability to accommodate multiple users having different and typically disparate requirements. These goals may be achieved, in part, by employing multi-carrier modulation, time division multiplexing (TDM), multiple transmit and/or receive antennas, and other techniques. The features, aspects, and advantages of the invention are described in further detail below. Wallace '467 at 3:55–67 As shown in FIG. 1A, communications system 100 includes a first system 110 in communication with a second system 120. System 110 includes a (transmit) data processor 112 that (1) receives or generates data, (2) processes the data to provide antenna, frequency, or temporal diversity, or a combination thereof, and (3) provides processed modulation symbols to a number of modulators (MOD) 114a through 114t. Each modulator 114 further processes the modulation symbols and generates an RF modulated signal suitable for transmission. The RF modulated signals from modulators 114a through 114t are then transmitted from respective antennas 116a through 116t over communications links 118 to system 120. Wallace '467 at 4:1–17 In FIG. 1A, system 120 includes a number of receive antennas 122a through 122r that receive the transmitted signals and provide the received signals to respective demodulators (DEMOD) 124a through 124r. As shown in FIG. 1A, each receive antenna 122 may receive signals from one or more transmit antennas 116 depending on a number of factors such as, for example, the operating mode used at system 110, the directivity of the transmit and receive antennas, the characteristics of the communications links, and others. Each demodulator 124 demodulates the respective received signal using a demodulation scheme that is complementary to the modulation scheme used at the transmitter. The demodulated symbols from demodulators 124a through 124r are then provided to a (receive) data processor 126 that further processes the symbols to provide the output data. The data processing at the transmitter and receiver units is described in further detail below.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 4:18–27 FIG. 1A shows only the forward link transmission from system 110 to system 120. This configuration may be used for data broadcast and other one-way data transmission applications. In a bidirectional communications system, a reverse link from system 120 to system 110 is also provided, although not shown in FIG. 1A for simplicity. For the bidirectional communications system, each of systems 110 and 120 may operate as a transmitter unit or a receiver unit, or both concurrently, depending on whether data is being transmitted from, or received at, the unit. Wallace '467 at 4:28–34 For simplicity, communications system 100 is shown to include one transmitter unit (i.e., system 110) and one receiver unit (i.e., system 120). However, in general, multiple transmit antennas and multiple receive antennas are present on each transmitter unit and each receiver unit. The communications system of the invention may include any number of transmitter units and receiver units. Wallace '467 at 4:36–47 Each transmitter unit may include a single transmit antenna or a number of transmit antennas, such as that shown in FIG. 1A. Similarly, each receiver unit may include a single receive antenna or a number of receive antennas, again such as that shown in FIG. 1A. For example, the communications system may include a central system (i.e., similar to a base station in the IS-95 CDMA system) having a number of antennas that transmit data to, and receive data from, a number of remote systems (i.e., subscriber units, similar to remote stations in the CDMA system), some of which may include one antenna and others of which may include multiple antennas. Wallace '467 at 4:48–63 As used herein, an antenna refers to a collection of one or more antenna elements that are distributed in space. The antenna elements may be physically located at a single site or distributed over multiple sites. Antenna elements physically co-located at a single site may be operated as an antenna array (e.g., such as for a CDMA base station). An antenna network consists of a collection of antenna arrays or elements that are physically separated (e.g., several CDMA base stations). An antenna array or an antenna network may be designed with the ability to form beams and to transmit multiple beams from the antenna array or network. For example, a CDMA base station may be designed with the capability to transmit up to three beams to three different sections of a coverage area (or sectors) from the same antenna array. Thus, the

Claim Element	Exemplary Citations to Wallace '467
	three beams may be viewed as three transmissions from three antennas. Wallace '467 at 4:64–5:4 The communications system of the invention can be designed to provide a multi-user, multiple access communications scheme capable of supporting subscriber units having different requirements as well as capabilities. The scheme allows the system's total operating bandwidth, W, (e.g., 1.2288 MHz) to be efficiently shared among different types of services that may have highly disparate data rate, delay, and quality of service (QOS) requirements. Wallace '467 at 5:47–53 The communications system of the invention provides the above-described features and advantages, and is capable of supporting different types of services having disparate requirements. The features are achieved by employing antenna, frequency, or temporal diversity, or a combination thereof. Antenna, frequency, or temporal diversity can be independently achieved and dynamically selected. Wallace '467 at 5:54–67 As used herein, antenna diversity refers to the transmission and/or reception of data over more than one antenna, frequency diversity refers to the transmission of data over more than one sub-band, and temporal diversity refers to the transmission of data over more than one time period. Antenna, frequency, and temporal diversity may include subcategories. For example, transmit diversity refers to the use of more than one transmit antenna in a manner to improve the reliability of the communications link, receive diversity refers to the use of more than one receive antenna in a manner to improve the reliability of the communications link, and spatial diversity refers to the use of multiple transmit and receive antennas to improve the reliability and/or increase the capacity of the communications link. Wallace '467 at 6:1–5 Transmit and receive diversity can also be used in combination to improve the reliability of the communications link without increasing the link capacity. Various combinations of antenna, frequency, and temporal diversity can thus be achieved and are within the scope of the present invention. Wallace '467 at 6:6–14 Frequency diversity can be provided by use of a multi-carrier modulation scheme such as orthogonal

Claim Element	Exemplary Citations to Wallace '467
	frequency division multiplexing (OFDM), which allows for transmission of data over various sub-bands of the operating bandwidth. Temporal diversity is achieved by transmitting the data over different times, which can be more easily accomplished with the use of time-division multiplexing (TDM). These various aspects of the communications system of the invention are described in further detail below. Wallace '467 at 6:15–32 In accordance with an aspect of the invention, antenna diversity is achieved by employing a number of (N_T) transmit antennas at the transmitter unit or a number of (N_R) receive antennas at the receiver unit, or multiple antennas at both the transmitter and receiver units. In a terrestrial communications system (e.g., a cellular system, a broadcast system, an MMDS system, and others), an RF modulated signal from a transmitter unit may reach the receiver unit via a number of transmission paths. The characteristics of the transmission paths typically vary over time based on a number of factors. If more than one transmit or receive antenna is used, and if the transmission paths between the transmit and receive antennas are independent (i.e., uncorrelated), which is generally true to at least an extent, then the likelihood of correctly receiving the transmitted signal increases as the number of antennas increases. Generally, as the number of transmit and receive antennas increases, diversity increases and performance improves. Wallace '467 at 6:33–52 Antenna diversity is dynamically provided based on the characteristics of the communications link to provide the required performance. For example, a higher degree of antenna diversity can be provided for some types of communication (e.g., signaling), for some types of services (e.g., voice), for some communications link characteristics (e.g., low C/I), or for some other conditions or considerations. As used herein, antenna diversity includes transmit diversity and receive diversity. For transmit diversity, data is transmitted over multiple transmit antennas. Typically, additional processing is performed on the data transmitted from the transmit antennas to achieve the desired diversity. For example, the data transmitted from different transmit antennas may be delayed or reordered in time, or coded and interleaved across the available transmit antennas. Also, frequency and temporal diversity may be used in conjunction with the different transmit antennas. For receive diversity, modulated signals are received on multiple receive antennas, and diversity is achieved by simply receiving the signals via different transmission paths. Wallace '467 at 6:53–7:14 In accordance with another aspect of the invention, frequency diversity can be achieved by employing a multi-carrier modulation scheme. One such scheme that has numerous advantages is OFDM. With OFDM

Claim Element	Exemplary Citations to Wallace '467
	modulation, the overall transmission channel is essentially divided into a number of (L) parallel sub-channels that are used to transmit the same or different data. The overall transmission channel occupies the total operating bandwidth of W, and each of the sub-channels occupies a sub-band having a bandwidth of W/L and centered at a different center frequency. Each sub-channel has a bandwidth that is a portion of the total operating bandwidth. Each of the sub-channels may also be considered an independent data transmission channel that may be associated with a particular (and possibly unique) processing, coding, and modulation scheme, as described below. The data may be partitioned and transmitted over any defined set of two or more sub-bands to provide frequency diversity. For example, the transmission to a particular subscriber unit may occur over sub-channel 1 at time slot 1, sub-channel 5 at time slot 2, sub-channel 2 at time slot 3, and so on. As another example, data for a particular subscriber unit may be transmitted over sub-channels 1 and 2 at time slot 1 (e.g., with the same data being transmitted on both sub-channels), sub-channels 4 and 6 at time slot 2, only sub-channel 2 at time slot 3, and so on. Transmission of data over different sub-channels over time can improve the performance of a communications system experiencing frequency selective fading and channel distortion. Other benefits of OFDM modulation are described below. Wallace '467 at 7:15–31 In accordance with yet another aspect of the invention, temporal diversity is achieved by transmitting data at different times, which can be more easily accomplished using time division multiplexing (TDM). For data services (and possibly for voice services), data transmission occurs over time slots that may be selected to provide immunity to time dependent degradation in the communications link. Temporal diversity may also be achieved through the use of interleaving. For example, the transmission to a particular subscriber unit may occur over time slots 1 through x, or on a subset of the possible time slots from 1 through x (e.g., time slots 1, 5, 8, and so on). The amount of data transmitted at each time slot may be variable or fixed. Transmission over multiple time slots improves the likelihood of correct data reception due to, for example, impulse noise and interference. Wallace '467 at 7:33–8:3 The combination of antenna, frequency, and temporal diversity allows the communications system of the invention to provide robust performance. Antenna, frequency, and/or temporal diversity improves the likelihood of correct reception of at least some of the transmitted data, which may then be used (e.g., through decoding) to correct for some errors that may have occurred in the other transmissions. The combination of antenna, frequency, and temporal diversity also allows the communications system to concurrently accommodate different types of services having disparate data rate, processing delay, and quality of service requirements.

Claim Element	Exemplary Citations to Wallace '467
	The communications system of the invention can be designed and operated in a number of different communications modes, with each communications mode employing antenna, frequency, or temporal diversity, or a combination thereof. The communications modes include, for example, a diversity communications mode and a MIMO communications mode. Various combinations of the diversity and MIMO communications modes can also be supported by the communications system. Also, other communications modes can be implemented and are within the scope of the present invention. The diversity communications mode employs transmit and/or receive diversity, frequency, or temporal diversity, or a combination thereof, and is generally used to improve the reliability of the communications link. In one implementation of the diversity communications mode, the transmitter unit selects a modulation and coding scheme (i.e., configuration) from a finite set of possible configurations, which are known to the receiver units. For example, each overhead and common channel may be associated with a particular configuration that is known to all receiver units. When using the diversity communications mode for a specific user (e.g., for a voice call or a data transmission), the mode and/or configuration may be known a priori (e.g., from a previous set up) or negotiated (e.g., via a common channel) by the receiver unit. Wallace '467 at 8:16–52 The MIMO communications mode employs antenna diversity at both ends of the communication link and is generally used to improve both the reliability and increase the capacity of the communications link. The MIMO communications mode may further employ frequency and/or temporal diversity in combination with the antenna diversity. The MIMO communications mode, which may also be referred to herein as the spatial communications mode, employs one or more processing modes to be described below. The diversity communications mode generally has lower spectral efficiency than the MIMO communications mode, especially at high C/I levels. However, at low to moderate C/I values, the diversity communications mode achieves comparable efficiency and can be simpler to implement. In general, the use of the MIMO communications mode provides greater spectral efficiency when used, particularly at moderate to high C/I values. The MIMO communications mode may thus be advantageously used when the data rate requirements are moderate to high. The communications system can be designed to concurrently support both diversity and MIMO communications modes. The communications modes can be applied in various manners and, for increased flexibility, may be applied independently on a sub-channel basis. The MIMO communications mode is typically applied to specific users. However, each communications mode may be applied on each sub-channel independently, across a subset of sub-channels, across all sub-channels, or on some other basis. For example, the use of the MIMO communications mode may be applied to a specific user (e.g., a data user) and, concurrently, the use of the diversity communications mode may be applied to another specific

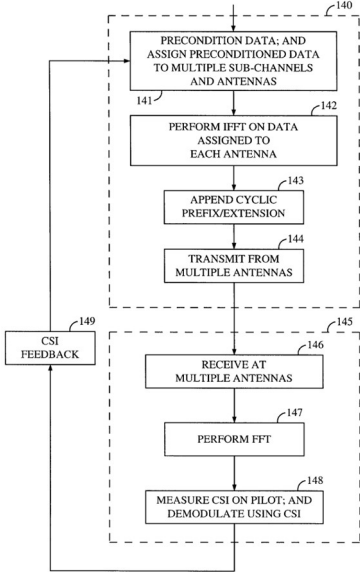
Claim Element	Exemplary Citations to Wallace '467
	user (e.g., a voice user) on a different sub-channel. The diversity communications mode may also be applied, for example, on sub-channels experiencing higher path loss. Wallace '467 at 8:53–9:3 The communications system of the invention can also be designed to support a number of processing modes. When the transmitter unit is provided with information indicative of the conditions (i.e., the “state”) of the communications links, additional processing can be performed at the transmitter unit to further improve performance and increase efficiency. Full channel state information (CSI) or partial CSI may be available to the transmitter unit. Full CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-band. Full CSI also includes the C/I per sub-band. The full CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. Partial CSI may include, for example, the C/I of the sub-band . With full CSI or partial CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 9:4–15 The transmitter unit can precondition the signals presented to the transmit antennas in a way that is unique to a specific receiver unit (e.g., the pre-conditioning is performed for each sub-band assigned to that receiver unit). As long as the channel does not change appreciably from the time it is measured by the receiver unit and subsequently sent back to the transmitter and used to precondition the transmission, the intended receiver unit can demodulate the transmission. In this implementation, a full-CSI based MIMO communication can only be demodulated by the receiver unit associated with the CSI used to precondition the transmitted signals. Wallace '467 at 9:29–48 As an example, assume that the MIMO communications mode is applied to a channel data stream that is transmitted on one particular sub-channel from four transmit antennas. The channel data stream is demultiplexed into four data sub-streams, one data sub-stream for each transmit antenna. Each data sub-stream is then modulated using a particular modulation scheme (e.g., M-PSK, M-QAM, or other) selected based on the CSI for that sub-band and for that transmit antenna. Four modulation sub-streams are thus generated for the four data sub-streams, with each modulation sub-streams including a stream of modulation symbols. The four modulation sub-streams are then pre-conditioned using the eigenvector matrix, as expressed below in equation (1), to generate pre-conditioned modulation symbols. The four

Claim Element	Exemplary Citations to Wallace '467
	streams of pre-conditioned modulation symbols are respectively provided to the four combiners of the four transmit antennas. Each combiner combines the received pre-conditioned modulation symbols with the modulation symbols for the other sub-channels to generate a modulation symbol vector stream for the associated transmit antenna. Wallace '467 at 9:64–10:4 In instances where full CSI is not available, less descriptive information on the transmission path (or partial CSI) may be available and can be used to pre-condition the data prior to transmission. For example, the C/I of each of the sub-channels may be available. The C/I information can then be used to control the transmission from various transmit antennas to provide the required performance in the sub-channels of interest and increase system capacity. Wallace '467 at 13:3–21 Given the complexity of a system using multiple transmit antennas and multiple receive antennas, with the associated dispersive channel effects, the preferred modulation technique is OFDM, which effectively decomposes the channel into a set of non-interfering narrowband channels, or sub-channels. With proper OFDM signal design, a signal transmitted on one subchannel sees “flat fading”, i.e., the channel response is effectively constant over the subchannel bandwidth. The channel state information or CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-channel. CSI also includes the information of the relative levels of interference and noise in each sub-channel, that is known as C/I information. The CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. With CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 14:56–15:2 Multiple antennas at a receiver unit 145 receive signals at step 146. At step 147, the received signals undergo a Discrete Fourier Transform (DFT) operation to channelize the received signals. At step 148, the data from each subchannel over all of the receive antennas is processed. At this processing step, information regarding channel characteristics is extracted from the data, and converted into a more compressed format. One compression technique is the use of the conjugate channel response and the eigenmode matrix to reduce the amount of information needed to describe channel characteristics. At step 149, a message containing the compressed channel state information is transmitted from the receiver unit

Claim Element	Exemplary Citations to Wallace '467
	145 to the transmitter unit 140, which will then be used to precondition further transmissions. Wallace '467 at 15:3–7 To facilitate the derivation of the CSI, the transmit waveform is made up of known pilot symbols for an initial preamble. The pilot waveforms for different transmit antennas comprise disjoint sets of OFDM subchannels as illustrated for the case when $N_t=4$ in FIG. 1C. Wallace '467 at 15:38–58 From each transmit antenna at a transmitter unit, the receiver unit receives pilot symbols on disjoint sub-channels and makes determinations as to channel characteristics of the disjoint sub-channels. As discussed previously, the receiver unit may have one or more receive antennas. Suppose $x=\{x_i, i=1, \dots, K\}$ are the pilot symbol values that are to be transmitted on K pilot sub-channels for a single transmit antenna. The receiver unit will receive the values $y_{ij}=h_{ij}x_i+n_{ij}$, wherein h_{ij} is the complex channel response for the i^{th} pilot sub-channel received at the j^{th} receive antenna, and n_{ij} is noise. From this relationship, the receiver unit can determine noisy estimates of the channel response of K sub-channels of a single transmit antenna. These noisy estimates may be used to derive estimates for all sub-channels of the propagation channel through a number of different methods, such as simple interpolation to more complex estimation using a priori information on the channel dispersion and noise level. The estimates may be improved by transmitting pilot symbols over consecutive OFDM symbols and then averaging the estimates for each consecutive OFDM symbol. Wallace '467 at 18:5–32 The embodiments of the invention discussed herein have been directed to the design and transmission of pilot signals that will allow a person skilled in the art to derive characteristics of the propagation channel and to report such characteristics to the transmission site. However, the full CSI is a large amount of information and also highly redundant. Many methods are available for compressing the amount of CSI information to be transmitted. One method discussed previously is the use of the Hermitian matrix H^*H, wherein H is the channel response as determined at the receiver unit. The Hermitian matrix H^*H can be reported to the transmitter unit and be used to precondition transmissions. Due to the properties of Hermitian matrices, only half of the matrix elements need to be transmitted, such as the complex lower triangular portion of the matrix H^*H, and the real-valued diagonal. Additional efficiencies are realized if the number of receive antennas is larger than the number of transmit antennas. Another method to reduce the amount of information transmitted to the transmitter unit on the reverse link is to report only a subset

Claim Element	Exemplary Citations to Wallace '467
	of the channel response matrices H_i to the transmitter unit, from which the unreported channel response matrices can be determined through interpolation schemes. In another method, a functional representation of the channel response across the sub-channels may be derived for each transmit/receive antenna pair, e.g., a polynomial function representative of the channel response can be generated. The coefficients of the polynomial function are then transmitted to the transmitter unit. Wallace '467 at 18:33–44 As an alternative to these methods for compressing CSI information, one embodiment of the invention is directed to the transmission of a time-domain representation of the channel response, which is the channel impulse response. If a time-domain representation of the channel response is simple, as in cases where there are only two or three multipath components, an inverse FFT can be performed upon the set of channel frequency responses. The inverse FFT operation can be performed for each link between a transmit/receive antenna pair. The resulting channel impulse responses are then translated into a set of amplitudes and delays that are reported to the transmitter. Wallace '467 at 25:45–56 OFDM modulation can improve system performance due to multipath delay spread or differential path delay introduced by the propagation environment between the transmitting antenna and the receiver antenna. The communications link (i.e., the RF channel) has a delay spread that may potentially be greater than the reciprocal of the system operating bandwidth, W. Because of this, a communications system employing a modulation scheme that has a transmit symbol duration of less than the delay spread will experience inter-symbol interference (ISI). The ISI distorts the received symbol and increases the likelihood of incorrect detection. Wallace '467 at 29:16–38 1. A method for measuring and reporting transmission characteristics of a multiple input/multiple output communication system, comprising: assigning a first subset of sub-channels of a plurality of sub-channels to a first transmit antenna of a plurality of transmit antennas of a first transmitter unit, wherein the sub-channels of the first subset of sub-channels are noncontiguous; transmitting, by the first transmit antenna, a first pilot symbol over the sub-channels of the first subset of sub-channels; receiving, by a first receive antenna of a first receiver unit, the first pilot symbol;

Claim Element	Exemplary Citations to Wallace '467
	determining, from the received first pilot symbol, the transmission characteristics of the sub-channels of the first subset of sub-channels; reporting, by the first receiver unit to the first transmitter unit, an information signal that carries the determined transmission characteristics for the sub-channels of the first subset of sub-channels; and optimizing a set of transmission parameters at the first transmitter unit, based on the information signal. Wallace '467 at 31:8–32 19. A method for measuring and reporting channel state information (CSI) in a multiple input/multiple output (MIMO) system, comprising: assigning a plurality of sub-channel subsets to a plurality of transmit antennas of at least one transmitter unit, wherein the sub-channels of each of the sub-channel subsets are noncontiguous; transmitting a plurality of Orthogonal Frequency Division Multiplexed (OFDM) pilot waveforms from the at least one transmitter unit to at least one receiver unit, wherein each of the plurality of OFDM pilot waveforms is transmitted over a separate one of the plurality of sub-channel subsets; receiving, by the at least one receiver unit, the plurality of OFDM pilot waveforms; demodulating the received plurality of OFDM pilot waveforms; determining the CSI of the sub-channels corresponding to each of the plurality of sub-channel subsets from the demodulated plurality of OFDM pilot waveforms; transmitting the determined CSI to the at least one transmitter unit, and preconditioning a transmission symbol according to the determined CSI. To the extent this element is not disclosed by Wallace '467, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Wallace '467, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
[19e] performing a channel estimation based on the first signal to obtain path parameter information of the first propagation path;	Wallace '467 discloses or renders obvious “performing a channel estimation based on the first signal to obtain path parameter information of the first propagation path.” For example: Wallace '467 at Abstract Channel state information (CSI) can be used by a communications system to precondition transmissions between transmitter units and receiver units. In one aspect of the invention, disjoint sub-channel sets are assigned to transmit antennas located at a transmitter unit. Pilot symbols are generated and transmitted on a subset of the disjoint sub-channels. Upon receipt of the transmitted pilot symbols, the receiver units determine the CSI for the disjoint sub-channels that carried pilot symbols. These CSI values are reported to the transmitter unit, which will use these CSI values to generate CSI estimates for the disjoint sub-channels that did not carry pilot symbols. The amount of information necessary to report CSI on the

Claim Element	Exemplary Citations to Wallace '467
	reverse link can be further minimized through compression techniques and resource allocation techniques. Wallace '467 at Wallace-467 at Fig. 1B  <pre> graph TD subgraph 140 141[PRECONDITION DATA; AND ASSIGN PRECONDITIONED DATA TO MULTIPLE SUB-CHANNELS AND ANTENNAS] --> 142[PERFORM IFFT ON DATA ASSIGNED TO EACH ANTENNA] 142 --> 143[APPEND CYCLIC PREFIX/EXTENSION] 143 --> 144[TRANSMIT FROM MULTIPLE ANTENNAS] end 144 --> 145 subgraph 145 146[RECEIVE AT MULTIPLE ANTENNAS] --> 147[PERFORM FFT] 147 --> 148[MEASURE CSI ON PILOT; AND DEMODULATE USING CSI] end 148 -- 149 CSI FEEDBACK --> 141 </pre> FIG. 1B Wallace '467 at 1:57–2:8 Given the ever-growing demand for wireless communication, a higher efficiency, higher performance wireless communications system is desirable. One type of higher performance wireless communications system is a Multiple Input/Multiple Output (MIMO) system that employs multiple transmit antennas to transmit over a propagation channel to multiple receive antennas. As in lower performance systems, the propagation channel in a MIMO system is subject to the deleterious effects of multipath, as well as interference from adjacent antennas. Multipath occurs when a transmitted signal arrives at a receiver unit through multiple propagation paths with differing delays. When signals arrive from multiple propagation paths, components of the signals can combine destructively, which is referred to as “fading.” In order to improve the efficiency and decrease the complexity of the MIMO system, information as to the characteristics of the propagation channel can be transmitted back to the transmitter unit in order to precondition the signal before transmission.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 2:25–48 The present invention is directed to a method and apparatus for the measuring and reporting of channel state information in a high efficiency, high performance communications system, comprising the steps of: generating a plurality of pilot signals; transmitting the plurality of pilot signals over a propagation channel between a transmitter unit and a plurality of receiver units, wherein the transmitter unit comprises at least one transmit antenna, each of the plurality of receiver units comprises at least one receive antenna, and the propagation channel comprises a plurality of sub-channels between the transmitter unit and the plurality of receiver units; receiving at least one of the plurality of pilot signals at each of the plurality of receiver units; determining a set of transmission characteristics for at least one of the plurality of sub-channels, wherein the step of determining the set of transmission characteristics uses at least one of the plurality of pilot signals received at each of the plurality of receiver units; reporting an information signal from each of the plurality of receiver units to the transmitter unit, wherein the information signal carries the set of transmission characteristics for at least one of the plurality of sub-channels; and optimizing a set of transmission parameters at the transmitter unit, based on the information signal. Wallace '467 at 2:49–62 In one aspect of the invention, pilot symbols are transmitted on a plurality of disjoint OFDM sub-channel sets. When the pilot symbols are transmitted on disjoint OFDM sub-channels, the characteristics of the propagation channel can be determined through a set of K sub-channels carrying the pilot symbols, wherein K is less than the number of OFDM sub-channels in the system. In addition to transmitting pilot symbols on disjoint sub-channels, the system can transmit a time-domain pilot sequence that can be used to determine characteristics of the propagation channel. Along with the generation and transmission of pilot symbols, an aspect of the invention is the compression of the amount of information necessary to reconstruct the characteristics of the propagation channel. Wallace '467 at 4:1–17 In FIG. 1A, system 120 includes a number of receive antennas 122a through 122r that receive the transmitted signals and provide the received signals to respective demodulators (DEMOD) 124a through 124r. As shown in FIG. 1A, each receive antenna 122 may receive signals from one or more transmit antennas 116 depending on a number of factors such as, for example, the operating mode used at system 110, the directivity of the transmit and receive antennas, the characteristics of the communications links, and others. Each demodulator 124 demodulates the respective received signal using a demodulation scheme that is complementary to the modulation scheme used at the transmitter. The demodulated

Claim Element	Exemplary Citations to Wallace '467
	symbols from demodulators 124a through 124r are then provided to a (receive) data processor 126 that further processes the symbols to provide the output data. The data processing at the transmitter and receiver units is described in further detail below. Wallace '467 at 4:64–5:4 The communications system of the invention can be designed to provide a multi-user, multiple access communications scheme capable of supporting subscriber units having different requirements as well as capabilities. The scheme allows the system's total operating bandwidth, W, (e.g., 1.2288 MHz) to be efficiently shared among different types of services that may have highly disparate data rate, delay, and quality of service (QOS) requirements. Wallace '467 at 5:47–53 The communications system of the invention provides the above-described features and advantages, and is capable of supporting different types of services having disparate requirements. The features are achieved by employing antenna, frequency, or temporal diversity, or a combination thereof. Antenna, frequency, or temporal diversity can be independently achieved and dynamically selected. Wallace '467 at 5:54–67 As used herein, antenna diversity refers to the transmission and/or reception of data over more than one antenna, frequency diversity refers to the transmission of data over more than one sub-band, and temporal diversity refers to the transmission of data over more than one time period. Antenna, frequency, and temporal diversity may include subcategories. For example, transmit diversity refers to the use of more than one transmit antenna in a manner to improve the reliability of the communications link, receive diversity refers to the use of more than one receive antenna in a manner to improve the reliability of the communications link, and spatial diversity refers to the use of multiple transmit and receive antennas to improve the reliability and/or increase the capacity of the communications link. Wallace '467 at 6:1–5 Transmit and receive diversity can also be used in combination to improve the reliability of the communications link without increasing the link capacity. Various combinations of antenna, frequency, and temporal diversity can thus be achieved and are within the scope of the present invention.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 6:6–14 Frequency diversity can be provided by use of a multi-carrier modulation scheme such as orthogonal frequency division multiplexing (OFDM), which allows for transmission of data over various sub-bands of the operating bandwidth. Temporal diversity is achieved by transmitting the data over different times, which can be more easily accomplished with the use of time-division multiplexing (TDM). These various aspects of the communications system of the invention are described in further detail below. Wallace '467 at 6:15–32 In accordance with an aspect of the invention, antenna diversity is achieved by employing a number of (N_T) transmit antennas at the transmitter unit or a number of (N_R) receive antennas at the receiver unit, or multiple antennas at both the transmitter and receiver units. In a terrestrial communications system (e.g., a cellular system, a broadcast system, an MMDS system, and others), an RF modulated signal from a transmitter unit may reach the receiver unit via a number of transmission paths. The characteristics of the transmission paths typically vary over time based on a number of factors. If more than one transmit or receive antenna is used, and if the transmission paths between the transmit and receive antennas are independent (i.e., uncorrelated), which is generally true to at least an extent, then the likelihood of correctly receiving the transmitted signal increases as the number of antennas increases. Generally, as the number of transmit and receive antennas increases, diversity increases and performance improves. Wallace '467 at 6:33–52 Antenna diversity is dynamically provided based on the characteristics of the communications link to provide the required performance. For example, a higher degree of antenna diversity can be provided for some types of communication (e.g., signaling), for some types of services (e.g., voice), for some communications link characteristics (e.g., low C/I), or for some other conditions or considerations. As used herein, antenna diversity includes transmit diversity and receive diversity. For transmit diversity, data is transmitted over multiple transmit antennas. Typically, additional processing is performed on the data transmitted from the transmit antennas to achieve the desired diversity. For example, the data transmitted from different transmit antennas may be delayed or reordered in time, or coded and interleaved across the available transmit antennas. Also, frequency and temporal diversity may be used in conjunction with the different transmit antennas. For receive diversity, modulated signals are received on multiple receive antennas, and diversity is achieved by simply receiving the signals via different transmission paths.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 7:15–31 In accordance with yet another aspect of the invention, temporal diversity is achieved by transmitting data at different times, which can be more easily accomplished using time division multiplexing (TDM). For data services (and possibly for voice services), data transmission occurs over time slots that may be selected to provide immunity to time dependent degradation in the communications link. Temporal diversity may also be achieved through the use of interleaving. For example, the transmission to a particular subscriber unit may occur over time slots 1 through x, or on a subset of the possible time slots from 1 through x (e.g., time slots 1, 5, 8, and so on). The amount of data transmitted at each time slot may be variable or fixed. Transmission over multiple time slots improves the likelihood of correct data reception due to, for example, impulse noise and interference. Wallace '467 at 7:33–8:3 The combination of antenna, frequency, and temporal diversity allows the communications system of the invention to provide robust performance. Antenna, frequency, and/or temporal diversity improves the likelihood of correct reception of at least some of the transmitted data, which may then be used (e.g., through decoding) to correct for some errors that may have occurred in the other transmissions. The combination of antenna, frequency, and temporal diversity also allows the communications system to concurrently accommodate different types of services having disparate data rate, processing delay, and quality of service requirements. The communications system of the invention can be designed and operated in a number of different communications modes, with each communications mode employing antenna, frequency, or temporal diversity, or a combination thereof. The communications modes include, for example, a diversity communications mode and a MIMO communications mode. Various combinations of the diversity and MIMO communications modes can also be supported by the communications system. Also, other communications modes can be implemented and are within the scope of the present invention. The diversity communications mode employs transmit and/or receive diversity, frequency, or temporal diversity, or a combination thereof, and is generally used to improve the reliability of the communications link. In one implementation of the diversity communications mode, the transmitter unit selects a modulation and coding scheme (i.e., configuration) from a finite set of possible configurations, which are known to the receiver units. For example, each overhead and common channel may be associated with a particular configuration that is known to all receiver units. When using the diversity communications mode for a specific user (e.g., for a voice call or a data transmission), the mode and/or configuration may be known a priori (e.g., from a previous set up) or negotiated (e.g., via a common channel) by the receiver unit.

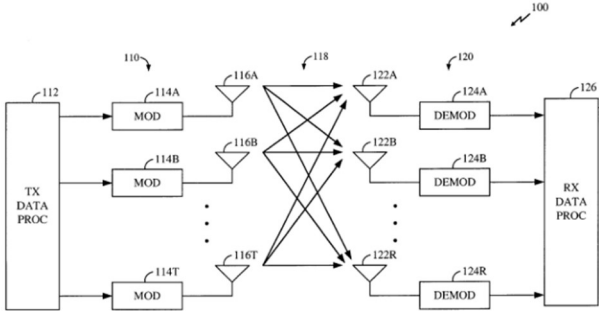
Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 8:16–52 The MIMO communications mode employs antenna diversity at both ends of the communication link and is generally used to improve both the reliability and increase the capacity of the communications link. The MIMO communications mode may further employ frequency and/or temporal diversity in combination with the antenna diversity. The MIMO communications mode, which may also be referred to herein as the spatial communications mode, employs one or more processing modes to be described below. The diversity communications mode generally has lower spectral efficiency than the MIMO communications mode, especially at high C/I levels. However, at low to moderate C/I values, the diversity communications mode achieves comparable efficiency and can be simpler to implement. In general, the use of the MIMO communications mode provides greater spectral efficiency when used, particularly at moderate to high C/I values. The MIMO communications mode may thus be advantageously used when the data rate requirements are moderate to high. The communications system can be designed to concurrently support both diversity and MIMO communications modes. The communications modes can be applied in various manners and, for increased flexibility, may be applied independently on a sub-channel basis. The MIMO communications mode is typically applied to specific users. However, each communications mode may be applied on each sub-channel independently, across a subset of sub-channels, across all sub-channels, or on some other basis. For example, the use of the MIMO communications mode may be applied to a specific user (e.g., a data user) and, concurrently, the use of the diversity communications mode may be applied to another specific user (e.g., a voice user) on a different sub-channel. The diversity communications mode may also be applied, for example, on sub-channels experiencing higher path loss. Wallace '467 at 8:53–9:3 The communications system of the invention can also be designed to support a number of processing modes. When the transmitter unit is provided with information indicative of the conditions (i.e., the “state”) of the communications links, additional processing can be performed at the transmitter unit to further improve performance and increase efficiency. Full channel state information (CSI) or partial CSI may be available to the transmitter unit. Full CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-band. Full CSI also includes the C/I per sub-band. The full CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. Partial CSI may include, for example, the C/I of the sub-band . With full CSI or partial CSI, the transmitter unit pre-conditions the data prior to transmission to receiver

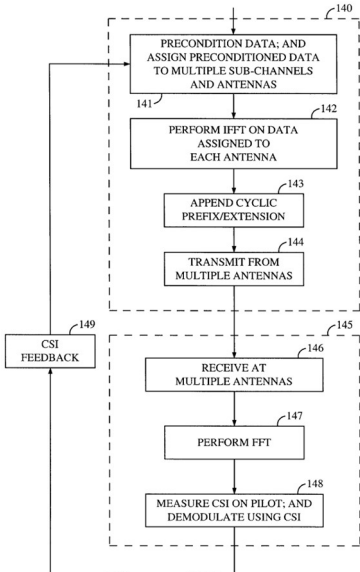
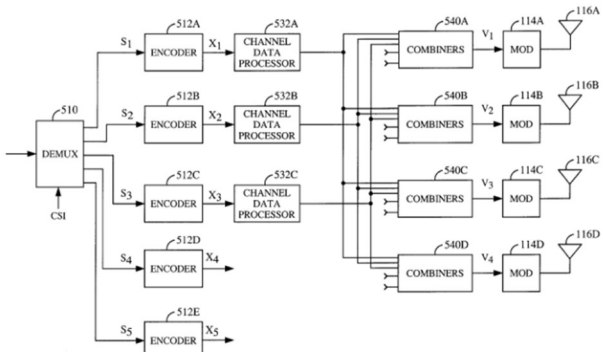
Claim Element	Exemplary Citations to Wallace '467
	unit. Wallace '467 at 9:29–48 As an example, assume that the MIMO communications mode is applied to a channel data stream that is transmitted on one particular sub-channel from four transmit antennas. The channel data stream is demultiplexed into four data sub-streams, one data sub-stream for each transmit antenna. Each data sub-stream is then modulated using a particular modulation scheme (e.g., M-PSK, M-QAM, or other) selected based on the CSI for that sub-band and for that transmit antenna. Four modulation sub-streams are thus generated for the four data sub-streams, with each modulation sub-streams including a stream of modulation symbols. The four modulation sub-streams are then pre-conditioned using the eigenvector matrix, as expressed below in equation (1), to generate pre-conditioned modulation symbols. The four streams of pre-conditioned modulation symbols are respectively provided to the four combiners of the four transmit antennas. Each combiner combines the received pre-conditioned modulation symbols with the modulation symbols for the other sub-channels to generate a modulation symbol vector stream for the associated transmit antenna. Wallace '467 at 9:64–10:4 In instances where full CSI is not available, less descriptive information on the transmission path (or partial CSI) may be available and can be used to pre-condition the data prior to transmission. For example, the C/I of each of the sub-channels may be available. The C/I information can then be used to control the transmission from various transmit antennas to provide the required performance in the sub-channels of interest and increase system capacity. Wallace '467 at 13:3–21 Given the complexity of a system using multiple transmit antennas and multiple receive antennas, with the associated dispersive channel effects, the preferred modulation technique is OFDM, which effectively decomposes the channel into a set of non-interfering narrowband channels, or sub-channels. With proper OFDM signal design, a signal transmitted on one subchannel sees “flat fading”, i.e., the channel response is effectively constant over the subchannel bandwidth. The channel state information or CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-channel. CSI also includes the information of the relative levels of interference and noise in each sub-channel, that is known as C/I information. The CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths

Claim Element	Exemplary Citations to Wallace '467
	from the transmit antennas to the receive antennas, as described below. With CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 14:56–15:2 Multiple antennas at a receiver unit 145 receive signals at step 146. At step 147, the received signals undergo a Discrete Fourier Transform (DFT) operation to channelize the received signals. At step 148, the data from each subchannel over all of the receive antennas is processed. At this processing step, information regarding channel characteristics is extracted from the data, and converted into a more compressed format. One compression technique is the use of the conjugate channel response and the eigenmode matrix to reduce the amount of information needed to describe channel characteristics. At step 149, a message containing the compressed channel state information is transmitted from the receiver unit 145 to the transmitter unit 140, which will then be used to precondition further transmissions. Wallace '467 at 15:3–7 To facilitate the derivation of the CSI, the transmit waveform is made up of known pilot symbols for an initial preamble. The pilot waveforms for different transmit antennas comprise disjoint sets of OFDM subchannels as illustrated for the case when $N_t=4$ in FIG. 1C. Wallace '467 at 15:38–58 From each transmit antenna at a transmitter unit, the receiver unit receives pilot symbols on disjoint sub-channels and makes determinations as to channel characteristics of the disjoint sub-channels. As discussed previously, the receiver unit may have one or more receive antennas. Suppose $x=\{x_i, i=1, \dots, K\}$ are the pilot symbol values that are to be transmitted on K pilot sub-channels for a single transmit antenna. The receiver unit will receive the values $y_{ij}=h_{ij}x_i+n_{ij}$, wherein h_{ij} is the complex channel response for the i^{th} pilot sub-channel received at the j^{th} receive antenna, and n_{ij} is noise. From this relationship, the receiver unit can determine noisy estimates of the channel response of K sub-channels of a single transmit antenna. These noisy estimates may be used to derive estimates for all sub-channels of the propagation channel through a number of different methods, such as simple interpolation to more complex estimation using a priori information on the channel dispersion and noise level. The estimates may be improved by transmitting pilot symbols over consecutive OFDM symbols and then averaging the estimates for each consecutive OFDM symbol.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 18:5–32 The embodiments of the invention discussed herein have been directed to the design and transmission of pilot signals that will allow a person skilled in the art to derive characteristics of the propagation channel and to report such characteristics to the transmission site. However, the full CSI is a large amount of information and also highly redundant. Many methods are available for compressing the amount of CSI information to be transmitted. One method discussed previously is the use of the Hermitian matrix H^*H, wherein H is the channel response as determined at the receiver unit. The Hermitian matrix H^*H can be reported to the transmitter unit and be used to precondition transmissions. Due to the properties of Hermitian matrices, only half of the matrix elements need to be transmitted, such as the complex lower triangular portion of the matrix H^*H, and the real-valued diagonal. Additional efficiencies are realized if the number of receive antennas is larger than the number of transmit antennas. Another method to reduce the amount of information transmitted to the transmitter unit on the reverse link is to report only a subset of the channel response matrices H_i to the transmitter unit, from which the unreported channel response matrices can be determined through interpolation schemes. In another method, a functional representation of the channel response across the sub-channels may be derived for each transmit/receive antenna pair, e.g., a polynomial function representative of the channel response can be generated. The coefficients of the polynomial function are then transmitted to the transmitter unit. Wallace '467 at 18:33–44 As an alternative to these methods for compressing CSI information, one embodiment of the invention is directed to the transmission of a time-domain representation of the channel response, which is the channel impulse response. If a time-domain representation of the channel response is simple, as in cases where there are only two or three multipath components, an inverse FFT can be performed upon the set of channel frequency responses. The inverse FFT operation can be performed for each link between a transmit/receive antenna pair. The resulting channel impulse responses are then translated into a set of amplitudes and delays that are reported to the transmitter. Wallace '467 at 29:16–38 1. A method for measuring and reporting transmission characteristics of a multiple input/multiple output communication system, comprising: assigning a first subset of sub-channels of a plurality of sub-channels to a first transmit antenna of a plurality of transmit antennas of a first transmitter unit, wherein the sub-channels of the first subset of sub-channels are noncontiguous;

Claim Element	Exemplary Citations to Wallace '467
	transmitting, by the first transmit antenna, a first pilot symbol over the sub-channels of the first subset of sub-channels; receiving, by a first receive antenna of a first receiver unit, the first pilot symbol; determining, from the received first pilot symbol, the transmission characteristics of the sub-channels of the first subset of sub-channels; reporting, by the first receiver unit to the first transmitter unit, an information signal that carries the determined transmission characteristics for the sub-channels of the first subset of sub-channels; and optimizing a set of transmission parameters at the first transmitter unit, based on the information signal. Wallace '467 at 31:8–32 19. A method for measuring and reporting channel state information (CSI) in a multiple input/multiple output (MIMO) system, comprising: assigning a plurality of sub-channel subsets to a plurality of transmit antennas of at least one transmitter unit, wherein the sub-channels of each of the sub-channel subsets are noncontiguous; transmitting a plurality of Orthogonal Frequency Division Multiplexed (OFDM) pilot waveforms from the at least one transmitter unit to at least one receiver unit, wherein each of the plurality of OFDM pilot waveforms is transmitted over a separate one of the plurality of sub-channel subsets; receiving, by the at least one receiver unit, the plurality of OFDM pilot waveforms; demodulating the received plurality of OFDM pilot waveforms; determining the CSI of the sub-channels corresponding to each of the plurality of sub-channel subsets from the demodulated plurality of OFDM pilot waveforms; transmitting the determined CSI to the at least one transmitter unit, and preconditioning a transmission symbol according to the determined CSI. To the extent this element is not disclosed by Wallace '467, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Wallace '467, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
[19f] sending the channel estimation that includes the path parameter information to the transmitter; and	Wallace '467 discloses or renders obvious “sending the channel estimation that includes the path parameter information to the transmitter.” For example: Wallace '467 at Abstract Channel state information (CSI) can be used by a communications system to precondition transmissions between transmitter units and receiver units. In one aspect of the invention, disjoint sub-channel sets are assigned to transmit antennas located at a transmitter unit. Pilot symbols are generated and transmitted on a subset of the disjoint sub-channels. Upon receipt of the transmitted pilot symbols, the receiver units

Claim Element	Exemplary Citations to Wallace '467
	determine the CSI for the disjoint sub-channels that carried pilot symbols. These CSI values are reported to the transmitter unit, which will use these CSI values to generate CSI estimates for the disjoint sub-channels that did not carry pilot symbols. The amount of information necessary to report CSI on the reverse link can be further minimized through compression techniques and resource allocation techniques. Wallace '467 at Wallace-467 at Fig. 1A  FIG. 1A

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at Wallace-467 at Fig. 1B  FIG. 1B Wallace '467 at Wallace-467 at Fig. 5A  FIG. 5A Wallace '467 at 1:57-2:8 Given the ever-growing demand for wireless communication, a higher efficiency, higher performance wireless communications system is desirable. One type of higher performance wireless communications system is a Multiple Input/Multiple Output (MIMO) system that employs multiple transmit antennas to

Claim Element	Exemplary Citations to Wallace '467
	transmit over a propagation channel to multiple receive antennas. As in lower performance systems, the propagation channel in a MIMO system is subject to the deleterious effects of multipath, as well as interference from adjacent antennas. Multipath occurs when a transmitted signal arrives at a receiver unit through multiple propagation paths with differing delays. When signals arrive from multiple propagation paths, components of the signals can combine destructively, which is referred to as “fading.” In order to improve the efficiency and decrease the complexity of the MIMO system, information as to the characteristics of the propagation channel can be transmitted back to the transmitter unit in order to precondition the signal before transmission. Wallace '467 at 2:25–48 The present invention is directed to a method and apparatus for the measuring and reporting of channel state information in a high efficiency, high performance communications system, comprising the steps of: generating a plurality of pilot signals; transmitting the plurality of pilot signals over a propagation channel between a transmitter unit and a plurality of receiver units, wherein the transmitter unit comprises at least one transmit antenna, each of the plurality of receiver units comprises at least one receive antenna, and the propagation channel comprises a plurality of sub-channels between the transmitter unit and the plurality of receiver units; receiving at least one of the plurality of pilot signals at each of the plurality of receiver units; determining a set of transmission characteristics for at least one of the plurality of sub-channels, wherein the step of determining the set of transmission characteristics uses at least one of the plurality of pilot signals received at each of the plurality of receiver units; reporting an information signal from each of the plurality of receiver units to the transmitter unit, wherein the information signal carries the set of transmission characteristics for at least one of the plurality of sub-channels; and optimizing a set of transmission parameters at the transmitter unit, based on the information signal. Wallace '467 at 2:49–62 In one aspect of the invention, pilot symbols are transmitted on a plurality of disjoint OFDM sub-channel sets. When the pilot symbols are transmitted on disjoint OFDM sub-channels, the characteristics of the propagation channel can be determined through a set of K sub-channels carrying the pilot symbols, wherein K is less than the number of OFDM sub-channels in the system. In addition to transmitting pilot symbols on disjoint sub-channels, the system can transmit a time-domain pilot sequence that can be used to determine characteristics of the propagation channel. Along with the generation and transmission of pilot symbols, an aspect of the invention is the compression of the amount of information necessary to

Claim Element	Exemplary Citations to Wallace '467
	reconstruct the characteristics of the propagation channel. Wallace '467 at 3:34–54 FIG. 1A is a diagram of a Multiple Input/Multiple Output (MIMO) communications system 100 capable of implementing some embodiments of the invention. Communications system 100 can be operative to provide a combination of antenna, frequency, and temporal diversity to increase spectral efficiency, improve performance, and enhance flexibility. Increased spectral efficiency is characterized by the ability to transmit more bits per second per Hertz (bps/Hz) when and where possible to better utilize the available system bandwidth. Techniques to obtain higher spectral efficiency are described in further detail below. Improved performance may be quantified, for example, by a lower bit-error-rate (BER) or frame-error-rate (FER) for a given link carrier-to-noise-plus-interference ratio (C/I). And enhanced flexibility is characterized by the ability to accommodate multiple users having different and typically disparate requirements. These goals may be achieved, in part, by employing multi-carrier modulation, time division multiplexing (TDM), multiple transmit and/or receive antennas, and other techniques. The features, aspects, and advantages of the invention are described in further detail below. Wallace '467 at 3:55–67 As shown in FIG. 1A, communications system 100 includes a first system 110 in communication with a second system 120. System 110 includes a (transmit) data processor 112 that (1) receives or generates data, (2) processes the data to provide antenna, frequency, or temporal diversity, or a combination thereof, and (3) provides processed modulation symbols to a number of modulators (MOD) 114a through 114t. Each modulator 114 further processes the modulation symbols and generates an RF modulated signal suitable for transmission. The RF modulated signals from modulators 114a through 114t are then transmitted from respective antennas 116a through 116t over communications links 118 to system 120. Wallace '467 at 4:1–17 In FIG. 1A, system 120 includes a number of receive antennas 122a through 122r that receive the transmitted signals and provide the received signals to respective demodulators (DEMOD) 124a through 124r. As shown in FIG. 1A, each receive antenna 122 may receive signals from one or more transmit antennas 116 depending on a number of factors such as, for example, the operating mode used at system 110, the directivity of the transmit and receive antennas, the characteristics of the communications links, and others. Each demodulator 124 demodulates the respective received signal using a demodulation scheme that is complementary to the modulation scheme used at the transmitter. The demodulated

Claim Element	Exemplary Citations to Wallace '467
	symbols from demodulators 124a through 124r are then provided to a (receive) data processor 126 that further processes the symbols to provide the output data. The data processing at the transmitter and receiver units is described in further detail below. Wallace '467 at 4:18–27 FIG. 1A shows only the forward link transmission from system 110 to system 120. This configuration may be used for data broadcast and other one-way data transmission applications. In a bidirectional communications system, a reverse link from system 120 to system 110 is also provided, although not shown in FIG. 1A for simplicity. For the bidirectional communications system, each of systems 110 and 120 may operate as a transmitter unit or a receiver unit, or both concurrently, depending on whether data is being transmitted from, or received at, the unit. Wallace '467 at 4:28–34 For simplicity, communications system 100 is shown to include one transmitter unit (i.e., system 110) and one receiver unit (i.e., system 120). However, in general, multiple transmit antennas and multiple receive antennas are present on each transmitter unit and each receiver unit. The communications system of the invention may include any number of transmitter units and receiver units. Wallace '467 at 4:36–47 Each transmitter unit may include a single transmit antenna or a number of transmit antennas, such as that shown in FIG. 1A. Similarly, each receiver unit may include a single receive antenna or a number of receive antennas, again such as that shown in FIG. 1A. For example, the communications system may include a central system (i.e., similar to a base station in the IS-95 CDMA system) having a number of antennas that transmit data to, and receive data from, a number of remote systems (i.e., subscriber units, similar to remote stations in the CDMA system), some of which may include one antenna and others of which may include multiple antennas. Wallace '467 at 4:48–63 As used herein, an antenna refers to a collection of one or more antenna elements that are distributed in space. The antenna elements may be physically located at a single site or distributed over multiple sites. Antenna elements physically co-located at a single site may be operated as an antenna array (e.g., such as for a CDMA base station). An antenna network consists of a collection of antenna arrays or elements that

Claim Element	Exemplary Citations to Wallace '467
	are physically separated (e.g., several CDMA base stations). An antenna array or an antenna network may be designed with the ability to form beams and to transmit multiple beams from the antenna array or network. For example, a CDMA base station may be designed with the capability to transmit up to three beams to three different sections of a coverage area (or sectors) from the same antenna array. Thus, the three beams may be viewed as three transmissions from three antennas. Wallace '467 at 4:64–5:4 The communications system of the invention can be designed to provide a multi-user, multiple access communications scheme capable of supporting subscriber units having different requirements as well as capabilities. The scheme allows the system's total operating bandwidth, W, (e.g., 1.2288 MHz) to be efficiently shared among different types of services that may have highly disparate data rate, delay, and quality of service (QOS) requirements. Wallace '467 at 5:47–53 The communications system of the invention provides the above-described features and advantages, and is capable of supporting different types of services having disparate requirements. The features are achieved by employing antenna, frequency, or temporal diversity, or a combination thereof. Antenna, frequency, or temporal diversity can be independently achieved and dynamically selected. Wallace '467 at 5:54–67 As used herein, antenna diversity refers to the transmission and/or reception of data over more than one antenna, frequency diversity refers to the transmission of data over more than one sub-band, and temporal diversity refers to the transmission of data over more than one time period. Antenna, frequency, and temporal diversity may include subcategories. For example, transmit diversity refers to the use of more than one transmit antenna in a manner to improve the reliability of the communications link, receive diversity refers to the use of more than one receive antenna in a manner to improve the reliability of the communications link, and spatial diversity refers to the use of multiple transmit and receive antennas to improve the reliability and/or increase the capacity of the communications link. Wallace '467 at 6:1–5 Transmit and receive diversity can also be used in combination to improve the reliability of the communications link without increasing the link capacity. Various combinations of antenna, frequency,

Claim Element	Exemplary Citations to Wallace '467
	and temporal diversity can thus be achieved and are within the scope of the present invention. Wallace '467 at 6:6–14 Frequency diversity can be provided by use of a multi-carrier modulation scheme such as orthogonal frequency division multiplexing (OFDM), which allows for transmission of data over various sub-bands of the operating bandwidth. Temporal diversity is achieved by transmitting the data over different times, which can be more easily accomplished with the use of time-division multiplexing (TDM). These various aspects of the communications system of the invention are described in further detail below. Wallace '467 at 6:15–32 In accordance with an aspect of the invention, antenna diversity is achieved by employing a number of (N_T) transmit antennas at the transmitter unit or a number of (N_R) receive antennas at the receiver unit, or multiple antennas at both the transmitter and receiver units. In a terrestrial communications system (e.g., a cellular system, a broadcast system, an MMDS system, and others), an RF modulated signal from a transmitter unit may reach the receiver unit via a number of transmission paths. The characteristics of the transmission paths typically vary over time based on a number of factors. If more than one transmit or receive antenna is used, and if the transmission paths between the transmit and receive antennas are independent (i.e., uncorrelated), which is generally true to at least an extent, then the likelihood of correctly receiving the transmitted signal increases as the number of antennas increases. Generally, as the number of transmit and receive antennas increases, diversity increases and performance improves. Wallace '467 at 6:33–52 Antenna diversity is dynamically provided based on the characteristics of the communications link to provide the required performance. For example, a higher degree of antenna diversity can be provided for some types of communication (e.g., signaling), for some types of services (e.g., voice), for some communications link characteristics (e.g., low C/I), or for some other conditions or considerations. As used herein, antenna diversity includes transmit diversity and receive diversity. For transmit diversity, data is transmitted over multiple transmit antennas. Typically, additional processing is performed on the data transmitted from the transmit antennas to achieve the desired diversity. For example, the data transmitted from different transmit antennas may be delayed or reordered in time, or coded and interleaved across the available transmit antennas. Also, frequency and temporal diversity may be used in conjunction with the different transmit antennas. For receive diversity, modulated signals are received on

Claim Element	Exemplary Citations to Wallace '467
	multiple receive antennas, and diversity is achieved by simply receiving the signals via different transmission paths. Wallace '467 at 6:53–7:14 In accordance with another aspect of the invention, frequency diversity can be achieved by employing a multi-carrier modulation scheme. One such scheme that has numerous advantages is OFDM. With OFDM modulation, the overall transmission channel is essentially divided into a number of (L) parallel sub-channels that are used to transmit the same or different data. The overall transmission channel occupies the total operating bandwidth of W, and each of the sub-channels occupies a sub-band having a bandwidth of W/L and centered at a different center frequency. Each sub-channel has a bandwidth that is a portion of the total operating bandwidth. Each of the sub-channels may also be considered an independent data transmission channel that may be associated with a particular (and possibly unique) processing, coding, and modulation scheme, as described below. The data may be partitioned and transmitted over any defined set of two or more sub-bands to provide frequency diversity. For example, the transmission to a particular subscriber unit may occur over sub-channel 1 at time slot 1, sub-channel 5 at time slot 2, sub-channel 2 at time slot 3, and so on. As another example, data for a particular subscriber unit may be transmitted over sub-channels 1 and 2 at time slot 1 (e.g., with the same data being transmitted on both sub-channels), sub-channels 4 and 6 at time slot 2, only sub-channel 2 at time slot 3, and so on. Transmission of data over different sub-channels over time can improve the performance of a communications system experiencing frequency selective fading and channel distortion. Other benefits of OFDM modulation are described below. Wallace '467 at 7:15–31 In accordance with yet another aspect of the invention, temporal diversity is achieved by transmitting data at different times, which can be more easily accomplished using time division multiplexing (TDM). For data services (and possibly for voice services), data transmission occurs over time slots that may be selected to provide immunity to time dependent degradation in the communications link. Temporal diversity may also be achieved through the use of interleaving. For example, the transmission to a particular subscriber unit may occur over time slots 1 through x, or on a subset of the possible time slots from 1 through x (e.g., time slots 1, 5, 8, and so on). The amount of data transmitted at each time slot may be variable or fixed. Transmission over multiple time slots improves the likelihood of correct data reception due to, for example, impulse noise and interference. Wallace '467 at 7:33–8:3 The combination of antenna, frequency, and temporal diversity allows the communications system of the invention to provide robust performance. Antenna, frequency, and/or temporal diversity improves the

Claim Element	Exemplary Citations to Wallace '467
	likelihood of correct reception of at least some of the transmitted data, which may then be used (e.g., through decoding) to correct for some errors that may have occurred in the other transmissions. The combination of antenna, frequency, and temporal diversity also allows the communications system to concurrently accommodate different types of services having disparate data rate, processing delay, and quality of service requirements. The communications system of the invention can be designed and operated in a number of different communications modes, with each communications mode employing antenna, frequency, or temporal diversity, or a combination thereof. The communications modes include, for example, a diversity communications mode and a MIMO communications mode. Various combinations of the diversity and MIMO communications modes can also be supported by the communications system. Also, other communications modes can be implemented and are within the scope of the present invention. The diversity communications mode employs transmit and/or receive diversity, frequency, or temporal diversity, or a combination thereof, and is generally used to improve the reliability of the communications link. In one implementation of the diversity communications mode, the transmitter unit selects a modulation and coding scheme (i.e., configuration) from a finite set of possible configurations, which are known to the receiver units. For example, each overhead and common channel may be associated with a particular configuration that is known to all receiver units. When using the diversity communications mode for a specific user (e.g., for a voice call or a data transmission), the mode and/or configuration may be known a priori (e.g., from a previous set up) or negotiated (e.g., via a common channel) by the receiver unit. Wallace '467 at 8:16–52 The MIMO communications mode employs antenna diversity at both ends of the communication link and is generally used to improve both the reliability and increase the capacity of the communications link. The MIMO communications mode may further employ frequency and/or temporal diversity in combination with the antenna diversity. The MIMO communications mode, which may also be referred to herein as the spatial communications mode, employs one or more processing modes to be described below. The diversity communications mode generally has lower spectral efficiency than the MIMO communications mode, especially at high C/I levels. However, at low to moderate C/I values, the diversity communications mode achieves comparable efficiency and can be simpler to implement. In general, the use of the MIMO communications mode provides greater spectral efficiency when used, particularly at moderate to high C/I values. The MIMO communications mode may thus be advantageously used when the data rate requirements are moderate to high. The communications system can be designed to concurrently support both diversity and MIMO communications modes. The communications modes can be applied in various manners and, for increased

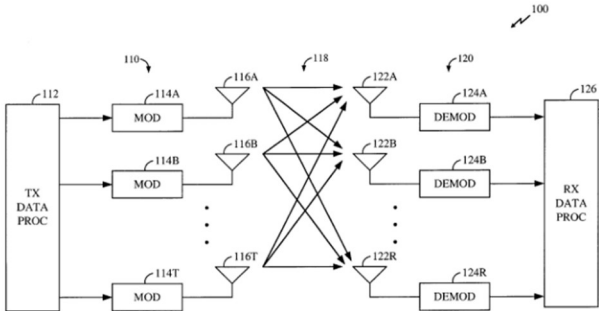
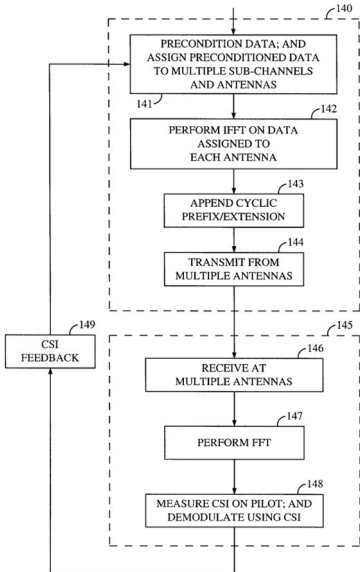
Claim Element	Exemplary Citations to Wallace '467
	flexibility, may be applied independently on a sub-channel basis. The MIMO communications mode is typically applied to specific users. However, each communications mode may be applied on each sub-channel independently, across a subset of sub-channels, across all sub-channels, or on some other basis. For example, the use of the MIMO communications mode may be applied to a specific user (e.g., a data user) and, concurrently, the use of the diversity communications mode may be applied to another specific user (e.g., a voice user) on a different sub-channel. The diversity communications mode may also be applied, for example, on sub-channels experiencing higher path loss. Wallace '467 at 8:53–9:3 The communications system of the invention can also be designed to support a number of processing modes. When the transmitter unit is provided with information indicative of the conditions (i.e., the “state”) of the communications links, additional processing can be performed at the transmitter unit to further improve performance and increase efficiency. Full channel state information (CSI) or partial CSI may be available to the transmitter unit. Full CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-band. Full CSI also includes the C/I per sub-band. The full CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. Partial CSI may include, for example, the C/I of the sub-band . With full CSI or partial CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 9:4–15 The transmitter unit can precondition the signals presented to the transmit antennas in a way that is unique to a specific receiver unit (e.g., the pre-conditioning is performed for each sub-band assigned to that receiver unit). As long as the channel does not change appreciably from the time it is measured by the receiver unit and subsequently sent back to the transmitter and used to precondition the transmission, the intended receiver unit can demodulate the transmission. In this implementation, a full-CSI based MIMO communication can only be demodulated by the receiver unit associated with the CSI used to precondition the transmitted signals. Wallace '467 at 9:29–48 As an example, assume that the MIMO communications mode is applied to a channel data stream that is transmitted on one particular sub-channel from four transmit antennas. The channel data stream is demultiplexed into four data sub-streams, one data sub-stream for each transmit antenna. Each data sub-

Claim Element	Exemplary Citations to Wallace '467
	stream is then modulated using a particular modulation scheme (e.g., M-PSK, M-QAM, or other) selected based on the CSI for that sub-band and for that transmit antenna. Four modulation sub-streams are thus generated for the four data sub-streams, with each modulation sub-streams including a stream of modulation symbols. The four modulation sub-streams are then pre-conditioned using the eigenvector matrix, as expressed below in equation (1), to generate pre-conditioned modulation symbols. The four streams of pre-conditioned modulation symbols are respectively provided to the four combiners of the four transmit antennas. Each combiner combines the received pre-conditioned modulation symbols with the modulation symbols for the other sub-channels to generate a modulation symbol vector stream for the associated transmit antenna. Wallace '467 at 9:64–10:4 In instances where full CSI is not available, less descriptive information on the transmission path (or partial CSI) may be available and can be used to pre-condition the data prior to transmission. For example, the C/I of each of the sub-channels may be available. The C/I information can then be used to control the transmission from various transmit antennas to provide the required performance in the sub-channels of interest and increase system capacity. Wallace '467 at 13:3–21 Given the complexity of a system using multiple transmit antennas and multiple receive antennas, with the associated dispersive channel effects, the preferred modulation technique is OFDM, which effectively decomposes the channel into a set of non-interfering narrowband channels, or sub-channels. With proper OFDM signal design, a signal transmitted on one subchannel sees “flat fading”, i.e., the channel response is effectively constant over the subchannel bandwidth. The channel state information or CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-channel. CSI also includes the information of the relative levels of interference and noise in each sub-channel, that is known as C/I information. The CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. With CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 14:56–15:2 Multiple antennas at a receiver unit 145 receive signals at step 146. At step 147, the received signals undergo a Discrete Fourier Transform (DFT) operation to channelize the received signals. At step 148, the

Claim Element	Exemplary Citations to Wallace '467
	data from each subchannel over all of the receive antennas is processed. At this processing step, information regarding channel characteristics is extracted from the data, and converted into a more compressed format. One compression technique is the use of the conjugate channel response and the eigenmode matrix to reduce the amount of information needed to describe channel characteristics. At step 149, a message containing the compressed channel state information is transmitted from the receiver unit 145 to the transmitter unit 140, which will then be used to precondition further transmissions. Wallace '467 at 15:3–7 To facilitate the derivation of the CSI, the transmit waveform is made up of known pilot symbols for an initial preamble. The pilot waveforms for different transmit antennas comprise disjoint sets of OFDM subchannels as illustrated for the case when $N_t=4$ in FIG. 1C. Wallace '467 at 15:38–58 From each transmit antenna at a transmitter unit, the receiver unit receives pilot symbols on disjoint sub-channels and makes determinations as to channel characteristics of the disjoint sub-channels. As discussed previously, the receiver unit may have one or more receive antennas. Suppose $x=\{x_i, i=1, \dots, K\}$ are the pilot symbol values that are to be transmitted on K pilot sub-channels for a single transmit antenna. The receiver unit will receive the values $y_{ij}=h_{ij}x_i+n_{ij}$, wherein h_{ij} is the complex channel response for the i^{th} pilot sub-channel received at the j^{th} receive antenna, and n_{ij} is noise. From this relationship, the receiver unit can determine noisy estimates of the channel response of K sub-channels of a single transmit antenna. These noisy estimates may be used to derive estimates for all sub-channels of the propagation channel through a number of different methods, such as simple interpolation to more complex estimation using a priori information on the channel dispersion and noise level. The estimates may be improved by transmitting pilot symbols over consecutive OFDM symbols and then averaging the estimates for each consecutive OFDM symbol. Wallace '467 at 18:5–32 The embodiments of the invention discussed herein have been directed to the design and transmission of pilot signals that will allow a person skilled in the art to derive characteristics of the propagation channel and to report such characteristics to the transmission site. However, the full CSI is a large amount of information and also highly redundant. Many methods are available for compressing the amount of CSI information to be transmitted. One method discussed previously is the use of the Hermitian matrix H^*H, wherein H is the channel response as determined at the receiver unit. The Hermitian matrix H^*H can be

Claim Element	Exemplary Citations to Wallace '467
	reported to the transmitter unit and be used to precondition transmissions. Due to the properties of Hermitian matrices, only half of the matrix elements need to be transmitted, such as the complex lower triangular portion of the matrix H^*H, and the real-valued diagonal. Additional efficiencies are realized if the number of receive antennas is larger than the number of transmit antennas. Another method to reduce the amount of information transmitted to the transmitter unit on the reverse link is to report only a subset of the channel response matrices H_i to the transmitter unit, from which the unreported channel response matrices can be determined through interpolation schemes. In another method, a functional representation of the channel response across the sub-channels may be derived for each transmit/receive antenna pair, e.g., a polynomial function representative of the channel response can be generated. The coefficients of the polynomial function are then transmitted to the transmitter unit. Wallace '467 at 18:33–44 As an alternative to these methods for compressing CSI information, one embodiment of the invention is directed to the transmission of a time-domain representation of the channel response, which is the channel impulse response. If a time-domain representation of the channel response is simple, as in cases where there are only two or three multipath components, an inverse FFT can be performed upon the set of channel frequency responses. The inverse FFT operation can be performed for each link between a transmit/receive antenna pair. The resulting channel impulse responses are then translated into a set of amplitudes and delays that are reported to the transmitter. Wallace '467 at 29:16–38 1. A method for measuring and reporting transmission characteristics of a multiple input/multiple output communication system, comprising: - assigning a first subset of sub-channels of a plurality of sub-channels to a first transmit antenna of a plurality of transmit antennas of a first transmitter unit, wherein the sub-channels of the first subset of sub-channels are noncontiguous; - transmitting, by the first transmit antenna, a first pilot symbol over the sub-channels of the first subset of sub-channels; - receiving, by a first receive antenna of a first receiver unit, the first pilot symbol; - determining, from the received first pilot symbol, the transmission characteristics of the sub-channels of the first subset of sub-channels; - reporting, by the first receiver unit to the first transmitter unit, an information signal that carries the

Claim Element	Exemplary Citations to Wallace '467
	determined transmission characteristics for the sub-channels of the first subset of sub-channels; and optimizing a set of transmission parameters at the first transmitter unit, based on the information signal. Wallace '467 at 31:8–32 19. A method for measuring and reporting channel state information (CSI) in a multiple input/multiple output (MIMO) system, comprising: assigning a plurality of sub-channel subsets to a plurality of transmit antennas of at least one transmitter unit, wherein the sub-channels of each of the sub-channel subsets are noncontiguous; transmitting a plurality of Orthogonal Frequency Division Multiplexed (OFDM) pilot waveforms from the at least one transmitter unit to at least one receiver unit, wherein each of the plurality of OFDM pilot waveforms is transmitted over a separate one of the plurality of sub-channel subsets; receiving, by the at least one receiver unit, the plurality of OFDM pilot waveforms; demodulating the received plurality of OFDM pilot waveforms; determining the CSI of the sub-channels corresponding to each of the plurality of sub-channel subsets from the demodulated plurality of OFDM pilot waveforms; transmitting the determined CSI to the at least one transmitter unit, and preconditioning a transmission symbol according to the determined CSI. To the extent this element is not disclosed by Wallace '467, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Wallace '467, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
[19g] receiving a second signal via the first propagation path, the second signal predistorted in a time domain, a frequency domain, and a spatial domain according to the channel estimation based on the first signal.	Wallace '467 discloses or renders obvious “receiving a second signal via the first propagation path, the second signal predistorted in a time domain, a frequency domain, and a spatial domain according to the channel estimation based on the first signal.” For example: Wallace '467 at Abstract Channel state information (CSI) can be used by a communications system to precondition transmissions between transmitter units and receiver units. In one aspect of the invention, disjoint sub-channel sets are assigned to transmit antennas located at a transmitter unit. Pilot symbols are generated and transmitted on a subset of the disjoint sub-channels. Upon receipt of the transmitted pilot symbols, the receiver units determine the CSI for the disjoint sub-channels that carried pilot symbols. These CSI values are reported to the transmitter unit, which will use these CSI values to generate CSI estimates for the disjoint sub-channels that did not carry pilot symbols. The amount of information necessary to report CSI on the reverse link can be further minimized through compression techniques and resource allocation techniques.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at Wallace-467 at Fig. 1A  FIG. 1A Wallace '467 at Wallace-467 at Fig. 1B  FIG. 1B Wallace '467 at 1:57-2:8 Given the ever-growing demand for wireless communication, a higher efficiency, higher performance wireless communications system is desirable. One type of higher performance wireless communications system is a Multiple Input/Multiple Output (MIMO) system that employs multiple transmit antennas to transmit over a propagation channel to multiple receive antennas. As in lower performance systems, the

Claim Element	Exemplary Citations to Wallace '467
	propagation channel in a MIMO system is subject to the deleterious effects of multipath, as well as interference from adjacent antennas. Multipath occurs when a transmitted signal arrives at a receiver unit through multiple propagation paths with differing delays. When signals arrive from multiple propagation paths, components of the signals can combine destructively, which is referred to as “fading.” In order to improve the efficiency and decrease the complexity of the MIMO system, information as to the characteristics of the propagation channel can be transmitted back to the transmitter unit in order to precondition the signal before transmission. Wallace '467 at 2:25–48 The present invention is directed to a method and apparatus for the measuring and reporting of channel state information in a high efficiency, high performance communications system, comprising the steps of: generating a plurality of pilot signals; transmitting the plurality of pilot signals over a propagation channel between a transmitter unit and a plurality of receiver units, wherein the transmitter unit comprises at least one transmit antenna, each of the plurality of receiver units comprises at least one receive antenna, and the propagation channel comprises a plurality of sub-channels between the transmitter unit and the plurality of receiver units; receiving at least one of the plurality of pilot signals at each of the plurality of receiver units; determining a set of transmission characteristics for at least one of the plurality of sub-channels, wherein the step of determining the set of transmission characteristics uses at least one of the plurality of pilot signals received at each of the plurality of receiver units; reporting an information signal from each of the plurality of receiver units to the transmitter unit, wherein the information signal carries the set of transmission characteristics for at least one of the plurality of sub-channels; and optimizing a set of transmission parameters at the transmitter unit, based on the information signal. Wallace '467 at 2:49–62 In one aspect of the invention, pilot symbols are transmitted on a plurality of disjoint OFDM sub-channel sets. When the pilot symbols are transmitted on disjoint OFDM sub-channels, the characteristics of the propagation channel can be determined through a set of K sub-channels carrying the pilot symbols, wherein K is less than the number of OFDM sub-channels in the system. In addition to transmitting pilot symbols on disjoint sub-channels, the system can transmit a time-domain pilot sequence that can be used to determine characteristics of the propagation channel. Along with the generation and transmission of pilot symbols, an aspect of the invention is the compression of the amount of information necessary to reconstruct the characteristics of the propagation channel.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 3:34–54 FIG. 1A is a diagram of a Multiple Input/Multiple Output (MIMO) communications system 100 capable of implementing some embodiments of the invention. Communications system 100 can be operative to provide a combination of antenna, frequency, and temporal diversity to increase spectral efficiency, improve performance, and enhance flexibility. Increased spectral efficiency is characterized by the ability to transmit more bits per second per Hertz (bps/Hz) when and where possible to better utilize the available system bandwidth. Techniques to obtain higher spectral efficiency are described in further detail below. Improved performance may be quantified, for example, by a lower bit-error-rate (BER) or frame-error-rate (FER) for a given link carrier-to-noise-plus-interference ratio (C/I). And enhanced flexibility is characterized by the ability to accommodate multiple users having different and typically disparate requirements. These goals may be achieved, in part, by employing multi-carrier modulation, time division multiplexing (TDM), multiple transmit and/or receive antennas, and other techniques. The features, aspects, and advantages of the invention are described in further detail below. Wallace '467 at 3:55–67 As shown in FIG. 1A, communications system 100 includes a first system 110 in communication with a second system 120. System 110 includes a (transmit) data processor 112 that (1) receives or generates data, (2) processes the data to provide antenna, frequency, or temporal diversity, or a combination thereof, and (3) provides processed modulation symbols to a number of modulators (MOD) 114a through 114t. Each modulator 114 further processes the modulation symbols and generates an RF modulated signal suitable for transmission. The RF modulated signals from modulators 114a through 114t are then transmitted from respective antennas 116a through 116t over communications links 118 to system 120. Wallace '467 at 4:1–17 In FIG. 1A, system 120 includes a number of receive antennas 122a through 122r that receive the transmitted signals and provide the received signals to respective demodulators (DEMODO) 124a through 124r. As shown in FIG. 1A, each receive antenna 122 may receive signals from one or more transmit antennas 116 depending on a number of factors such as, for example, the operating mode used at system 110, the directivity of the transmit and receive antennas, the characteristics of the communications links, and others. Each demodulator 124 demodulates the respective received signal using a demodulation scheme that is complementary to the modulation scheme used at the transmitter. The demodulated symbols from demodulators 124a through 124r are then provided to a (receive) data processor 126 that further processes the symbols to provide the output data. The data processing at the transmitter and

Claim Element	Exemplary Citations to Wallace '467
	receiver units is described in further detail below. Wallace '467 at 4:18–27 FIG. 1A shows only the forward link transmission from system 110 to system 120. This configuration may be used for data broadcast and other one-way data transmission applications. In a bidirectional communications system, a reverse link from system 120 to system 110 is also provided, although not shown in FIG. 1A for simplicity. For the bidirectional communications system, each of systems 110 and 120 may operate as a transmitter unit or a receiver unit, or both concurrently, depending on whether data is being transmitted from, or received at, the unit. Wallace '467 at 4:28–34 For simplicity, communications system 100 is shown to include one transmitter unit (i.e., system 110) and one receiver unit (i.e., system 120). However, in general, multiple transmit antennas and multiple receive antennas are present on each transmitter unit and each receiver unit. The communications system of the invention may include any number of transmitter units and receiver units. Wallace '467 at 4:36–47 Each transmitter unit may include a single transmit antenna or a number of transmit antennas, such as that shown in FIG. 1A. Similarly, each receiver unit may include a single receive antenna or a number of receive antennas, again such as that shown in FIG. 1A. For example, the communications system may include a central system (i.e., similar to a base station in the IS-95 CDMA system) having a number of antennas that transmit data to, and receive data from, a number of remote systems (i.e., subscriber units, similar to remote stations in the CDMA system), some of which may include one antenna and others of which may include multiple antennas. Wallace '467 at 4:48–63 As used herein, an antenna refers to a collection of one or more antenna elements that are distributed in space. The antenna elements may be physically located at a single site or distributed over multiple sites. Antenna elements physically co-located at a single site may be operated as an antenna array (e.g., such as for a CDMA base station). An antenna network consists of a collection of antenna arrays or elements that are physically separated (e.g., several CDMA base stations). An antenna array or an antenna network may be designed with the ability to form beams and to transmit multiple beams from the antenna array or

Claim Element	Exemplary Citations to Wallace '467
	network. For example, a CDMA base station may be designed with the capability to transmit up to three beams to three different sections of a coverage area (or sectors) from the same antenna array. Thus, the three beams may be viewed as three transmissions from three antennas. Wallace '467 at 5:47–53 The communications system of the invention provides the above-described features and advantages, and is capable of supporting different types of services having disparate requirements. The features are achieved by employing antenna, frequency, or temporal diversity, or a combination thereof. Antenna, frequency, or temporal diversity can be independently achieved and dynamically selected. Wallace '467 at 5:54–67 As used herein, antenna diversity refers to the transmission and/or reception of data over more than one antenna, frequency diversity refers to the transmission of data over more than one sub-band, and temporal diversity refers to the transmission of data over more than one time period. Antenna, frequency, and temporal diversity may include subcategories. For example, transmit diversity refers to the use of more than one transmit antenna in a manner to improve the reliability of the communications link, receive diversity refers to the use of more than one receive antenna in a manner to improve the reliability of the communications link, and spatial diversity refers to the use of multiple transmit and receive antennas to improve the reliability and/or increase the capacity of the communications link. Wallace '467 at 6:1–5 Transmit and receive diversity can also be used in combination to improve the reliability of the communications link without increasing the link capacity. Various combinations of antenna, frequency, and temporal diversity can thus be achieved and are within the scope of the present invention. Wallace '467 at 6:6–14 Frequency diversity can be provided by use of a multi-carrier modulation scheme such as orthogonal frequency division multiplexing (OFDM), which allows for transmission of data over various sub-bands of the operating bandwidth. Temporal diversity is achieved by transmitting the data over different times, which can be more easily accomplished with the use of time-division multiplexing (TDM). These various aspects of the communications system of the invention are described in further detail below.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 6:15–32 In accordance with an aspect of the invention, antenna diversity is achieved by employing a number of (N_T) transmit antennas at the transmitter unit or a number of (N_R) receive antennas at the receiver unit, or multiple antennas at both the transmitter and receiver units. In a terrestrial communications system (e.g., a cellular system, a broadcast system, an MMDS system, and others), an RF modulated signal from a transmitter unit may reach the receiver unit via a number of transmission paths. The characteristics of the transmission paths typically vary over time based on a number of factors. If more than one transmit or receive antenna is used, and if the transmission paths between the transmit and receive antennas are independent (i.e., uncorrelated), which is generally true to at least an extent, then the likelihood of correctly receiving the transmitted signal increases as the number of antennas increases. Generally, as the number of transmit and receive antennas increases, diversity increases and performance improves. Wallace '467 at 6:33–52 Antenna diversity is dynamically provided based on the characteristics of the communications link to provide the required performance. For example, a higher degree of antenna diversity can be provided for some types of communication (e.g., signaling), for some types of services (e.g., voice), for some communications link characteristics (e.g., low C/I), or for some other conditions or considerations. As used herein, antenna diversity includes transmit diversity and receive diversity. For transmit diversity, data is transmitted over multiple transmit antennas. Typically, additional processing is performed on the data transmitted from the transmit antennas to achieve the desired diversity. For example, the data transmitted from different transmit antennas may be delayed or reordered in time, or coded and interleaved across the available transmit antennas. Also, frequency and temporal diversity may be used in conjunction with the different transmit antennas. For receive diversity, modulated signals are received on multiple receive antennas, and diversity is achieved by simply receiving the signals via different transmission paths. Wallace '467 at 6:53–7:14 In accordance with another aspect of the invention, frequency diversity can be achieved by employing a multi-carrier modulation scheme. One such scheme that has numerous advantages is OFDM. With OFDM modulation, the overall transmission channel is essentially divided into a number of (L) parallel sub-channels that are used to transmit the same or different data. The overall transmission channel occupies the total operating bandwidth of W, and each of the sub-channels occupies a sub-band having a bandwidth of W/L and centered at a different center frequency. Each sub-channel has a bandwidth that is a portion of the total operating bandwidth. Each of the sub-channels may also be considered an independent data

Claim Element	Exemplary Citations to Wallace '467
	transmission channel that may be associated with a particular (and possibly unique) processing, coding, and modulation scheme, as described below. The data may be partitioned and transmitted over any defined set of two or more sub-bands to provide frequency diversity. For example, the transmission to a particular subscriber unit may occur over sub-channel 1 at time slot 1, sub-channel 5 at time slot 2, sub-channel 2 at time slot 3, and so on. As another example, data for a particular subscriber unit may be transmitted over sub-channels 1 and 2 at time slot 1 (e.g., with the same data being transmitted on both sub-channels), sub-channels 4 and 6 at time slot 2, only sub-channel 2 at time slot 3, and so on. Transmission of data over different sub-channels over time can improve the performance of a communications system experiencing frequency selective fading and channel distortion. Other benefits of OFDM modulation are described below. Wallace '467 at 7:15–31 In accordance with yet another aspect of the invention, temporal diversity is achieved by transmitting data at different times, which can be more easily accomplished using time division multiplexing (TDM). For data services (and possibly for voice services), data transmission occurs over time slots that may be selected to provide immunity to time dependent degradation in the communications link. Temporal diversity may also be achieved through the use of interleaving. For example, the transmission to a particular subscriber unit may occur over time slots 1 through x, or on a subset of the possible time slots from 1 through x (e.g., time slots 1, 5, 8, and so on). The amount of data transmitted at each time slot may be variable or fixed. Transmission over multiple time slots improves the likelihood of correct data reception due to, for example, impulse noise and interference. Wallace '467 at 7:33–8:3 The combination of antenna, frequency, and temporal diversity allows the communications system of the invention to provide robust performance. Antenna, frequency, and/or temporal diversity improves the likelihood of correct reception of at least some of the transmitted data, which may then be used (e.g., through decoding) to correct for some errors that may have occurred in the other transmissions. The combination of antenna, frequency, and temporal diversity also allows the communications system to concurrently accommodate different types of services having disparate data rate, processing delay, and quality of service requirements. The communications system of the invention can be designed and operated in a number of different communications modes, with each communications mode employing antenna, frequency, or temporal diversity, or a combination thereof. The communications modes include, for example, a diversity communications mode and a MIMO communications mode. Various combinations of the diversity and MIMO communications modes can also be supported by the communications system. Also, other

Claim Element	Exemplary Citations to Wallace '467
	communications modes can be implemented and are within the scope of the present invention. The diversity communications mode employs transmit and/or receive diversity, frequency, or temporal diversity, or a combination thereof, and is generally used to improve the reliability of the communications link. In one implementation of the diversity communications mode, the transmitter unit selects a modulation and coding scheme (i.e., configuration) from a finite set of possible configurations, which are known to the receiver units. For example, each overhead and common channel may be associated with a particular configuration that is known to all receiver units. When using the diversity communications mode for a specific user (e.g., for a voice call or a data transmission), the mode and/or configuration may be known a priori (e.g., from a previous set up) or negotiated (e.g., via a common channel) by the receiver unit. Wallace '467 at 8:4–15 In the diversity communications mode, data is transmitted on one or more sub-channels, from one or more antennas, and at one or more time periods. The allocated sub-channels may be associated with the same antenna, or may be sub-channels associated with different antennas. In a common application of the diversity communications mode, which is also referred to as a “pure” diversity communications mode, data is transmitted from all available transmit antennas to the destination receiver unit. The pure diversity communications mode can be used in instances where the data rate requirements are low or when the C/I is low, or when both are true. Wallace '467 at 8:16–52 The MIMO communications mode employs antenna diversity at both ends of the communication link and is generally used to improve both the reliability and increase the capacity of the communications link. The MIMO communications mode may further employ frequency and/or temporal diversity in combination with the antenna diversity. The MIMO communications mode, which may also be referred to herein as the spatial communications mode, employs one or more processing modes to be described below. The diversity communications mode generally has lower spectral efficiency than the MIMO communications mode, especially at high C/I levels. However, at low to moderate C/I values, the diversity communications mode achieves comparable efficiency and can be simpler to implement. In general, the use of the MIMO communications mode provides greater spectral efficiency when used, particularly at moderate to high C/I values. The MIMO communications mode may thus be advantageously used when the data rate requirements are moderate to high. The communications system can be designed to concurrently support both diversity and MIMO communications modes. The communications modes can be applied in various manners and, for increased

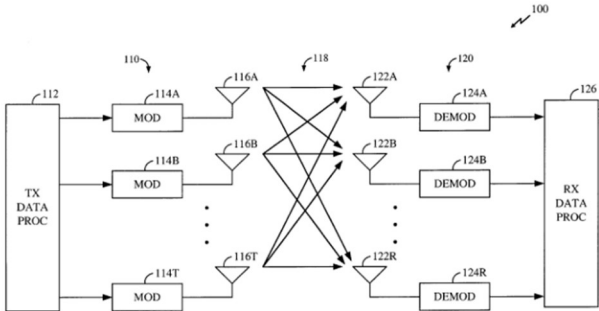
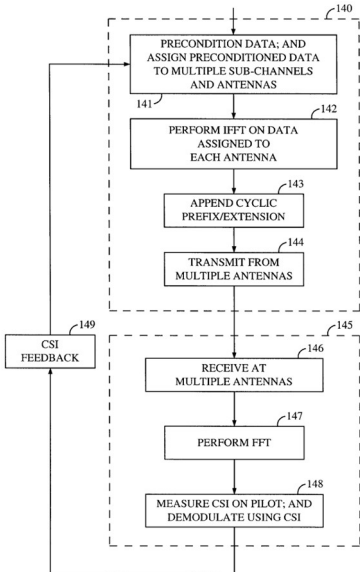
Claim Element	Exemplary Citations to Wallace '467
	flexibility, may be applied independently on a sub-channel basis. The MIMO communications mode is typically applied to specific users. However, each communications mode may be applied on each sub-channel independently, across a subset of sub-channels, across all sub-channels, or on some other basis. For example, the use of the MIMO communications mode may be applied to a specific user (e.g., a data user) and, concurrently, the use of the diversity communications mode may be applied to another specific user (e.g., a voice user) on a different sub-channel. The diversity communications mode may also be applied, for example, on sub-channels experiencing higher path loss. Wallace '467 at 8:53–9:3 The communications system of the invention can also be designed to support a number of processing modes. When the transmitter unit is provided with information indicative of the conditions (i.e., the “state”) of the communications links, additional processing can be performed at the transmitter unit to further improve performance and increase efficiency. Full channel state information (CSI) or partial CSI may be available to the transmitter unit. Full CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-band. Full CSI also includes the C/I per sub-band. The full CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. Partial CSI may include, for example, the C/I of the sub-band . With full CSI or partial CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 9:4–15 The transmitter unit can precondition the signals presented to the transmit antennas in a way that is unique to a specific receiver unit (e.g., the pre-conditioning is performed for each sub-band assigned to that receiver unit). As long as the channel does not change appreciably from the time it is measured by the receiver unit and subsequently sent back to the transmitter and used to precondition the transmission, the intended receiver unit can demodulate the transmission. In this implementation, a full-CSI based MIMO communication can only be demodulated by the receiver unit associated with the CSI used to precondition the transmitted signals. Wallace '467 at 9:29–48 As an example, assume that the MIMO communications mode is applied to a channel data stream that is transmitted on one particular sub-channel from four transmit antennas. The channel data stream is demultiplexed into four data sub-streams, one data sub-stream for each transmit antenna. Each data sub-

Claim Element	Exemplary Citations to Wallace '467
	stream is then modulated using a particular modulation scheme (e.g., M-PSK, M-QAM, or other) selected based on the CSI for that sub-band and for that transmit antenna. Four modulation sub-streams are thus generated for the four data sub-streams, with each modulation sub-streams including a stream of modulation symbols. The four modulation sub-streams are then pre-conditioned using the eigenvector matrix, as expressed below in equation (1), to generate pre-conditioned modulation symbols. The four streams of pre-conditioned modulation symbols are respectively provided to the four combiners of the four transmit antennas. Each combiner combines the received pre-conditioned modulation symbols with the modulation symbols for the other sub-channels to generate a modulation symbol vector stream for the associated transmit antenna. Wallace '467 at 9:64–10:4 In instances where full CSI is not available, less descriptive information on the transmission path (or partial CSI) may be available and can be used to pre-condition the data prior to transmission. For example, the C/I of each of the sub-channels may be available. The C/I information can then be used to control the transmission from various transmit antennas to provide the required performance in the sub-channels of interest and increase system capacity. Wallace '467 at 13:3–21 Given the complexity of a system using multiple transmit antennas and multiple receive antennas, with the associated dispersive channel effects, the preferred modulation technique is OFDM, which effectively decomposes the channel into a set of non-interfering narrowband channels, or sub-channels. With proper OFDM signal design, a signal transmitted on one subchannel sees “flat fading”, i.e., the channel response is effectively constant over the subchannel bandwidth. The channel state information or CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-channel. CSI also includes the information of the relative levels of interference and noise in each sub-channel, that is known as C/I information. The CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. With CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 14:56–15:2 Multiple antennas at a receiver unit 145 receive signals at step 146. At step 147, the received signals undergo a Discrete Fourier Transform (DFT) operation to channelize the received signals. At step 148, the

Claim Element	Exemplary Citations to Wallace '467
	data from each subchannel over all of the receive antennas is processed. At this processing step, information regarding channel characteristics is extracted from the data, and converted into a more compressed format. One compression technique is the use of the conjugate channel response and the eigenmode matrix to reduce the amount of information needed to describe channel characteristics. At step 149, a message containing the compressed channel state information is transmitted from the receiver unit 145 to the transmitter unit 140, which will then be used to precondition further transmissions. Wallace '467 at 15:3–7 To facilitate the derivation of the CSI, the transmit waveform is made up of known pilot symbols for an initial preamble. The pilot waveforms for different transmit antennas comprise disjoint sets of OFDM subchannels as illustrated for the case when $N_t=4$ in FIG. 1C. Wallace '467 at 15:38–58 From each transmit antenna at a transmitter unit, the receiver unit receives pilot symbols on disjoint sub-channels and makes determinations as to channel characteristics of the disjoint sub-channels. As discussed previously, the receiver unit may have one or more receive antennas. Suppose $x=\{x_i, i=1, \dots, K\}$ are the pilot symbol values that are to be transmitted on K pilot sub-channels for a single transmit antenna. The receiver unit will receive the values $y_{ij}=h_{ij}x_i+n_{ij}$, wherein h_{ij} is the complex channel response for the i^{th} pilot sub-channel received at the j^{th} receive antenna, and n_{ij} is noise. From this relationship, the receiver unit can determine noisy estimates of the channel response of K sub-channels of a single transmit antenna. These noisy estimates may be used to derive estimates for all sub-channels of the propagation channel through a number of different methods, such as simple interpolation to more complex estimation using a priori information on the channel dispersion and noise level. The estimates may be improved by transmitting pilot symbols over consecutive OFDM symbols and then averaging the estimates for each consecutive OFDM symbol. Wallace '467 at 18:33–44 As an alternative to these methods for compressing CSI information, one embodiment of the invention is directed to the transmission of a time-domain representation of the channel response, which is the channel impulse response. If a time-domain representation of the channel response is simple, as in cases where there are only two or three multipath components, an inverse FFT can be performed upon the set of channel frequency responses. The inverse FFT operation can be performed for each link between a transmit/receive antenna pair. The resulting channel impulse responses are then translated into a set of

Claim Element	Exemplary Citations to Wallace '467
	amplitudes and delays that are reported to the transmitter. Wallace '467 at 25:45–56 OFDM modulation can improve system performance due to multipath delay spread or differential path delay introduced by the propagation environment between the transmitting antenna and the receiver antenna. The communications link (i.e., the RF channel) has a delay spread that may potentially be greater than the reciprocal of the system operating bandwidth, W. Because of this, a communications system employing a modulation scheme that has a transmit symbol duration of less than the delay spread will experience inter-symbol interference (ISI). The ISI distorts the received symbol and increases the likelihood of incorrect detection. Wallace '467 at 29:16–38 1. A method for measuring and reporting transmission characteristics of a multiple input/multiple output communication system, comprising: assigning a first subset of sub-channels of a plurality of sub-channels to a first transmit antenna of a plurality of transmit antennas of a first transmitter unit, wherein the sub-channels of the first subset of sub-channels are noncontiguous; transmitting, by the first transmit antenna, a first pilot symbol over the sub-channels of the first subset of sub-channels; receiving, by a first receive antenna of a first receiver unit, the first pilot symbol; determining, from the received first pilot symbol, the transmission characteristics of the sub-channels of the first subset of sub-channels; reporting, by the first receiver unit to the first transmitter unit, an information signal that carries the determined transmission characteristics for the sub-channels of the first subset of sub-channels; and optimizing a set of transmission parameters at the first transmitter unit, based on the information signal. Wallace '467 at 31:8–32 19. A method for measuring and reporting channel state information (CSI) in a multiple input/multiple output (MIMO) system, comprising: assigning a plurality of sub-channel subsets to a plurality of transmit antennas of at least one transmitter unit, wherein the sub-channels of each of the sub-channel subsets are noncontiguous; transmitting a plurality of Orthogonal Frequency Division Multiplexed (OFDM) pilot waveforms from the at least one transmitter unit to at least one receiver unit, wherein each of the plurality of OFDM pilot waveforms is transmitted over a separate one of the plurality of sub-channel subsets;

Claim Element	Exemplary Citations to Wallace '467
	receiving, by the at least one receiver unit, the plurality of OFDM pilot waveforms; demodulating the received plurality of OFDM pilot waveforms; determining the CSI of the sub-channels corresponding to each of the plurality of sub-channel subsets from the demodulated plurality of OFDM pilot waveforms; transmitting the determined CSI to the at least one transmitter unit, and preconditioning a transmission symbol according to the determined CSI. To the extent this element is not disclosed by Wallace '467, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Wallace '467, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
20. The wireless device of claim 19, wherein the path parameter information of the first propagation path includes at least one of an estimation of a delay, an estimation of a Doppler frequency, an estimation of a direction of arrival, an estimation of a direction of departure, and an estimation of a complex amplitude of the first propagation path.	Wallace '467 discloses or renders obvious “[t]he wireless device of claim 19, wherein the path parameter information of the first propagation path includes at least one of an estimation of a delay, an estimation of a Doppler frequency, an estimation of a direction of arrival, an estimation of a direction of departure, and an estimation of a complex amplitude of the first propagation path.” For example: Wallace '467 at Abstract Channel state information (CSI) can be used by a communications system to precondition transmissions between transmitter units and receiver units. In one aspect of the invention, disjoint sub-channel sets are assigned to transmit antennas located at a transmitter unit. Pilot symbols are generated and transmitted on a subset of the disjoint sub-channels. Upon receipt of the transmitted pilot symbols, the receiver units determine the CSI for the disjoint sub-channels that carried pilot symbols. These CSI values are reported to the transmitter unit, which will use these CSI values to generate CSI estimates for the disjoint sub-channels that did not carry pilot symbols. The amount of information necessary to report CSI on the reverse link can be further minimized through compression techniques and resource allocation techniques.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at Wallace-467 at Fig. 1A  FIG. 1A Wallace '467 at Wallace-467 at Fig. 1B  FIG. 1B Wallace '467 at 1:57-2:8 Given the ever-growing demand for wireless communication, a higher efficiency, higher performance wireless communications system is desirable. One type of higher performance wireless communications system is a Multiple Input/Multiple Output (MIMO) system that employs multiple transmit antennas to transmit over a propagation channel to multiple receive antennas. As in lower performance systems, the

Claim Element	Exemplary Citations to Wallace '467
	propagation channel in a MIMO system is subject to the deleterious effects of multipath, as well as interference from adjacent antennas. Multipath occurs when a transmitted signal arrives at a receiver unit through multiple propagation paths with differing delays. When signals arrive from multiple propagation paths, components of the signals can combine destructively, which is referred to as “fading.” In order to improve the efficiency and decrease the complexity of the MIMO system, information as to the characteristics of the propagation channel can be transmitted back to the transmitter unit in order to precondition the signal before transmission. Wallace '467 at 2:25–48 The present invention is directed to a method and apparatus for the measuring and reporting of channel state information in a high efficiency, high performance communications system, comprising the steps of: generating a plurality of pilot signals; transmitting the plurality of pilot signals over a propagation channel between a transmitter unit and a plurality of receiver units, wherein the transmitter unit comprises at least one transmit antenna, each of the plurality of receiver units comprises at least one receive antenna, and the propagation channel comprises a plurality of sub-channels between the transmitter unit and the plurality of receiver units; receiving at least one of the plurality of pilot signals at each of the plurality of receiver units; determining a set of transmission characteristics for at least one of the plurality of sub-channels, wherein the step of determining the set of transmission characteristics uses at least one of the plurality of pilot signals received at each of the plurality of receiver units; reporting an information signal from each of the plurality of receiver units to the transmitter unit, wherein the information signal carries the set of transmission characteristics for at least one of the plurality of sub-channels; and optimizing a set of transmission parameters at the transmitter unit, based on the information signal. Wallace '467 at 2:49–62 In one aspect of the invention, pilot symbols are transmitted on a plurality of disjoint OFDM sub-channel sets. When the pilot symbols are transmitted on disjoint OFDM sub-channels, the characteristics of the propagation channel can be determined through a set of K sub-channels carrying the pilot symbols, wherein K is less than the number of OFDM sub-channels in the system. In addition to transmitting pilot symbols on disjoint sub-channels, the system can transmit a time-domain pilot sequence that can be used to determine characteristics of the propagation channel. Along with the generation and transmission of pilot symbols, an aspect of the invention is the compression of the amount of information necessary to reconstruct the characteristics of the propagation channel.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 3:34–54 FIG. 1A is a diagram of a Multiple Input/Multiple Output (MIMO) communications system 100 capable of implementing some embodiments of the invention. Communications system 100 can be operative to provide a combination of antenna, frequency, and temporal diversity to increase spectral efficiency, improve performance, and enhance flexibility. Increased spectral efficiency is characterized by the ability to transmit more bits per second per Hertz (bps/Hz) when and where possible to better utilize the available system bandwidth. Techniques to obtain higher spectral efficiency are described in further detail below. Improved performance may be quantified, for example, by a lower bit-error-rate (BER) or frame-error-rate (FER) for a given link carrier-to-noise-plus-interference ratio (C/I). And enhanced flexibility is characterized by the ability to accommodate multiple users having different and typically disparate requirements. These goals may be achieved, in part, by employing multi-carrier modulation, time division multiplexing (TDM), multiple transmit and/or receive antennas, and other techniques. The features, aspects, and advantages of the invention are described in further detail below. Wallace '467 at 3:55–67 As shown in FIG. 1A, communications system 100 includes a first system 110 in communication with a second system 120. System 110 includes a (transmit) data processor 112 that (1) receives or generates data, (2) processes the data to provide antenna, frequency, or temporal diversity, or a combination thereof, and (3) provides processed modulation symbols to a number of modulators (MOD) 114a through 114t. Each modulator 114 further processes the modulation symbols and generates an RF modulated signal suitable for transmission. The RF modulated signals from modulators 114a through 114t are then transmitted from respective antennas 116a through 116t over communications links 118 to system 120. Wallace '467 at 4:1–17 In FIG. 1A, system 120 includes a number of receive antennas 122a through 122r that receive the transmitted signals and provide the received signals to respective demodulators (DEMOD) 124a through 124r. As shown in FIG. 1A, each receive antenna 122 may receive signals from one or more transmit antennas 116 depending on a number of factors such as, for example, the operating mode used at system 110, the directivity of the transmit and receive antennas, the characteristics of the communications links, and others. Each demodulator 124 demodulates the respective received signal using a demodulation scheme that is complementary to the modulation scheme used at the transmitter. The demodulated symbols from demodulators 124a through 124r are then provided to a (receive) data processor 126 that further processes the symbols to provide the output data. The data processing at the transmitter and

Claim Element	Exemplary Citations to Wallace '467
	receiver units is described in further detail below. Wallace '467 at 4:18–27 FIG. 1A shows only the forward link transmission from system 110 to system 120. This configuration may be used for data broadcast and other one-way data transmission applications. In a bidirectional communications system, a reverse link from system 120 to system 110 is also provided, although not shown in FIG. 1A for simplicity. For the bidirectional communications system, each of systems 110 and 120 may operate as a transmitter unit or a receiver unit, or both concurrently, depending on whether data is being transmitted from, or received at, the unit. Wallace '467 at 4:28–34 For simplicity, communications system 100 is shown to include one transmitter unit (i.e., system 110) and one receiver unit (i.e., system 120). However, in general, multiple transmit antennas and multiple receive antennas are present on each transmitter unit and each receiver unit. The communications system of the invention may include any number of transmitter units and receiver units. Wallace '467 at 4:36–47 Each transmitter unit may include a single transmit antenna or a number of transmit antennas, such as that shown in FIG. 1A. Similarly, each receiver unit may include a single receive antenna or a number of receive antennas, again such as that shown in FIG. 1A. For example, the communications system may include a central system (i.e., similar to a base station in the IS-95 CDMA system) having a number of antennas that transmit data to, and receive data from, a number of remote systems (i.e., subscriber units, similar to remote stations in the CDMA system), some of which may include one antenna and others of which may include multiple antennas. Wallace '467 at 4:48–63 As used herein, an antenna refers to a collection of one or more antenna elements that are distributed in space. The antenna elements may be physically located at a single site or distributed over multiple sites. Antenna elements physically co-located at a single site may be operated as an antenna array (e.g., such as for a CDMA base station). An antenna network consists of a collection of antenna arrays or elements that are physically separated (e.g., several CDMA base stations). An antenna array or an antenna network may be designed with the ability to form beams and to transmit multiple beams from the antenna array or

Claim Element	Exemplary Citations to Wallace '467
	network. For example, a CDMA base station may be designed with the capability to transmit up to three beams to three different sections of a coverage area (or sectors) from the same antenna array. Thus, the three beams may be viewed as three transmissions from three antennas. Wallace '467 at 4:64–5:4 The communications system of the invention can be designed to provide a multi-user, multiple access communications scheme capable of supporting subscriber units having different requirements as well as capabilities. The scheme allows the system's total operating bandwidth, W, (e.g., 1.2288 MHz) to be efficiently shared among different types of services that may have highly disparate data rate, delay, and quality of service (QOS) requirements. Wallace '467 at 5:47–53 The communications system of the invention provides the above-described features and advantages, and is capable of supporting different types of services having disparate requirements. The features are achieved by employing antenna, frequency, or temporal diversity, or a combination thereof. Antenna, frequency, or temporal diversity can be independently achieved and dynamically selected. Wallace '467 at 5:54–67 As used herein, antenna diversity refers to the transmission and/or reception of data over more than one antenna, frequency diversity refers to the transmission of data over more than one sub-band, and temporal diversity refers to the transmission of data over more than one time period. Antenna, frequency, and temporal diversity may include subcategories. For example, transmit diversity refers to the use of more than one transmit antenna in a manner to improve the reliability of the communications link, receive diversity refers to the use of more than one receive antenna in a manner to improve the reliability of the communications link, and spatial diversity refers to the use of multiple transmit and receive antennas to improve the reliability and/or increase the capacity of the communications link. Wallace '467 at 6:1–5 Transmit and receive diversity can also be used in combination to improve the reliability of the communications link without increasing the link capacity. Various combinations of antenna, frequency, and temporal diversity can thus be achieved and are within the scope of the present invention.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 6:6–14 Frequency diversity can be provided by use of a multi-carrier modulation scheme such as orthogonal frequency division multiplexing (OFDM), which allows for transmission of data over various sub-bands of the operating bandwidth. Temporal diversity is achieved by transmitting the data over different times, which can be more easily accomplished with the use of time-division multiplexing (TDM). These various aspects of the communications system of the invention are described in further detail below. Wallace '467 at 6:15–32 In accordance with an aspect of the invention, antenna diversity is achieved by employing a number of (N_T) transmit antennas at the transmitter unit or a number of (N_R) receive antennas at the receiver unit, or multiple antennas at both the transmitter and receiver units. In a terrestrial communications system (e.g., a cellular system, a broadcast system, an MMDS system, and others), an RF modulated signal from a transmitter unit may reach the receiver unit via a number of transmission paths. The characteristics of the transmission paths typically vary over time based on a number of factors. If more than one transmit or receive antenna is used, and if the transmission paths between the transmit and receive antennas are independent (i.e., uncorrelated), which is generally true to at least an extent, then the likelihood of correctly receiving the transmitted signal increases as the number of antennas increases. Generally, as the number of transmit and receive antennas increases, diversity increases and performance improves. Wallace '467 at 6:33–52 Antenna diversity is dynamically provided based on the characteristics of the communications link to provide the required performance. For example, a higher degree of antenna diversity can be provided for some types of communication (e.g., signaling), for some types of services (e.g., voice), for some communications link characteristics (e.g., low C/I), or for some other conditions or considerations. As used herein, antenna diversity includes transmit diversity and receive diversity. For transmit diversity, data is transmitted over multiple transmit antennas. Typically, additional processing is performed on the data transmitted from the transmit antennas to achieve the desired diversity. For example, the data transmitted from different transmit antennas may be delayed or reordered in time, or coded and interleaved across the available transmit antennas. Also, frequency and temporal diversity may be used in conjunction with the different transmit antennas. For receive diversity, modulated signals are received on multiple receive antennas, and diversity is achieved by simply receiving the signals via different transmission paths.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 6:53–7:14 In accordance with another aspect of the invention, frequency diversity can be achieved by employing a multi-carrier modulation scheme. One such scheme that has numerous advantages is OFDM. With OFDM modulation, the overall transmission channel is essentially divided into a number of (L) parallel sub-channels that are used to transmit the same or different data. The overall transmission channel occupies the total operating bandwidth of W, and each of the sub-channels occupies a sub-band having a bandwidth of W/L and centered at a different center frequency. Each sub-channel has a bandwidth that is a portion of the total operating bandwidth. Each of the sub-channels may also be considered an independent data transmission channel that may be associated with a particular (and possibly unique) processing, coding, and modulation scheme, as described below. The data may be partitioned and transmitted over any defined set of two or more sub-bands to provide frequency diversity. For example, the transmission to a particular subscriber unit may occur over sub-channel 1 at time slot 1, sub-channel 5 at time slot 2, sub-channel 2 at time slot 3, and so on. As another example, data for a particular subscriber unit may be transmitted over sub-channels 1 and 2 at time slot 1 (e.g., with the same data being transmitted on both sub-channels), sub-channels 4 and 6 at time slot 2, only sub-channel 2 at time slot 3, and so on. Transmission of data over different sub-channels over time can improve the performance of a communications system experiencing frequency selective fading and channel distortion. Other benefits of OFDM modulation are described below. Wallace '467 at 7:15–31 In accordance with yet another aspect of the invention, temporal diversity is achieved by transmitting data at different times, which can be more easily accomplished using time division multiplexing (TDM). For data services (and possibly for voice services), data transmission occurs over time slots that may be selected to provide immunity to time dependent degradation in the communications link. Temporal diversity may also be achieved through the use of interleaving. For example, the transmission to a particular subscriber unit may occur over time slots 1 through x, or on a subset of the possible time slots from 1 through x (e.g., time slots 1, 5, 8, and so on). The amount of data transmitted at each time slot may be variable or fixed. Transmission over multiple time slots improves the likelihood of correct data reception due to, for example, impulse noise and interference. Wallace '467 at 7:33–8:3 The combination of antenna, frequency, and temporal diversity allows the communications system of the invention to provide robust performance. Antenna, frequency, and/or temporal diversity improves the likelihood of correct reception of at least some of the transmitted data, which may then be used (e.g., through decoding) to correct for some errors that may have occurred in the other transmissions. The

Claim Element	Exemplary Citations to Wallace '467
	combination of antenna, frequency, and temporal diversity also allows the communications system to concurrently accommodate different types of services having disparate data rate, processing delay, and quality of service requirements. The communications system of the invention can be designed and operated in a number of different communications modes, with each communications mode employing antenna, frequency, or temporal diversity, or a combination thereof. The communications modes include, for example, a diversity communications mode and a MIMO communications mode. Various combinations of the diversity and MIMO communications modes can also be supported by the communications system. Also, other communications modes can be implemented and are within the scope of the present invention. The diversity communications mode employs transmit and/or receive diversity, frequency, or temporal diversity, or a combination thereof, and is generally used to improve the reliability of the communications link. In one implementation of the diversity communications mode, the transmitter unit selects a modulation and coding scheme (i.e., configuration) from a finite set of possible configurations, which are known to the receiver units. For example, each overhead and common channel may be associated with a particular configuration that is known to all receiver units. When using the diversity communications mode for a specific user (e.g., for a voice call or a data transmission), the mode and/or configuration may be known a priori (e.g., from a previous set up) or negotiated (e.g., via a common channel) by the receiver unit. Wallace '467 at 8:16–52 The MIMO communications mode employs antenna diversity at both ends of the communication link and is generally used to improve both the reliability and increase the capacity of the communications link. The MIMO communications mode may further employ frequency and/or temporal diversity in combination with the antenna diversity. The MIMO communications mode, which may also be referred to herein as the spatial communications mode, employs one or more processing modes to be described below. The diversity communications mode generally has lower spectral efficiency than the MIMO communications mode, especially at high C/I levels. However, at low to moderate C/I values, the diversity communications mode achieves comparable efficiency and can be simpler to implement. In general, the use of the MIMO communications mode provides greater spectral efficiency when used, particularly at moderate to high C/I values. The MIMO communications mode may thus be advantageously used when the data rate requirements are moderate to high. The communications system can be designed to concurrently support both diversity and MIMO communications modes. The communications modes can be applied in various manners and, for increased flexibility, may be applied independently on a sub-channel basis. The MIMO communications mode is typically applied to specific users. However, each communications mode may be applied on each sub-

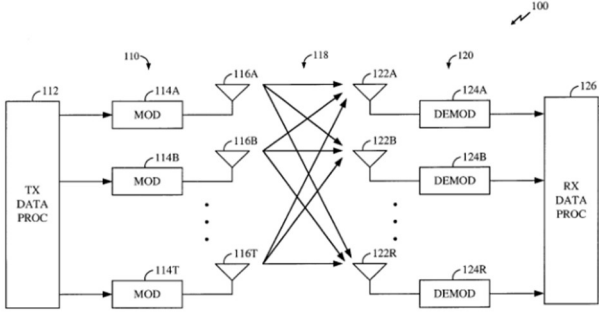
Claim Element	Exemplary Citations to Wallace '467
	channel independently, across a subset of sub-channels, across all sub-channels, or on some other basis. For example, the use of the MIMO communications mode may be applied to a specific user (e.g., a data user) and, concurrently, the use of the diversity communications mode may be applied to another specific user (e.g., a voice user) on a different sub-channel. The diversity communications mode may also be applied, for example, on sub-channels experiencing higher path loss. Wallace '467 at 8:53–9:3 The communications system of the invention can also be designed to support a number of processing modes. When the transmitter unit is provided with information indicative of the conditions (i.e., the “state”) of the communications links, additional processing can be performed at the transmitter unit to further improve performance and increase efficiency. Full channel state information (CSI) or partial CSI may be available to the transmitter unit. Full CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-band. Full CSI also includes the C/I per sub-band. The full CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. Partial CSI may include, for example, the C/I of the sub-band . With full CSI or partial CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 9:16–27 In the partial-CSI or no-CSI processing modes, the transmitter unit can employ a common modulation and coding scheme (e.g., on each data channel transmission), which then can be (in theory) demodulated by all receiver units. In the partial-CSI processing mode, a single receiver unit can specify the C/I, and the modulation employed on all antennas can be selected accordingly (e.g., for reliable transmission) for that receiver unit. Other receiver units can attempt to demodulate the transmission and, if they have adequate C/I, may be able to successfully recover the transmission. A common (e.g., broadcast) channel can use a no-CSI processing mode to reach all users. Wallace '467 at 9:29–48 As an example, assume that the MIMO communications mode is applied to a channel data stream that is transmitted on one particular sub-channel from four transmit antennas. The channel data stream is demultiplexed into four data sub-streams, one data sub-stream for each transmit antenna. Each data sub-stream is then modulated using a particular modulation scheme (e.g., M-PSK, M-QAM, or other) selected based on the CSI for that sub-band and for that transmit antenna. Four modulation sub-streams are thus

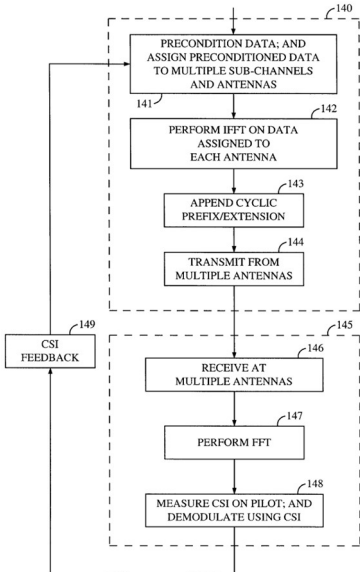
Claim Element	Exemplary Citations to Wallace '467
	generated for the four data sub-streams, with each modulation sub-streams including a stream of modulation symbols. The four modulation sub-streams are then pre-conditioned using the eigenvector matrix, as expressed below in equation (1), to generate pre-conditioned modulation symbols. The four streams of pre-conditioned modulation symbols are respectively provided to the four combiners of the four transmit antennas. Each combiner combines the received pre-conditioned modulation symbols with the modulation symbols for the other sub-channels to generate a modulation symbol vector stream for the associated transmit antenna. Wallace '467 at 9:64–10:4 In instances where full CSI is not available, less descriptive information on the transmission path (or partial CSI) may be available and can be used to pre-condition the data prior to transmission. For example, the C/I of each of the sub-channels may be available. The C/I information can then be used to control the transmission from various transmit antennas to provide the required performance in the sub-channels of interest and increase system capacity. Wallace '467 at 13:3–21 Given the complexity of a system using multiple transmit antennas and multiple receive antennas, with the associated dispersive channel effects, the preferred modulation technique is OFDM, which effectively decomposes the channel into a set of non-interfering narrowband channels, or sub-channels. With proper OFDM signal design, a signal transmitted on one subchannel sees “flat fading”, i.e., the channel response is effectively constant over the subchannel bandwidth. The channel state information or CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-channel. CSI also includes the information of the relative levels of interference and noise in each sub-channel, that is known as C/I information. The CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. With CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 14:56–15:2 Multiple antennas at a receiver unit 145 receive signals at step 146. At step 147, the received signals undergo a Discrete Fourier Transform (DFT) operation to channelize the received signals. At step 148, the data from each subchannel over all of the receive antennas is processed. At this processing step, information regarding channel characteristics is extracted from the data, and converted into a more

Claim Element	Exemplary Citations to Wallace '467
	compressed format. One compression technique is the use of the conjugate channel response and the eigenmode matrix to reduce the amount of information needed to describe channel characteristics. At step 149, a message containing the compressed channel state information is transmitted from the receiver unit 145 to the transmitter unit 140, which will then be used to precondition further transmissions. Wallace '467 at 15:3–7 To facilitate the derivation of the CSI, the transmit waveform is made up of known pilot symbols for an initial preamble. The pilot waveforms for different transmit antennas comprise disjoint sets of OFDM subchannels as illustrated for the case when $N_t=4$ in FIG. 1C. Wallace '467 at 15:38–58 From each transmit antenna at a transmitter unit, the receiver unit receives pilot symbols on disjoint sub-channels and makes determinations as to channel characteristics of the disjoint sub-channels. As discussed previously, the receiver unit may have one or more receive antennas. Suppose $x=\{x_i, i=1, \dots, K\}$ are the pilot symbol values that are to be transmitted on K pilot sub-channels for a single transmit antenna. The receiver unit will receive the values $y_{ij}=h_{ij}x_i+n_{ij}$, wherein h_{ij} is the complex channel response for the i^{th} pilot sub-channel received at the j^{th} receive antenna, and n_{ij} is noise. From this relationship, the receiver unit can determine noisy estimates of the channel response of K sub-channels of a single transmit antenna. These noisy estimates may be used to derive estimates for all sub-channels of the propagation channel through a number of different methods, such as simple interpolation to more complex estimation using a priori information on the channel dispersion and noise level. The estimates may be improved by transmitting pilot symbols over consecutive OFDM symbols and then averaging the estimates for each consecutive OFDM symbol. Wallace '467 at 18:5–32 The embodiments of the invention discussed herein have been directed to the design and transmission of pilot signals that will allow a person skilled in the art to derive characteristics of the propagation channel and to report such characteristics to the transmission site. However, the full CSI is a large amount of information and also highly redundant. Many methods are available for compressing the amount of CSI information to be transmitted. One method discussed previously is the use of the Hermitian matrix H^*H, wherein H is the channel response as determined at the receiver unit. The Hermitian matrix H^*H can be reported to the transmitter unit and be used to precondition transmissions. Due to the properties of Hermitian matrices, only half of the matrix elements need to be transmitted, such as the complex lower

Claim Element	Exemplary Citations to Wallace '467
	triangular portion of the matrix H^*H, and the real-valued diagonal. Additional efficiencies are realized if the number of receive antennas is larger than the number of transmit antennas. Another method to reduce the amount of information transmitted to the transmitter unit on the reverse link is to report only a subset of the channel response matrices H_i to the transmitter unit, from which the unreported channel response matrices can be determined through interpolation schemes. In another method, a functional representation of the channel response across the sub-channels may be derived for each transmit/receive antenna pair, e.g., a polynomial function representative of the channel response can be generated. The coefficients of the polynomial function are then transmitted to the transmitter unit. Wallace '467 at 18:33–44 As an alternative to these methods for compressing CSI information, one embodiment of the invention is directed to the transmission of a time-domain representation of the channel response, which is the channel impulse response. If a time-domain representation of the channel response is simple, as in cases where there are only two or three multipath components, an inverse FFT can be performed upon the set of channel frequency responses. The inverse FFT operation can be performed for each link between a transmit/receive antenna pair. The resulting channel impulse responses are then translated into a set of amplitudes and delays that are reported to the transmitter. Wallace '467 at 25:45–56 OFDM modulation can improve system performance due to multipath delay spread or differential path delay introduced by the propagation environment between the transmitting antenna and the receiver antenna. The communications link (i.e., the RF channel) has a delay spread that may potentially be greater than the reciprocal of the system operating bandwidth, W. Because of this, a communications system employing a modulation scheme that has a transmit symbol duration of less than the delay spread will experience inter-symbol interference (ISI). The ISI distorts the received symbol and increases the likelihood of incorrect detection. Wallace '467 at 29:16–38 1. A method for measuring and reporting transmission characteristics of a multiple input/multiple output communication system, comprising: assigning a first subset of sub-channels of a plurality of sub-channels to a first transmit antenna of a plurality of transmit antennas of a first transmitter unit, wherein the sub-channels of the first subset of sub-channels are noncontiguous;

Claim Element	Exemplary Citations to Wallace '467
	transmitting, by the first transmit antenna, a first pilot symbol over the sub-channels of the first subset of sub-channels; receiving, by a first receive antenna of a first receiver unit, the first pilot symbol; determining, from the received first pilot symbol, the transmission characteristics of the sub-channels of the first subset of sub-channels; reporting, by the first receiver unit to the first transmitter unit, an information signal that carries the determined transmission characteristics for the sub-channels of the first subset of sub-channels; and optimizing a set of transmission parameters at the first transmitter unit, based on the information signal. Wallace '467 at 31:8–32 19. A method for measuring and reporting channel state information (CSI) in a multiple input/multiple output (MIMO) system, comprising: assigning a plurality of sub-channel subsets to a plurality of transmit antennas of at least one transmitter unit, wherein the sub-channels of each of the sub-channel subsets are noncontiguous; transmitting a plurality of Orthogonal Frequency Division Multiplexed (OFDM) pilot waveforms from the at least one transmitter unit to at least one receiver unit, wherein each of the plurality of OFDM pilot waveforms is transmitted over a separate one of the plurality of sub-channel subsets; receiving, by the at least one receiver unit, the plurality of OFDM pilot waveforms; demodulating the received plurality of OFDM pilot waveforms; determining the CSI of the sub-channels corresponding to each of the plurality of sub-channel subsets from the demodulated plurality of OFDM pilot waveforms; transmitting the determined CSI to the at least one transmitter unit, and preconditioning a transmission symbol according to the determined CSI. To the extent this element is not disclosed by Wallace '467, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Wallace '467, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
21. The wireless device of claim 20, wherein the path parameter information of the first propagation path further includes an estimation of a polarization status of the first propagation path.	Wallace '467 discloses or renders obvious “[t]he wireless device of claim 20, wherein the path parameter information of the first propagation path further includes an estimation of a polarization status of the first propagation path.” For example: Wallace '467 at Abstract Channel state information (CSI) can be used by a communications system to precondition transmissions between transmitter units and receiver units. In one aspect of the invention, disjoint sub-channel sets are assigned to transmit antennas located at a transmitter unit. Pilot symbols are generated and transmitted on

Claim Element	Exemplary Citations to Wallace '467
	a subset of the disjoint sub-channels. Upon receipt of the transmitted pilot symbols, the receiver units determine the CSI for the disjoint sub-channels that carried pilot symbols. These CSI values are reported to the transmitter unit, which will use these CSI values to generate CSI estimates for the disjoint sub-channels that did not carry pilot symbols. The amount of information necessary to report CSI on the reverse link can be further minimized through compression techniques and resource allocation techniques. Wallace '467 at Wallace-467 at Fig. 1A  FIG. 1A

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at Wallace-467 at Fig. 1B  FIG. 1B Wallace '467 at 1:57–2:8 Given the ever-growing demand for wireless communication, a higher efficiency, higher performance wireless communications system is desirable. One type of higher performance wireless communications system is a Multiple Input/Multiple Output (MIMO) system that employs multiple transmit antennas to transmit over a propagation channel to multiple receive antennas. As in lower performance systems, the propagation channel in a MIMO system is subject to the deleterious effects of multipath, as well as interference from adjacent antennas. Multipath occurs when a transmitted signal arrives at a receiver unit through multiple propagation paths with differing delays. When signals arrive from multiple propagation paths, components of the signals can combine destructively, which is referred to as “fading.” In order to improve the efficiency and decrease the complexity of the MIMO system, information as to the characteristics of the propagation channel can be transmitted back to the transmitter unit in order to precondition the signal before transmission. Wallace '467 at 2:25–48 The present invention is directed to a method and apparatus for the measuring and reporting of channel state information in a high efficiency, high performance communications system, comprising the steps of:

Claim Element	Exemplary Citations to Wallace '467
	generating a plurality of pilot signals; transmitting the plurality of pilot signals over a propagation channel between a transmitter unit and a plurality of receiver units, wherein the transmitter unit comprises at least one transmit antenna, each of the plurality of receiver units comprises at least one receive antenna, and the propagation channel comprises a plurality of sub-channels between the transmitter unit and the plurality of receiver units; receiving at least one of the plurality of pilot signals at each of the plurality of receiver units; determining a set of transmission characteristics for at least one of the plurality of sub-channels, wherein the step of determining the set of transmission characteristics uses at least one of the plurality of pilot signals received at each of the plurality of receiver units; reporting an information signal from each of the plurality of receiver units to the transmitter unit, wherein the information signal carries the set of transmission characteristics for at least one of the plurality of sub-channels; and optimizing a set of transmission parameters at the transmitter unit, based on the information signal. Wallace '467 at 2:49–62 In one aspect of the invention, pilot symbols are transmitted on a plurality of disjoint OFDM sub-channel sets. When the pilot symbols are transmitted on disjoint OFDM sub-channels, the characteristics of the propagation channel can be determined through a set of K sub-channels carrying the pilot symbols, wherein K is less than the number of OFDM sub-channels in the system. In addition to transmitting pilot symbols on disjoint sub-channels, the system can transmit a time-domain pilot sequence that can be used to determine characteristics of the propagation channel. Along with the generation and transmission of pilot symbols, an aspect of the invention is the compression of the amount of information necessary to reconstruct the characteristics of the propagation channel. Wallace '467 at 3:34–54 FIG. 1A is a diagram of a Multiple Input/Multiple Output (MIMO) communications system 100 capable of implementing some embodiments of the invention. Communications system 100 can be operative to provide a combination of antenna, frequency, and temporal diversity to increase spectral efficiency, improve performance, and enhance flexibility. Increased spectral efficiency is characterized by the ability to transmit more bits per second per Hertz (bps/Hz) when and where possible to better utilize the available system bandwidth. Techniques to obtain higher spectral efficiency are described in further detail below. Improved performance may be quantified, for example, by a lower bit-error-rate (BER) or frame-error-rate (FER) for a given link carrier-to-noise-plus-interference ratio (C/I). And enhanced flexibility is characterized by the ability to accommodate multiple users having different and typically disparate requirements. These goals may be achieved, in part, by employing multi-carrier modulation, time division

Claim Element	Exemplary Citations to Wallace '467
	multiplexing (TDM), multiple transmit and/or receive antennas, and other techniques. The features, aspects, and advantages of the invention are described in further detail below. Wallace '467 at 3:55–67 As shown in FIG. 1A, communications system 100 includes a first system 110 in communication with a second system 120. System 110 includes a (transmit) data processor 112 that (1) receives or generates data, (2) processes the data to provide antenna, frequency, or temporal diversity, or a combination thereof, and (3) provides processed modulation symbols to a number of modulators (MOD) 114a through 114t. Each modulator 114 further processes the modulation symbols and generates an RF modulated signal suitable for transmission. The RF modulated signals from modulators 114a through 114t are then transmitted from respective antennas 116a through 116t over communications links 118 to system 120. Wallace '467 at 4:1–17 In FIG. 1A, system 120 includes a number of receive antennas 122a through 122r that receive the transmitted signals and provide the received signals to respective demodulators (DEMOD) 124a through 124r. As shown in FIG. 1A, each receive antenna 122 may receive signals from one or more transmit antennas 116 depending on a number of factors such as, for example, the operating mode used at system 110, the directivity of the transmit and receive antennas, the characteristics of the communications links, and others. Each demodulator 124 demodulates the respective received signal using a demodulation scheme that is complementary to the modulation scheme used at the transmitter. The demodulated symbols from demodulators 124a through 124r are then provided to a (receive) data processor 126 that further processes the symbols to provide the output data. The data processing at the transmitter and receiver units is described in further detail below. Wallace '467 at 4:18–27 FIG. 1A shows only the forward link transmission from system 110 to system 120. This configuration may be used for data broadcast and other one-way data transmission applications. In a bidirectional communications system, a reverse link from system 120 to system 110 is also provided, although not shown in FIG. 1A for simplicity. For the bidirectional communications system, each of systems 110 and 120 may operate as a transmitter unit or a receiver unit, or both concurrently, depending on whether data is being transmitted from, or received at, the unit.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 4:28–34 For simplicity, communications system 100 is shown to include one transmitter unit (i.e., system 110) and one receiver unit (i.e., system 120). However, in general, multiple transmit antennas and multiple receive antennas are present on each transmitter unit and each receiver unit. The communications system of the invention may include any number of transmitter units and receiver units. Wallace '467 at 4:36–47 Each transmitter unit may include a single transmit antenna or a number of transmit antennas, such as that shown in FIG. 1A. Similarly, each receiver unit may include a single receive antenna or a number of receive antennas, again such as that shown in FIG. 1A. For example, the communications system may include a central system (i.e., similar to a base station in the IS-95 CDMA system) having a number of antennas that transmit data to, and receive data from, a number of remote systems (i.e., subscriber units, similar to remote stations in the CDMA system), some of which may include one antenna and others of which may include multiple antennas. Wallace '467 at 4:48–63 As used herein, an antenna refers to a collection of one or more antenna elements that are distributed in space. The antenna elements may be physically located at a single site or distributed over multiple sites. Antenna elements physically co-located at a single site may be operated as an antenna array (e.g., such as for a CDMA base station). An antenna network consists of a collection of antenna arrays or elements that are physically separated (e.g., several CDMA base stations). An antenna array or an antenna network may be designed with the ability to form beams and to transmit multiple beams from the antenna array or network. For example, a CDMA base station may be designed with the capability to transmit up to three beams to three different sections of a coverage area (or sectors) from the same antenna array. Thus, the three beams may be viewed as three transmissions from three antennas. Wallace '467 at 4:64–5:4 The communications system of the invention can be designed to provide a multi-user, multiple access communications scheme capable of supporting subscriber units having different requirements as well as capabilities. The scheme allows the system's total operating bandwidth, W, (e.g., 1.2288 MHz) to be efficiently shared among different types of services that may have highly disparate data rate, delay, and

Claim Element	Exemplary Citations to Wallace '467
	quality of service (QOS) requirements. Wallace '467 at 5:47–53 The communications system of the invention provides the above-described features and advantages, and is capable of supporting different types of services having disparate requirements. The features are achieved by employing antenna, frequency, or temporal diversity, or a combination thereof. Antenna, frequency, or temporal diversity can be independently achieved and dynamically selected. Wallace '467 at 5:54–67 As used herein, antenna diversity refers to the transmission and/or reception of data over more than one antenna, frequency diversity refers to the transmission of data over more than one sub-band, and temporal diversity refers to the transmission of data over more than one time period. Antenna, frequency, and temporal diversity may include subcategories. For example, transmit diversity refers to the use of more than one transmit antenna in a manner to improve the reliability of the communications link, receive diversity refers to the use of more than one receive antenna in a manner to improve the reliability of the communications link, and spatial diversity refers to the use of multiple transmit and receive antennas to improve the reliability and/or increase the capacity of the communications link. Wallace '467 at 6:1–5 Transmit and receive diversity can also be used in combination to improve the reliability of the communications link without increasing the link capacity. Various combinations of antenna, frequency, and temporal diversity can thus be achieved and are within the scope of the present invention. Wallace '467 at 6:6–14 Frequency diversity can be provided by use of a multi-carrier modulation scheme such as orthogonal frequency division multiplexing (OFDM), which allows for transmission of data over various sub-bands of the operating bandwidth. Temporal diversity is achieved by transmitting the data over different times, which can be more easily accomplished with the use of time-division multiplexing (TDM). These various aspects of the communications system of the invention are described in further detail below. Wallace '467 at 6:15–32 In accordance with an aspect of the invention, antenna diversity is achieved by employing a number of

Claim Element	Exemplary Citations to Wallace '467
	(N_T) transmit antennas at the transmitter unit or a number of (N_R) receive antennas at the receiver unit, or multiple antennas at both the transmitter and receiver units. In a terrestrial communications system (e.g., a cellular system, a broadcast system, an MMDS system, and others), an RF modulated signal from a transmitter unit may reach the receiver unit via a number of transmission paths. The characteristics of the transmission paths typically vary over time based on a number of factors. If more than one transmit or receive antenna is used, and if the transmission paths between the transmit and receive antennas are independent (i.e., uncorrelated), which is generally true to at least an extent, then the likelihood of correctly receiving the transmitted signal increases as the number of antennas increases. Generally, as the number of transmit and receive antennas increases, diversity increases and performance improves. Wallace '467 at 6:33–52 Antenna diversity is dynamically provided based on the characteristics of the communications link to provide the required performance. For example, a higher degree of antenna diversity can be provided for some types of communication (e.g., signaling), for some types of services (e.g., voice), for some communications link characteristics (e.g., low C/I), or for some other conditions or considerations. As used herein, antenna diversity includes transmit diversity and receive diversity. For transmit diversity, data is transmitted over multiple transmit antennas. Typically, additional processing is performed on the data transmitted from the transmit antennas to achieve the desired diversity. For example, the data transmitted from different transmit antennas may be delayed or reordered in time, or coded and interleaved across the available transmit antennas. Also, frequency and temporal diversity may be used in conjunction with the different transmit antennas. For receive diversity, modulated signals are received on multiple receive antennas, and diversity is achieved by simply receiving the signals via different transmission paths. Wallace '467 at 6:53–7:14 In accordance with another aspect of the invention, frequency diversity can be achieved by employing a multi-carrier modulation scheme. One such scheme that has numerous advantages is OFDM. With OFDM modulation, the overall transmission channel is essentially divided into a number of (L) parallel sub-channels that are used to transmit the same or different data. The overall transmission channel occupies the total operating bandwidth of W, and each of the sub-channels occupies a sub-band having a bandwidth of W/L and centered at a different center frequency. Each sub-channel has a bandwidth that is a portion of the total operating bandwidth. Each of the sub-channels may also be considered an independent data transmission channel that may be associated with a particular (and possibly unique) processing, coding, and modulation scheme, as described below.

Claim Element	Exemplary Citations to Wallace '467
	The data may be partitioned and transmitted over any defined set of two or more sub-bands to provide frequency diversity. For example, the transmission to a particular subscriber unit may occur over sub-channel 1 at time slot 1, sub-channel 5 at time slot 2, sub-channel 2 at time slot 3, and so on. As another example, data for a particular subscriber unit may be transmitted over sub-channels 1 and 2 at time slot 1 (e.g., with the same data being transmitted on both sub-channels), sub-channels 4 and 6 at time slot 2, only sub-channel 2 at time slot 3, and so on. Transmission of data over different sub-channels over time can improve the performance of a communications system experiencing frequency selective fading and channel distortion. Other benefits of OFDM modulation are described below. Wallace '467 at 7:15–31 In accordance with yet another aspect of the invention, temporal diversity is achieved by transmitting data at different times, which can be more easily accomplished using time division multiplexing (TDM). For data services (and possibly for voice services), data transmission occurs over time slots that may be selected to provide immunity to time dependent degradation in the communications link. Temporal diversity may also be achieved through the use of interleaving. For example, the transmission to a particular subscriber unit may occur over time slots 1 through x, or on a subset of the possible time slots from 1 through x (e.g., time slots 1, 5, 8, and so on). The amount of data transmitted at each time slot may be variable or fixed. Transmission over multiple time slots improves the likelihood of correct data reception due to, for example, impulse noise and interference. Wallace '467 at 7:33–8:3 The combination of antenna, frequency, and temporal diversity allows the communications system of the invention to provide robust performance. Antenna, frequency, and/or temporal diversity improves the likelihood of correct reception of at least some of the transmitted data, which may then be used (e.g., through decoding) to correct for some errors that may have occurred in the other transmissions. The combination of antenna, frequency, and temporal diversity also allows the communications system to concurrently accommodate different types of services having disparate data rate, processing delay, and quality of service requirements. The communications system of the invention can be designed and operated in a number of different communications modes, with each communications mode employing antenna, frequency, or temporal diversity, or a combination thereof. The communications modes include, for example, a diversity communications mode and a MIMO communications mode. Various combinations of the diversity and MIMO communications modes can also be supported by the communications system. Also, other communications modes can be implemented and are within the scope of the present invention. The diversity communications mode employs transmit and/or receive diversity, frequency, or temporal

Claim Element	Exemplary Citations to Wallace '467
	diversity, or a combination thereof, and is generally used to improve the reliability of the communications link. In one implementation of the diversity communications mode, the transmitter unit selects a modulation and coding scheme (i.e., configuration) from a finite set of possible configurations, which are known to the receiver units. For example, each overhead and common channel may be associated with a particular configuration that is known to all receiver units. When using the diversity communications mode for a specific user (e.g., for a voice call or a data transmission), the mode and/or configuration may be known a priori (e.g., from a previous set up) or negotiated (e.g., via a common channel) by the receiver unit. Wallace '467 at 8:16–52 The MIMO communications mode employs antenna diversity at both ends of the communication link and is generally used to improve both the reliability and increase the capacity of the communications link. The MIMO communications mode may further employ frequency and/or temporal diversity in combination with the antenna diversity. The MIMO communications mode, which may also be referred to herein as the spatial communications mode, employs one or more processing modes to be described below. The diversity communications mode generally has lower spectral efficiency than the MIMO communications mode, especially at high C/I levels. However, at low to moderate C/I values, the diversity communications mode achieves comparable efficiency and can be simpler to implement. In general, the use of the MIMO communications mode provides greater spectral efficiency when used, particularly at moderate to high C/I values. The MIMO communications mode may thus be advantageously used when the data rate requirements are moderate to high. The communications system can be designed to concurrently support both diversity and MIMO communications modes. The communications modes can be applied in various manners and, for increased flexibility, may be applied independently on a sub-channel basis. The MIMO communications mode is typically applied to specific users. However, each communications mode may be applied on each sub-channel independently, across a subset of sub-channels, across all sub-channels, or on some other basis. For example, the use of the MIMO communications mode may be applied to a specific user (e.g., a data user) and, concurrently, the use of the diversity communications mode may be applied to another specific user (e.g., a voice user) on a different sub-channel. The diversity communications mode may also be applied, for example, on sub-channels experiencing higher path loss. Wallace '467 at 8:53–9:3 The communications system of the invention can also be designed to support a number of processing modes. When the transmitter unit is provided with information indicative of the conditions (i.e., the “state”) of the communications links, additional processing can be performed at the transmitter unit to

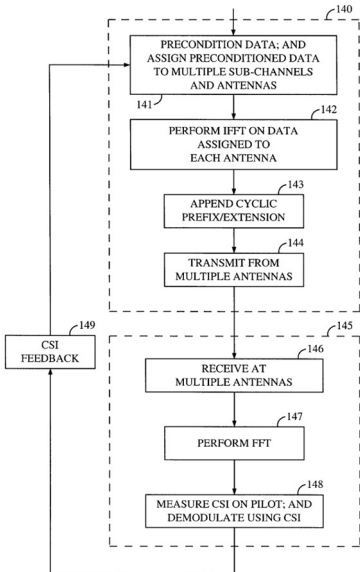
Claim Element	Exemplary Citations to Wallace '467
	further improve performance and increase efficiency. Full channel state information (CSI) or partial CSI may be available to the transmitter unit. Full CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-band. Full CSI also includes the C/I per sub-band. The full CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. Partial CSI may include, for example, the C/I of the sub-band . With full CSI or partial CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 9:29–48 As an example, assume that the MIMO communications mode is applied to a channel data stream that is transmitted on one particular sub-channel from four transmit antennas. The channel data stream is demultiplexed into four data sub-streams, one data sub-stream for each transmit antenna. Each data sub-stream is then modulated using a particular modulation scheme (e.g., M-PSK, M-QAM, or other) selected based on the CSI for that sub-band and for that transmit antenna. Four modulation sub-streams are thus generated for the four data sub-streams, with each modulation sub-streams including a stream of modulation symbols. The four modulation sub-streams are then pre-conditioned using the eigenvector matrix, as expressed below in equation (1), to generate pre-conditioned modulation symbols. The four streams of pre-conditioned modulation symbols are respectively provided to the four combiners of the four transmit antennas. Each combiner combines the received pre-conditioned modulation symbols with the modulation symbols for the other sub-channels to generate a modulation symbol vector stream for the associated transmit antenna. Wallace '467 at 9:49–63 The full-CSI based processing is typically employed in the MIMO communications mode where parallel data streams are transmitted to a specific user on each of the channel eigenmodes for the each of the allocated sub-channels. Similar processing based on full CSI can be performed where transmission on only a subset of the available eigenmodes is accommodated in each of the allocated sub-channels(e.g., to implement beam steering). Because of the cost associated with the full-CSI processing (e.g., increased complexity at the transmitter and receiver units, increased overhead for the transmission of the CSI from the receiver unit to the transmitter unit, and so on), full-CSI processing can be applied in certain instances in the MIMO communications mode where the additional increase in performance and efficiency is

Claim Element	Exemplary Citations to Wallace '467
	justified. Wallace '467 at 9:64–10:4 In instances where full CSI is not available, less descriptive information on the transmission path (or partial CSI) may be available and can be used to pre-condition the data prior to transmission. For example, the C/I of each of the sub-channels may be available. The C/I information can then be used to control the transmission from various transmit antennas to provide the required performance in the sub-channels of interest and increase system capacity. Wallace '467 at 10:5–10 As used herein, full-CSI based processing modes denote processing modes that use full CSI, and partial-CSI based processing modes denote processing modes that use partial CSI. The full-CSI based processing modes include, for example, the full-CSI MIMO mode that utilizes full-CSI based processing in the MIMO communications mode. Wallace '467 at 13:3–21 Given the complexity of a system using multiple transmit antennas and multiple receive antennas, with the associated dispersive channel effects, the preferred modulation technique is OFDM, which effectively decomposes the channel into a set of non-interfering narrowband channels, or sub-channels. With proper OFDM signal design, a signal transmitted on one subchannel sees “flat fading”, i.e., the channel response is effectively constant over the subchannel bandwidth. The channel state information or CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-channel. CSI also includes the information of the relative levels of interference and noise in each sub-channel, that is known as C/I information. The CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. With CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 14:56–15:2 Multiple antennas at a receiver unit 145 receive signals at step 146. At step 147, the received signals undergo a Discrete Fourier Transform (DFT) operation to channelize the received signals. At step 148, the data from each subchannel over all of the receive antennas is processed. At this processing step,

Claim Element	Exemplary Citations to Wallace '467
	information regarding channel characteristics is extracted from the data, and converted into a more compressed format. One compression technique is the use of the conjugate channel response and the eigenmode matrix to reduce the amount of information needed to describe channel characteristics. At step 149, a message containing the compressed channel state information is transmitted from the receiver unit 145 to the transmitter unit 140, which will then be used to precondition further transmissions. Wallace '467 at 15:3–7 To facilitate the derivation of the CSI, the transmit waveform is made up of known pilot symbols for an initial preamble. The pilot waveforms for different transmit antennas comprise disjoint sets of OFDM subchannels as illustrated for the case when $N_t=4$ in FIG. 1C. Wallace '467 at 15:38–58 From each transmit antenna at a transmitter unit, the receiver unit receives pilot symbols on disjoint sub-channels and makes determinations as to channel characteristics of the disjoint sub-channels. As discussed previously, the receiver unit may have one or more receive antennas. Suppose $x=\{x_i, i=1, \dots, K\}$ are the pilot symbol values that are to be transmitted on K pilot sub-channels for a single transmit antenna. The receiver unit will receive the values $y_{ij}=h_{ij}x_i+n_{ij}$, wherein h_{ij} is the complex channel response for the i^{th} pilot sub-channel received at the j^{th} receive antenna, and n_{ij} is noise. From this relationship, the receiver unit can determine noisy estimates of the channel response of K sub-channels of a single transmit antenna. These noisy estimates may be used to derive estimates for all sub-channels of the propagation channel through a number of different methods, such as simple interpolation to more complex estimation using a priori information on the channel dispersion and noise level. The estimates may be improved by transmitting pilot symbols over consecutive OFDM symbols and then averaging the estimates for each consecutive OFDM symbol. Wallace '467 at 18:5–32 The embodiments of the invention discussed herein have been directed to the design and transmission of pilot signals that will allow a person skilled in the art to derive characteristics of the propagation channel and to report such characteristics to the transmission site. However, the full CSI is a large amount of information and also highly redundant. Many methods are available for compressing the amount of CSI information to be transmitted. One method discussed previously is the use of the Hermitian matrix H^*H, wherein H is the channel response as determined at the receiver unit. The Hermitian matrix H^*H can be reported to the transmitter unit and be used to precondition transmissions. Due to the properties of

Claim Element	Exemplary Citations to Wallace '467
	Hermitian matrices, only half of the matrix elements need to be transmitted, such as the complex lower triangular portion of the matrix H^*H, and the real-valued diagonal. Additional efficiencies are realized if the number of receive antennas is larger than the number of transmit antennas. Another method to reduce the amount of information transmitted to the transmitter unit on the reverse link is to report only a subset of the channel response matrices H_i to the transmitter unit, from which the unreported channel response matrices can be determined through interpolation schemes. In another method, a functional representation of the channel response across the sub-channels may be derived for each transmit/receive antenna pair, e.g., a polynomial function representative of the channel response can be generated. The coefficients of the polynomial function are then transmitted to the transmitter unit. Wallace '467 at 18:33–44 As an alternative to these methods for compressing CSI information, one embodiment of the invention is directed to the transmission of a time-domain representation of the channel response, which is the channel impulse response. If a time-domain representation of the channel response is simple, as in cases where there are only two or three multipath components, an inverse FFT can be performed upon the set of channel frequency responses. The inverse FFT operation can be performed for each link between a transmit/receive antenna pair. The resulting channel impulse responses are then translated into a set of amplitudes and delays that are reported to the transmitter. Wallace '467 at 25:45–56 OFDM modulation can improve system performance due to multipath delay spread or differential path delay introduced by the propagation environment between the transmitting antenna and the receiver antenna. The communications link (i.e., the RF channel) has a delay spread that may potentially be greater than the reciprocal of the system operating bandwidth, W. Because of this, a communications system employing a modulation scheme that has a transmit symbol duration of less than the delay spread will experience inter-symbol interference (ISI). The ISI distorts the received symbol and increases the likelihood of incorrect detection. Wallace '467 at 29:16–38 1. A method for measuring and reporting transmission characteristics of a multiple input/multiple output communication system, comprising: assigning a first subset of sub-channels of a plurality of sub-channels to a first transmit antenna of a plurality of transmit antennas of a first transmitter unit, wherein the sub-channels of the first subset of

Claim Element	Exemplary Citations to Wallace '467
	sub-channels are noncontiguous; transmitting, by the first transmit antenna, a first pilot symbol over the sub-channels of the first subset of sub-channels; receiving, by a first receive antenna of a first receiver unit, the first pilot symbol; determining, from the received first pilot symbol, the transmission characteristics of the sub-channels of the first subset of sub-channels; reporting, by the first receiver unit to the first transmitter unit, an information signal that carries the determined transmission characteristics for the sub-channels of the first subset of sub-channels; and optimizing a set of transmission parameters at the first transmitter unit, based on the information signal. Wallace '467 at 31:8–32 19. A method for measuring and reporting channel state information (CSI) in a multiple input/multiple output (MIMO) system, comprising: assigning a plurality of sub-channel subsets to a plurality of transmit antennas of at least one transmitter unit, wherein the sub-channels of each of the sub-channel subsets are noncontiguous; transmitting a plurality of Orthogonal Frequency Division Multiplexed (OFDM) pilot waveforms from the at least one transmitter unit to at least one receiver unit, wherein each of the plurality of OFDM pilot waveforms is transmitted over a separate one of the plurality of sub-channel subsets; receiving, by the at least one receiver unit, the plurality of OFDM pilot waveforms; demodulating the received plurality of OFDM pilot waveforms; determining the CSI of the sub-channels corresponding to each of the plurality of sub-channel subsets from the demodulated plurality of OFDM pilot waveforms; transmitting the determined CSI to the at least one transmitter unit, and preconditioning a transmission symbol according to the determined CSI. To the extent this element is not disclosed by Wallace '467, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Wallace '467, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
22. The wireless device of claim 19, wherein the path parameter information is obtained by at least one estimation technique of the group consisting of a maximum likelihood estimation algorithm, periodogram, correlatorgram,	Wallace '467 discloses or renders obvious “[t]he wireless device of claim 19, wherein the path parameter information is obtained by at least one estimation technique of the group consisting of a maximum likelihood estimation algorithm, periodogram, correlatorgram, spectral-based methods, Bartlett beamformers, Capon beamformers, subspace-based techniques, MUSIC (MULTiple Signal Classification), ESPRIT (Estimation of Signal Parameters via Rotational Invariance Techniques), approximation of the maximum-likelihood method based on iterative schemes, SAGE (Space-Alternating Generalized Expectation-maximization), RiMAX (Richter's Maximum Likelihood method), maximum-a-posteriori based methods, Evidence Framework,

Claim Element	Exemplary Citations to Wallace '467
spectral-based methods, Bartlett beamformers, Capon beamformers, subspace-based techniques, MUSIC (Multiple Signal Classification), ESPRIT (Estimation of Signal Parameters via Rotational Invariance Techniques), approximation of the maximum-likelihood method based on iterative schemes, SAGE (Space-Alternating Generalized Expectation-maximization), RiMAX (Richter's Maximum Likelihood method), maximum-a-posteriori based methods, Evidence Framework, Bayesian techniques, tracking algorithms, Kalman filtering techniques, enhanced Kalman filtering techniques, particle filtering techniques, and least-square-error methods.	Bayesian techniques, tracking algorithms, Kalman filtering techniques, enhanced Kalman filtering techniques, particle filtering techniques, and least-square-error methods.” For example: Wallace '467 at Abstract Channel state information (CSI) can be used by a communications system to precondition transmissions between transmitter units and receiver units. In one aspect of the invention, disjoint sub-channel sets are assigned to transmit antennas located at a transmitter unit. Pilot symbols are generated and transmitted on a subset of the disjoint sub-channels. Upon receipt of the transmitted pilot symbols, the receiver units determine the CSI for the disjoint sub-channels that carried pilot symbols. These CSI values are reported to the transmitter unit, which will use these CSI values to generate CSI estimates for the disjoint sub-channels that did not carry pilot symbols. The amount of information necessary to report CSI on the reverse link can be further minimized through compression techniques and resource allocation techniques. Wallace '467 at Wallace-467 at Fig. 1B  <pre> graph TD 140[140] --> 141[141: PRECONDITION DATA; AND ASSIGN PRECONDITIONED DATA TO MULTIPLE SUB-CHANNELS AND ANTENNAS] 141 --> 142[142: PERFORM FFT ON DATA ASSIGNED TO EACH ANTENNA] 142 --> 143[143: APPEND CYCLIC PREFIX/EXTENSION] 143 --> 144[144: TRANSMIT FROM MULTIPLE ANTENNAS] 144 --> 145[145] 145 --> 146[146: RECEIVE AT MULTIPLE ANTENNAS] 146 --> 147[147: PERFORM FFT] 147 --> 148[148: MEASURE CSI ON PILOT; AND DEMODULATE USING CSI] 148 --> 149[149: CSI FEEDBACK] 149 --> 141 </pre> FIG. 1B Wallace '467 at 1:43–56 An IS-95 system can operate efficiently by estimating channel parameters at a receiver unit, which uses these estimated channel parameters to demodulate a received signal. The IS-95 system makes channel

Claim Element	Exemplary Citations to Wallace '467
	estimation efficient by requiring the transmission of a pilot signal from every base station. This pilot signal is a repeating PN-type sequence known by the receiver unit. Correlation of the received pilot signal with a local replica of the pilot signal enables the receiver unit to estimate the complex impulse response of the channel and adjust demodulator parameters accordingly. For the IS-95 waveform and system parameters it is not necessary or beneficial to report information on the channel conditions measured by the receiver unit back to the transmitter unit. Wallace '467 at 1:57–2:8 Given the ever-growing demand for wireless communication, a higher efficiency, higher performance wireless communications system is desirable. One type of higher performance wireless communications system is a Multiple Input/Multiple Output (MIMO) system that employs multiple transmit antennas to transmit over a propagation channel to multiple receive antennas. As in lower performance systems, the propagation channel in a MIMO system is subject to the deleterious effects of multipath, as well as interference from adjacent antennas. Multipath occurs when a transmitted signal arrives at a receiver unit through multiple propagation paths with differing delays. When signals arrive from multiple propagation paths, components of the signals can combine destructively, which is referred to as “fading.” In order to improve the efficiency and decrease the complexity of the MIMO system, information as to the characteristics of the propagation channel can be transmitted back to the transmitter unit in order to precondition the signal before transmission. Wallace '467 at 2:25–48 The present invention is directed to a method and apparatus for the measuring and reporting of channel state information in a high efficiency, high performance communications system, comprising the steps of: generating a plurality of pilot signals; transmitting the plurality of pilot signals over a propagation channel between a transmitter unit and a plurality of receiver units, wherein the transmitter unit comprises at least one transmit antenna, each of the plurality of receiver units comprises at least one receive antenna, and the propagation channel comprises a plurality of sub-channels between the transmitter unit and the plurality of receiver units; receiving at least one of the plurality of pilot signals at each of the plurality of receiver units; determining a set of transmission characteristics for at least one of the plurality of sub-channels, wherein the step of determining the set of transmission characteristics uses at least one of the plurality of pilot signals received at each of the plurality of receiver units; reporting an information signal from each of the plurality of receiver units to the transmitter unit, wherein the information signal carries the set of transmission characteristics for at least one of the plurality of sub-channels; and optimizing a set of

Claim Element	Exemplary Citations to Wallace '467
	transmission parameters at the transmitter unit, based on the information signal. Wallace '467 at 2:49–62 In one aspect of the invention, pilot symbols are transmitted on a plurality of disjoint OFDM sub-channel sets. When the pilot symbols are transmitted on disjoint OFDM sub-channels, the characteristics of the propagation channel can be determined through a set of K sub-channels carrying the pilot symbols, wherein K is less than the number of OFDM sub-channels in the system. In addition to transmitting pilot symbols on disjoint sub-channels, the system can transmit a time-domain pilot sequence that can be used to determine characteristics of the propagation channel. Along with the generation and transmission of pilot symbols, an aspect of the invention is the compression of the amount of information necessary to reconstruct the characteristics of the propagation channel. Wallace '467 at 4:1–17 In FIG. 1A, system 120 includes a number of receive antennas 122a through 122r that receive the transmitted signals and provide the received signals to respective demodulators (DEMOD) 124a through 124r. As shown in FIG. 1A, each receive antenna 122 may receive signals from one or more transmit antennas 116 depending on a number of factors such as, for example, the operating mode used at system 110, the directivity of the transmit and receive antennas, the characteristics of the communications links, and others. Each demodulator 124 demodulates the respective received signal using a demodulation scheme that is complementary to the modulation scheme used at the transmitter. The demodulated symbols from demodulators 124a through 124r are then provided to a (receive) data processor 126 that further processes the symbols to provide the output data. The data processing at the transmitter and receiver units is described in further detail below. Wallace '467 at 4:64–5:4 The communications system of the invention can be designed to provide a multi-user, multiple access communications scheme capable of supporting subscriber units having different requirements as well as capabilities. The scheme allows the system's total operating bandwidth, W, (e.g., 1.2288 MHz) to be efficiently shared among different types of services that may have highly disparate data rate, delay, and quality of service (QOS) requirements.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 5:47–53 The communications system of the invention provides the above-described features and advantages, and is capable of supporting different types of services having disparate requirements. The features are achieved by employing antenna, frequency, or temporal diversity, or a combination thereof. Antenna, frequency, or temporal diversity can be independently achieved and dynamically selected. Wallace '467 at 5:54–67 As used herein, antenna diversity refers to the transmission and/or reception of data over more than one antenna, frequency diversity refers to the transmission of data over more than one sub-band, and temporal diversity refers to the transmission of data over more than one time period. Antenna, frequency, and temporal diversity may include subcategories. For example, transmit diversity refers to the use of more than one transmit antenna in a manner to improve the reliability of the communications link, receive diversity refers to the use of more than one receive antenna in a manner to improve the reliability of the communications link, and spatial diversity refers to the use of multiple transmit and receive antennas to improve the reliability and/or increase the capacity of the communications link. Wallace '467 at 6:1–5 Transmit and receive diversity can also be used in combination to improve the reliability of the communications link without increasing the link capacity. Various combinations of antenna, frequency, and temporal diversity can thus be achieved and are within the scope of the present invention. Wallace '467 at 6:6–14 Frequency diversity can be provided by use of a multi-carrier modulation scheme such as orthogonal frequency division multiplexing (OFDM), which allows for transmission of data over various sub-bands of the operating bandwidth. Temporal diversity is achieved by transmitting the data over different times, which can be more easily accomplished with the use of time-division multiplexing (TDM). These various aspects of the communications system of the invention are described in further detail below. Wallace '467 at 6:15–32 In accordance with an aspect of the invention, antenna diversity is achieved by employing a number of (N_T) transmit antennas at the transmitter unit or a number of (N_R) receive antennas at the receiver unit, or multiple antennas at both the transmitter and receiver units. In a terrestrial communications system (e.g., a

Claim Element	Exemplary Citations to Wallace '467
	cellular system, a broadcast system, an MMDS system, and others), an RF modulated signal from a transmitter unit may reach the receiver unit via a number of transmission paths. The characteristics of the transmission paths typically vary over time based on a number of factors. If more than one transmit or receive antenna is used, and if the transmission paths between the transmit and receive antennas are independent (i.e., uncorrelated), which is generally true to at least an extent, then the likelihood of correctly receiving the transmitted signal increases as the number of antennas increases. Generally, as the number of transmit and receive antennas increases, diversity increases and performance improves. Wallace '467 at 6:33–52 Antenna diversity is dynamically provided based on the characteristics of the communications link to provide the required performance. For example, a higher degree of antenna diversity can be provided for some types of communication (e.g., signaling), for some types of services (e.g., voice), for some communications link characteristics (e.g., low C/I), or for some other conditions or considerations. As used herein, antenna diversity includes transmit diversity and receive diversity. For transmit diversity, data is transmitted over multiple transmit antennas. Typically, additional processing is performed on the data transmitted from the transmit antennas to achieve the desired diversity. For example, the data transmitted from different transmit antennas may be delayed or reordered in time, or coded and interleaved across the available transmit antennas. Also, frequency and temporal diversity may be used in conjunction with the different transmit antennas. For receive diversity, modulated signals are received on multiple receive antennas, and diversity is achieved by simply receiving the signals via different transmission paths. Wallace '467 at 7:15–31 In accordance with yet another aspect of the invention, temporal diversity is achieved by transmitting data at different times, which can be more easily accomplished using time division multiplexing (TDM). For data services (and possibly for voice services), data transmission occurs over time slots that may be selected to provide immunity to time dependent degradation in the communications link. Temporal diversity may also be achieved through the use of interleaving. For example, the transmission to a particular subscriber unit may occur over time slots 1 through x, or on a subset of the possible time slots from 1 through x (e.g., time slots 1, 5, 8, and so on). The amount of data transmitted at each time slot may be variable or fixed. Transmission over multiple time slots improves the likelihood of correct data reception due to, for example, impulse noise and interference. Wallace '467 at 7:33–8:3 The combination of antenna, frequency, and temporal diversity allows the communications system of the

Claim Element	Exemplary Citations to Wallace '467
	invention to provide robust performance. Antenna, frequency, and/or temporal diversity improves the likelihood of correct reception of at least some of the transmitted data, which may then be used (e.g., through decoding) to correct for some errors that may have occurred in the other transmissions. The combination of antenna, frequency, and temporal diversity also allows the communications system to concurrently accommodate different types of services having disparate data rate, processing delay, and quality of service requirements. The communications system of the invention can be designed and operated in a number of different communications modes, with each communications mode employing antenna, frequency, or temporal diversity, or a combination thereof. The communications modes include, for example, a diversity communications mode and a MIMO communications mode. Various combinations of the diversity and MIMO communications modes can also be supported by the communications system. Also, other communications modes can be implemented and are within the scope of the present invention. The diversity communications mode employs transmit and/or receive diversity, frequency, or temporal diversity, or a combination thereof, and is generally used to improve the reliability of the communications link. In one implementation of the diversity communications mode, the transmitter unit selects a modulation and coding scheme (i.e., configuration) from a finite set of possible configurations, which are known to the receiver units. For example, each overhead and common channel may be associated with a particular configuration that is known to all receiver units. When using the diversity communications mode for a specific user (e.g., for a voice call or a data transmission), the mode and/or configuration may be known a priori (e.g., from a previous set up) or negotiated (e.g., via a common channel) by the receiver unit. Wallace '467 at 8:16–52 The MIMO communications mode employs antenna diversity at both ends of the communication link and is generally used to improve both the reliability and increase the capacity of the communications link. The MIMO communications mode may further employ frequency and/or temporal diversity in combination with the antenna diversity. The MIMO communications mode, which may also be referred to herein as the spatial communications mode, employs one or more processing modes to be described below. The diversity communications mode generally has lower spectral efficiency than the MIMO communications mode, especially at high C/I levels. However, at low to moderate C/I values, the diversity communications mode achieves comparable efficiency and can be simpler to implement. In general, the use of the MIMO communications mode provides greater spectral efficiency when used, particularly at moderate to high C/I values. The MIMO communications mode may thus be advantageously used when the data rate requirements are moderate to high. The communications system can be designed to concurrently support both diversity and MIMO

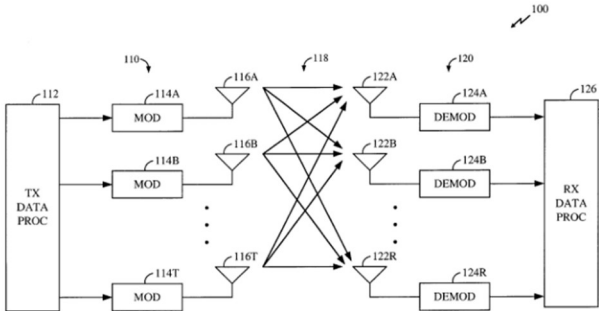
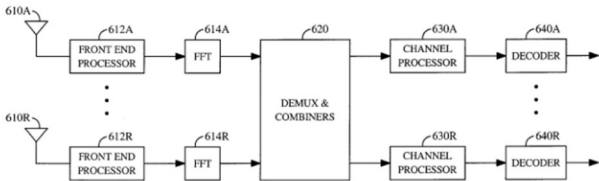
Claim Element	Exemplary Citations to Wallace '467
	communications modes. The communications modes can be applied in various manners and, for increased flexibility, may be applied independently on a sub-channel basis. The MIMO communications mode is typically applied to specific users. However, each communications mode may be applied on each sub-channel independently, across a subset of sub-channels, across all sub-channels, or on some other basis. For example, the use of the MIMO communications mode may be applied to a specific user (e.g., a data user) and, concurrently, the use of the diversity communications mode may be applied to another specific user (e.g., a voice user) on a different sub-channel. The diversity communications mode may also be applied, for example, on sub-channels experiencing higher path loss. Wallace '467 at 8:53–9:3 The communications system of the invention can also be designed to support a number of processing modes. When the transmitter unit is provided with information indicative of the conditions (i.e., the “state”) of the communications links, additional processing can be performed at the transmitter unit to further improve performance and increase efficiency. Full channel state information (CSI) or partial CSI may be available to the transmitter unit. Full CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-band. Full CSI also includes the C/I per sub-band. The full CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. Partial CSI may include, for example, the C/I of the sub-band . With full CSI or partial CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 9:29–48 As an example, assume that the MIMO communications mode is applied to a channel data stream that is transmitted on one particular sub-channel from four transmit antennas. The channel data stream is demultiplexed into four data sub-streams, one data sub-stream for each transmit antenna. Each data sub-stream is then modulated using a particular modulation scheme (e.g., M-PSK, M-QAM, or other) selected based on the CSI for that sub-band and for that transmit antenna. Four modulation sub-streams are thus generated for the four data sub-streams, with each modulation sub-streams including a stream of modulation symbols. The four modulation sub-streams are then pre-conditioned using the eigenvector matrix, as expressed below in equation (1), to generate pre-conditioned modulation symbols. The four streams of pre-conditioned modulation symbols are respectively provided to the four combiners of the four transmit antennas. Each combiner combines the received pre-conditioned modulation symbols with the modulation symbols for the other sub-channels to generate a modulation symbol vector stream for the

Claim Element	Exemplary Citations to Wallace '467
	associated transmit antenna. Wallace '467 at 9:64–10:4 In instances where full CSI is not available, less descriptive information on the transmission path (or partial CSI) may be available and can be used to pre-condition the data prior to transmission. For example, the C/I of each of the sub-channels may be available. The C/I information can then be used to control the transmission from various transmit antennas to provide the required performance in the sub-channels of interest and increase system capacity. Wallace '467 at 13:3–21 Given the complexity of a system using multiple transmit antennas and multiple receive antennas, with the associated dispersive channel effects, the preferred modulation technique is OFDM, which effectively decomposes the channel into a set of non-interfering narrowband channels, or sub-channels. With proper OFDM signal design, a signal transmitted on one subchannel sees “flat fading”, i.e., the channel response is effectively constant over the subchannel bandwidth. The channel state information or CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-channel. CSI also includes the information of the relative levels of interference and noise in each sub-channel, that is known as C/I information. The CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. With CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 14:56–15:2 Multiple antennas at a receiver unit 145 receive signals at step 146. At step 147, the received signals undergo a Discrete Fourier Transform (DFT) operation to channelize the received signals. At step 148, the data from each subchannel over all of the receive antennas is processed. At this processing step, information regarding channel characteristics is extracted from the data, and converted into a more compressed format. One compression technique is the use of the conjugate channel response and the eigenmode matrix to reduce the amount of information needed to describe channel characteristics. At step 149, a message containing the compressed channel state information is transmitted from the receiver unit 145 to the transmitter unit 140, which will then be used to precondition further transmissions.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 15:38–58 From each transmit antenna at a transmitter unit, the receiver unit receives pilot symbols on disjoint sub-channels and makes determinations as to channel characteristics of the disjoint sub-channels. As discussed previously, the receiver unit may have one or more receive antennas. Suppose $x = \{x_i, i=1, \dots, K\}$ are the pilot symbol values that are to be transmitted on K pilot sub-channels for a single transmit antenna. The receiver unit will receive the values $y_{ij} = h_{ij}x_i + n_{ij}$, wherein h_{ij} is the complex channel response for the i^{th} pilot sub-channel received at the j^{th} receive antenna, and n_{ij} is noise. From this relationship, the receiver unit can determine noisy estimates of the channel response of K sub-channels of a single transmit antenna. These noisy estimates may be used to derive estimates for all sub-channels of the propagation channel through a number of different methods, such as simple interpolation to more complex estimation using a priori information on the channel dispersion and noise level. The estimates may be improved by transmitting pilot symbols over consecutive OFDM symbols and then averaging the estimates for each consecutive OFDM symbol. Wallace '467 at 15:59–66 mates are generated at each receive antenna for each transmit antenna broadcasting pilot symbols. The CSI for the complete propagation channel can be represented by the set of channel response matrices $\{H_i, i=1, 2, \dots, 2^n\}$, where matrix H_i is associated with the i^{th} sub-channel, and the elements of each matrix H_i are $\{h_{ijk}, j=1, \dots, N_r, k=1, \dots, N_t\}$, the complex channel response values for each of the N_t transmit and N_r receive antennas. Wallace '467 at 18:5–32 The embodiments of the invention discussed herein have been directed to the design and transmission of pilot signals that will allow a person skilled in the art to derive characteristics of the propagation channel and to report such characteristics to the transmission site. However, the full CSI is a large amount of information and also highly redundant. Many methods are available for compressing the amount of CSI information to be transmitted. One method discussed previously is the use of the Hermitian matrix H^*H, wherein H is the channel response as determined at the receiver unit. The Hermitian matrix H^*H can be reported to the transmitter unit and be used to precondition transmissions. Due to the properties of Hermitian matrices, only half of the matrix elements need to be transmitted, such as the complex lower triangular portion of the matrix H^*H, and the real-valued diagonal. Additional efficiencies are realized if the number of receive antennas is larger than the number of transmit antennas. Another method to reduce the amount of information transmitted to the transmitter unit on the reverse link is to report only a subset

Claim Element	Exemplary Citations to Wallace '467
	of the channel response matrices H_i to the transmitter unit, from which the unreported channel response matrices can be determined through interpolation schemes. In another method, a functional representation of the channel response across the sub-channels may be derived for each transmit/receive antenna pair, e.g., a polynomial function representative of the channel response can be generated. The coefficients of the polynomial function are then transmitted to the transmitter unit. Wallace '467 at 18:33–44 As an alternative to these methods for compressing CSI information, one embodiment of the invention is directed to the transmission of a time-domain representation of the channel response, which is the channel impulse response. If a time-domain representation of the channel response is simple, as in cases where there are only two or three multipath components, an inverse FFT can be performed upon the set of channel frequency responses. The inverse FFT operation can be performed for each link between a transmit/receive antenna pair. The resulting channel impulse responses are then translated into a set of amplitudes and delays that are reported to the transmitter. Wallace '467 at 29:16–38 1. A method for measuring and reporting transmission characteristics of a multiple input/multiple output communication system, comprising: - assigning a first subset of sub-channels of a plurality of sub-channels to a first transmit antenna of a plurality of transmit antennas of a first transmitter unit, wherein the sub-channels of the first subset of sub-channels are noncontiguous; - transmitting, by the first transmit antenna, a first pilot symbol over the sub-channels of the first subset of sub-channels; - receiving, by a first receive antenna of a first receiver unit, the first pilot symbol; - determining, from the received first pilot symbol, the transmission characteristics of the sub-channels of the first subset of sub-channels; - reporting, by the first receiver unit to the first transmitter unit, an information signal that carries the determined transmission characteristics for the sub-channels of the first subset of sub-channels; and - optimizing a set of transmission parameters at the first transmitter unit, based on the information signal. Wallace '467 at 31:8–32 19. A method for measuring and reporting channel state information (CSI) in a multiple input/multiple output (MIMO) system, comprising: - assigning a plurality of sub-channel subsets to a plurality of transmit antennas of at least one transmitter

Claim Element	Exemplary Citations to Wallace '467
	unit, wherein the sub-channels of each of the sub-channel subsets are noncontiguous; transmitting a plurality of Orthogonal Frequency Division Multiplexed (OFDM) pilot waveforms from the at least one transmitter unit to at least one receiver unit, wherein each of the plurality of OFDM pilot waveforms is transmitted over a separate one of the plurality of sub-channel subsets; receiving, by the at least one receiver unit, the plurality of OFDM pilot waveforms; demodulating the received plurality of OFDM pilot waveforms; determining the CSI of the sub-channels corresponding to each of the plurality of sub-channel subsets from the demodulated plurality of OFDM pilot waveforms; transmitting the determined CSI to the at least one transmitter unit, and preconditioning a transmission symbol according to the determined CSI. To the extent this element is not disclosed by Wallace '467, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Wallace '467, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.
23. The wireless device of claim 19, wherein the receiver comprises multiple antennas in a multiple-input and multiple-output (MIMO) wireless communication system or a single antenna in a single-input and single-output (SISO) wireless communication system.	Wallace '467 discloses or renders obvious “[t]he wireless device of claim 19, wherein the receiver comprises multiple antennas in a multiple-input and multiple-output (MIMO) wireless communication system or a single antenna in a single-input and single-output (SISO) wireless communication system.” For example: Wallace '467 at Abstract Channel state information (CSI) can be used by a communications system to precondition transmissions between transmitter units and receiver units. In one aspect of the invention, disjoint sub-channel sets are assigned to transmit antennas located at a transmitter unit. Pilot symbols are generated and transmitted on a subset of the disjoint sub-channels. Upon receipt of the transmitted pilot symbols, the receiver units determine the CSI for the disjoint sub-channels that carried pilot symbols. These CSI values are reported to the transmitter unit, which will use these CSI values to generate CSI estimates for the disjoint sub-channels that did not carry pilot symbols. The amount of information necessary to report CSI on the reverse link can be further minimized through compression techniques and resource allocation techniques.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at Wallace-467 at Fig. 1A  FIG. 1A Wallace '467 at Wallace-467 at Fig. 6  FIG. 6 Wallace '467 at 1:57–2:8 Given the ever-growing demand for wireless communication, a higher efficiency, higher performance wireless communications system is desirable. One type of higher performance wireless communications system is a Multiple Input/Multiple Output (MIMO) system that employs multiple transmit antennas to transmit over a propagation channel to multiple receive antennas. As in lower performance systems, the propagation channel in a MIMO system is subject to the deleterious effects of multipath, as well as interference from adjacent antennas. Multipath occurs when a transmitted signal arrives at a receiver unit through multiple propagation paths with differing delays. When signals arrive from multiple propagation paths, components of the signals can combine destructively, which is referred to as “fading.” In order to improve the efficiency and decrease the complexity of the MIMO system, information as to the characteristics of the propagation channel can be transmitted back to the transmitter unit in order to precondition the signal before transmission. Wallace '467 at 2:25–48 The present invention is directed to a method and apparatus for the measuring and reporting of channel

Claim Element	Exemplary Citations to Wallace '467
	state information in a high efficiency, high performance communications system, comprising the steps of: generating a plurality of pilot signals; transmitting the plurality of pilot signals over a propagation channel between a transmitter unit and a plurality of receiver units, wherein the transmitter unit comprises at least one transmit antenna, each of the plurality of receiver units comprises at least one receive antenna, and the propagation channel comprises a plurality of sub-channels between the transmitter unit and the plurality of receiver units; receiving at least one of the plurality of pilot signals at each of the plurality of receiver units; determining a set of transmission characteristics for at least one of the plurality of sub-channels, wherein the step of determining the set of transmission characteristics uses at least one of the plurality of pilot signals received at each of the plurality of receiver units; reporting an information signal from each of the plurality of receiver units to the transmitter unit, wherein the information signal carries the set of transmission characteristics for at least one of the plurality of sub-channels; and optimizing a set of transmission parameters at the transmitter unit, based on the information signal. Wallace '467 at 2:49–62 In one aspect of the invention, pilot symbols are transmitted on a plurality of disjoint OFDM sub-channel sets. When the pilot symbols are transmitted on disjoint OFDM sub-channels, the characteristics of the propagation channel can be determined through a set of K sub-channels carrying the pilot symbols, wherein K is less than the number of OFDM sub-channels in the system. In addition to transmitting pilot symbols on disjoint sub-channels, the system can transmit a time-domain pilot sequence that can be used to determine characteristics of the propagation channel. Along with the generation and transmission of pilot symbols, an aspect of the invention is the compression of the amount of information necessary to reconstruct the characteristics of the propagation channel. Wallace '467 at 3:4–5 FIG. 1A is a diagram of a multiple-input multiple-output (MIMO) communications system; Wallace '467 at 3:34–54 FIG. 1A is a diagram of a Multiple Input/Multiple Output (MIMO) communications system 100 capable of implementing some embodiments of the invention. Communications system 100 can be operative to provide a combination of antenna, frequency, and temporal diversity to increase spectral efficiency, improve performance, and enhance flexibility. Increased spectral efficiency is characterized by the ability to transmit more bits per second per Hertz (bps/Hz) when and where possible to better utilize the available system bandwidth. Techniques to obtain higher spectral efficiency are described in further detail below.

Claim Element	Exemplary Citations to Wallace '467
	Improved performance may be quantified, for example, by a lower bit-error-rate (BER) or frame-error-rate (FER) for a given link carrier-to-noise-plus-interference ratio (C/I). And enhanced flexibility is characterized by the ability to accommodate multiple users having different and typically disparate requirements. These goals may be achieved, in part, by employing multi-carrier modulation, time division multiplexing (TDM), multiple transmit and/or receive antennas, and other techniques. The features, aspects, and advantages of the invention are described in further detail below. Wallace '467 at 3:55–67 As shown in FIG. 1A, communications system 100 includes a first system 110 in communication with a second system 120. System 110 includes a (transmit) data processor 112 that (1) receives or generates data, (2) processes the data to provide antenna, frequency, or temporal diversity, or a combination thereof, and (3) provides processed modulation symbols to a number of modulators (MOD) 114a through 114t. Each modulator 114 further processes the modulation symbols and generates an RF modulated signal suitable for transmission. The RF modulated signals from modulators 114a through 114t are then transmitted from respective antennas 116a through 116t over communications links 118 to system 120. Wallace '467 at 4:1–17 In FIG. 1A, system 120 includes a number of receive antennas 122a through 122r that receive the transmitted signals and provide the received signals to respective demodulators (DEMODO) 124a through 124r. As shown in FIG. 1A, each receive antenna 122 may receive signals from one or more transmit antennas 116 depending on a number of factors such as, for example, the operating mode used at system 110, the directivity of the transmit and receive antennas, the characteristics of the communications links, and others. Each demodulator 124 demodulates the respective received signal using a demodulation scheme that is complementary to the modulation scheme used at the transmitter. The demodulated symbols from demodulators 124a through 124r are then provided to a (receive) data processor 126 that further processes the symbols to provide the output data. The data processing at the transmitter and receiver units is described in further detail below. Wallace '467 at 4:18–27 FIG. 1A shows only the forward link transmission from system 110 to system 120. This configuration may be used for data broadcast and other one-way data transmission applications. In a bidirectional communications system, a reverse link from system 120 to system 110 is also provided, although not shown in FIG. 1A for simplicity. For the bidirectional communications system, each of systems 110 and

Claim Element	Exemplary Citations to Wallace '467
	120 may operate as a transmitter unit or a receiver unit, or both concurrently, depending on whether data is being transmitted from, or received at, the unit. Wallace '467 at 4:28–34 For simplicity, communications system 100 is shown to include one transmitter unit (i.e., system 110) and one receiver unit (i.e., system 120). However, in general, multiple transmit antennas and multiple receive antennas are present on each transmitter unit and each receiver unit. The communications system of the invention may include any number of transmitter units and receiver units. Wallace '467 at 4:36–47 Each transmitter unit may include a single transmit antenna or a number of transmit antennas, such as that shown in FIG. 1A. Similarly, each receiver unit may include a single receive antenna or a number of receive antennas, again such as that shown in FIG. 1A. For example, the communications system may include a central system (i.e., similar to a base station in the IS-95 CDMA system) having a number of antennas that transmit data to, and receive data from, a number of remote systems (i.e., subscriber units, similar to remote stations in the CDMA system), some of which may include one antenna and others of which may include multiple antennas. Wallace '467 at 4:48–63 As used herein, an antenna refers to a collection of one or more antenna elements that are distributed in space. The antenna elements may be physically located at a single site or distributed over multiple sites. Antenna elements physically co-located at a single site may be operated as an antenna array (e.g., such as for a CDMA base station). An antenna network consists of a collection of antenna arrays or elements that are physically separated (e.g., several CDMA base stations). An antenna array or an antenna network may be designed with the ability to form beams and to transmit multiple beams from the antenna array or network. For example, a CDMA base station may be designed with the capability to transmit up to three beams to three different sections of a coverage area (or sectors) from the same antenna array. Thus, the three beams may be viewed as three transmissions from three antennas. Wallace '467 at 4:64–5:4 The communications system of the invention can be designed to provide a multi-user, multiple access communications scheme capable of supporting subscriber units having different requirements as well as

Claim Element	Exemplary Citations to Wallace '467
	capabilities. The scheme allows the system's total operating bandwidth, W, (e.g., 1.2288 MHz) to be efficiently shared among different types of services that may have highly disparate data rate, delay, and quality of service (QOS) requirements. Wallace '467 at 5:47–53 The communications system of the invention provides the above-described features and advantages, and is capable of supporting different types of services having disparate requirements. The features are achieved by employing antenna, frequency, or temporal diversity, or a combination thereof. Antenna, frequency, or temporal diversity can be independently achieved and dynamically selected. Wallace '467 at 5:54–67 As used herein, antenna diversity refers to the transmission and/or reception of data over more than one antenna, frequency diversity refers to the transmission of data over more than one sub-band, and temporal diversity refers to the transmission of data over more than one time period. Antenna, frequency, and temporal diversity may include subcategories. For example, transmit diversity refers to the use of more than one transmit antenna in a manner to improve the reliability of the communications link, receive diversity refers to the use of more than one receive antenna in a manner to improve the reliability of the communications link, and spatial diversity refers to the use of multiple transmit and receive antennas to improve the reliability and/or increase the capacity of the communications link. Wallace '467 at 6:6–14 Frequency diversity can be provided by use of a multi-carrier modulation scheme such as orthogonal frequency division multiplexing (OFDM), which allows for transmission of data over various sub-bands of the operating bandwidth. Temporal diversity is achieved by transmitting the data over different times, which can be more easily accomplished with the use of time-division multiplexing (TDM). These various aspects of the communications system of the invention are described in further detail below. Wallace '467 at 6:15–32 In accordance with an aspect of the invention, antenna diversity is achieved by employing a number of (N_T) transmit antennas at the transmitter unit or a number of (N_R) receive antennas at the receiver unit, or multiple antennas at both the transmitter and receiver units. In a terrestrial communications system (e.g., a cellular system, a broadcast system, an MMDS system, and others), an RF modulated signal from a

Claim Element	Exemplary Citations to Wallace '467
	transmitter unit may reach the receiver unit via a number of transmission paths. The characteristics of the transmission paths typically vary over time based on a number of factors. If more than one transmit or receive antenna is used, and if the transmission paths between the transmit and receive antennas are independent (i.e., uncorrelated), which is generally true to at least an extent, then the likelihood of correctly receiving the transmitted signal increases as the number of antennas increases. Generally, as the number of transmit and receive antennas increases, diversity increases and performance improves. Wallace '467 at 6:33–52 Antenna diversity is dynamically provided based on the characteristics of the communications link to provide the required performance. For example, a higher degree of antenna diversity can be provided for some types of communication (e.g., signaling), for some types of services (e.g., voice), for some communications link characteristics (e.g., low C/I), or for some other conditions or considerations. As used herein, antenna diversity includes transmit diversity and receive diversity. For transmit diversity, data is transmitted over multiple transmit antennas. Typically, additional processing is performed on the data transmitted from the transmit antennas to achieve the desired diversity. For example, the data transmitted from different transmit antennas may be delayed or reordered in time, or coded and interleaved across the available transmit antennas. Also, frequency and temporal diversity may be used in conjunction with the different transmit antennas. For receive diversity, modulated signals are received on multiple receive antennas, and diversity is achieved by simply receiving the signals via different transmission paths. Wallace '467 at 6:53–7:14 In accordance with another aspect of the invention, frequency diversity can be achieved by employing a multi-carrier modulation scheme. One such scheme that has numerous advantages is OFDM. With OFDM modulation, the overall transmission channel is essentially divided into a number of (L) parallel sub-channels that are used to transmit the same or different data. The overall transmission channel occupies the total operating bandwidth of W, and each of the sub-channels occupies a sub-band having a bandwidth of W/L and centered at a different center frequency. Each sub-channel has a bandwidth that is a portion of the total operating bandwidth. Each of the sub-channels may also be considered an independent data transmission channel that may be associated with a particular (and possibly unique) processing, coding, and modulation scheme, as described below. The data may be partitioned and transmitted over any defined set of two or more sub-bands to provide frequency diversity. For example, the transmission to a particular subscriber unit may occur over sub-channel 1 at time slot 1, sub-channel 5 at time slot 2, sub-channel 2 at time slot 3, and so on. As another

Claim Element	Exemplary Citations to Wallace '467
	example, data for a particular subscriber unit may be transmitted over sub-channels 1 and 2 at time slot 1 (e.g., with the same data being transmitted on both sub-channels), sub-channels 4 and 6 at time slot 2, only sub-channel 2 at time slot 3, and so on. Transmission of data over different sub-channels over time can improve the performance of a communications system experiencing frequency selective fading and channel distortion. Other benefits of OFDM modulation are described below. Wallace '467 at 7:15–31 In accordance with yet another aspect of the invention, temporal diversity is achieved by transmitting data at different times, which can be more easily accomplished using time division multiplexing (TDM). For data services (and possibly for voice services), data transmission occurs over time slots that may be selected to provide immunity to time dependent degradation in the communications link. Temporal diversity may also be achieved through the use of interleaving. For example, the transmission to a particular subscriber unit may occur over time slots 1 through x, or on a subset of the possible time slots from 1 through x (e.g., time slots 1, 5, 8, and so on). The amount of data transmitted at each time slot may be variable or fixed. Transmission over multiple time slots improves the likelihood of correct data reception due to, for example, impulse noise and interference. Wallace '467 at 7:33–8:3 The combination of antenna, frequency, and temporal diversity allows the communications system of the invention to provide robust performance. Antenna, frequency, and/or temporal diversity improves the likelihood of correct reception of at least some of the transmitted data, which may then be used (e.g., through decoding) to correct for some errors that may have occurred in the other transmissions. The combination of antenna, frequency, and temporal diversity also allows the communications system to concurrently accommodate different types of services having disparate data rate, processing delay, and quality of service requirements. The communications system of the invention can be designed and operated in a number of different communications modes, with each communications mode employing antenna, frequency, or temporal diversity, or a combination thereof. The communications modes include, for example, a diversity communications mode and a MIMO communications mode. Various combinations of the diversity and MIMO communications modes can also be supported by the communications system. Also, other communications modes can be implemented and are within the scope of the present invention. The diversity communications mode employs transmit and/or receive diversity, frequency, or temporal diversity, or a combination thereof, and is generally used to improve the reliability of the communications link. In one implementation of the diversity communications mode, the transmitter unit selects a modulation and coding scheme (i.e., configuration) from a finite set of possible configurations, which are

Claim Element	Exemplary Citations to Wallace '467
	known to the receiver units. For example, each overhead and common channel may be associated with a particular configuration that is known to all receiver units. When using the diversity communications mode for a specific user (e.g., for a voice call or a data transmission), the mode and/or configuration may be known a priori (e.g., from a previous set up) or negotiated (e.g., via a common channel) by the receiver unit. Wallace '467 at 8:16–52 The MIMO communications mode employs antenna diversity at both ends of the communication link and is generally used to improve both the reliability and increase the capacity of the communications link. The MIMO communications mode may further employ frequency and/or temporal diversity in combination with the antenna diversity. The MIMO communications mode, which may also be referred to herein as the spatial communications mode, employs one or more processing modes to be described below. The diversity communications mode generally has lower spectral efficiency than the MIMO communications mode, especially at high C/I levels. However, at low to moderate C/I values, the diversity communications mode achieves comparable efficiency and can be simpler to implement. In general, the use of the MIMO communications mode provides greater spectral efficiency when used, particularly at moderate to high C/I values. The MIMO communications mode may thus be advantageously used when the data rate requirements are moderate to high. The communications system can be designed to concurrently support both diversity and MIMO communications modes. The communications modes can be applied in various manners and, for increased flexibility, may be applied independently on a sub-channel basis. The MIMO communications mode is typically applied to specific users. However, each communications mode may be applied on each sub-channel independently, across a subset of sub-channels, across all sub-channels, or on some other basis. For example, the use of the MIMO communications mode may be applied to a specific user (e.g., a data user) and, concurrently, the use of the diversity communications mode may be applied to another specific user (e.g., a voice user) on a different sub-channel. The diversity communications mode may also be applied, for example, on sub-channels experiencing higher path loss. Wallace '467 at 8:53–9:3 The communications system of the invention can also be designed to support a number of processing modes. When the transmitter unit is provided with information indicative of the conditions (i.e., the “state”) of the communications links, additional processing can be performed at the transmitter unit to further improve performance and increase efficiency. Full channel state information (CSI) or partial CSI may be available to the transmitter unit. Full CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-band. Full

Claim Element	Exemplary Citations to Wallace '467
	CSI also includes the C/I per sub-band. The full CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. Partial CSI may include, for example, the C/I of the sub-band . With full CSI or partial CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 9:4–15 The transmitter unit can precondition the signals presented to the transmit antennas in a way that is unique to a specific receiver unit (e.g., the pre-conditioning is performed for each sub-band assigned to that receiver unit). As long as the channel does not change appreciably from the time it is measured by the receiver unit and subsequently sent back to the transmitter and used to precondition the transmission, the intended receiver unit can demodulate the transmission. In this implementation, a full-CSI based MIMO communication can only be demodulated by the receiver unit associated with the CSI used to precondition the transmitted signals. Wallace '467 at 9:29–48 As an example, assume that the MIMO communications mode is applied to a channel data stream that is transmitted on one particular sub-channel from four transmit antennas. The channel data stream is demultiplexed into four data sub-streams, one data sub-stream for each transmit antenna. Each data sub-stream is then modulated using a particular modulation scheme (e.g., M-PSK, M-QAM, or other) selected based on the CSI for that sub-band and for that transmit antenna. Four modulation sub-streams are thus generated for the four data sub-streams, with each modulation sub-streams including a stream of modulation symbols. The four modulation sub-streams are then pre-conditioned using the eigenvector matrix, as expressed below in equation (1), to generate pre-conditioned modulation symbols. The four streams of pre-conditioned modulation symbols are respectively provided to the four combiners of the four transmit antennas. Each combiner combines the received pre-conditioned modulation symbols with the modulation symbols for the other sub-channels to generate a modulation symbol vector stream for the associated transmit antenna. Wallace '467 at 9:64–10:4 In instances where full CSI is not available, less descriptive information on the transmission path (or partial CSI) may be available and can be used to pre-condition the data prior to transmission. For example, the C/I of each of the sub-channels may be available. The C/I information can then be used to

Claim Element	Exemplary Citations to Wallace '467
	control the transmission from various transmit antennas to provide the required performance in the sub-channels of interest and increase system capacity. Wallace '467 at 13:3–21 Given the complexity of a system using multiple transmit antennas and multiple receive antennas, with the associated dispersive channel effects, the preferred modulation technique is OFDM, which effectively decomposes the channel into a set of non-interfering narrowband channels, or sub-channels. With proper OFDM signal design, a signal transmitted on one subchannel sees “flat fading”, i.e., the channel response is effectively constant over the subchannel bandwidth. The channel state information or CSI includes sufficient characterization of the propagation path (i.e., amplitude and phase) between all pairs of transmit and receive antennas for each sub-channel. CSI also includes the information of the relative levels of interference and noise in each sub-channel, that is known as C/I information. The CSI may be embodied in a set of matrices of complex gain values that are descriptive of the conditions of the transmission paths from the transmit antennas to the receive antennas, as described below. With CSI, the transmitter unit pre-conditions the data prior to transmission to receiver unit. Wallace '467 at 14:56–15:2 Multiple antennas at a receiver unit 145 receive signals at step 146. At step 147, the received signals undergo a Discrete Fourier Transform (DFT) operation to channelize the received signals. At step 148, the data from each subchannel over all of the receive antennas is processed. At this processing step, information regarding channel characteristics is extracted from the data, and converted into a more compressed format. One compression technique is the use of the conjugate channel response and the eigenmode matrix to reduce the amount of information needed to describe channel characteristics. At step 149, a message containing the compressed channel state information is transmitted from the receiver unit 145 to the transmitter unit 140, which will then be used to precondition further transmissions. Wallace '467 at 15:3–7 To facilitate the derivation of the CSI, the transmit waveform is made up of known pilot symbols for an initial preamble. The pilot waveforms for different transmit antennas comprise disjoint sets of OFDM subchannels as illustrated for the case when $N_t=4$ in FIG. 1C.

Claim Element	Exemplary Citations to Wallace '467
	Wallace '467 at 15:38–58 From each transmit antenna at a transmitter unit, the receiver unit receives pilot symbols on disjoint sub-channels and makes determinations as to channel characteristics of the disjoint sub-channels. As discussed previously, the receiver unit may have one or more receive antennas. Suppose $x = \{x_i, i=1, \dots, K\}$ are the pilot symbol values that are to be transmitted on K pilot sub-channels for a single transmit antenna. The receiver unit will receive the values $y_{ij} = h_{ij}x_i + n_{ij}$, wherein h_{ij} is the complex channel response for the i^{th} pilot sub-channel received at the j^{th} receive antenna, and n_{ij} is noise. From this relationship, the receiver unit can determine noisy estimates of the channel response of K sub-channels of a single transmit antenna. These noisy estimates may be used to derive estimates for all sub-channels of the propagation channel through a number of different methods, such as simple interpolation to more complex estimation using a priori information on the channel dispersion and noise level. The estimates may be improved by transmitting pilot symbols over consecutive OFDM symbols and then averaging the estimates for each consecutive OFDM symbol. Wallace '467 at 18:33–44 As an alternative to these methods for compressing CSI information, one embodiment of the invention is directed to the transmission of a time-domain representation of the channel response, which is the channel impulse response. If a time-domain representation of the channel response is simple, as in cases where there are only two or three multipath components, an inverse FFT can be performed upon the set of channel frequency responses. The inverse FFT operation can be performed for each link between a transmit/receive antenna pair. The resulting channel impulse responses are then translated into a set of amplitudes and delays that are reported to the transmitter. Wallace '467 at 29:16–38 1. A method for measuring and reporting transmission characteristics of a multiple input/multiple output communication system, comprising: assigning a first subset of sub-channels of a plurality of sub-channels to a first transmit antenna of a plurality of transmit antennas of a first transmitter unit, wherein the sub-channels of the first subset of sub-channels are noncontiguous; transmitting, by the first transmit antenna, a first pilot symbol over the sub-channels of the first subset of sub-channels; receiving, by a first receive antenna of a first receiver unit, the first pilot symbol; determining, from the received first pilot symbol, the transmission characteristics of the sub-channels of

Claim Element	Exemplary Citations to Wallace '467
	the first subset of sub-channels; reporting, by the first receiver unit to the first transmitter unit, an information signal that carries the determined transmission characteristics for the sub-channels of the first subset of sub-channels; and optimizing a set of transmission parameters at the first transmitter unit, based on the information signal. Wallace '467 at 31:8–32 19. A method for measuring and reporting channel state information (CSI) in a multiple input/multiple output (MIMO) system, comprising: assigning a plurality of sub-channel subsets to a plurality of transmit antennas of at least one transmitter unit, wherein the sub-channels of each of the sub-channel subsets are noncontiguous; transmitting a plurality of Orthogonal Frequency Division Multiplexed (OFDM) pilot waveforms from the at least one transmitter unit to at least one receiver unit, wherein each of the plurality of OFDM pilot waveforms is transmitted over a separate one of the plurality of sub-channel subsets; receiving, by the at least one receiver unit, the plurality of OFDM pilot waveforms; demodulating the received plurality of OFDM pilot waveforms; determining the CSI of the sub-channels corresponding to each of the plurality of sub-channel subsets from the demodulated plurality of OFDM pilot waveforms; transmitting the determined CSI to the at least one transmitter unit, and preconditioning a transmission symbol according to the determined CSI. To the extent this element is not disclosed by Wallace '467, it would have been obvious to one of ordinary skill in the art to combine, with the teachings of Wallace '467, those elements, as known to them or as disclosed by other prior art identified in the cover pleading.