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(54) SCALABLE AND BACKWARDS COMPATIBLE PREAMBLE FOR OFDM SYSTEMS

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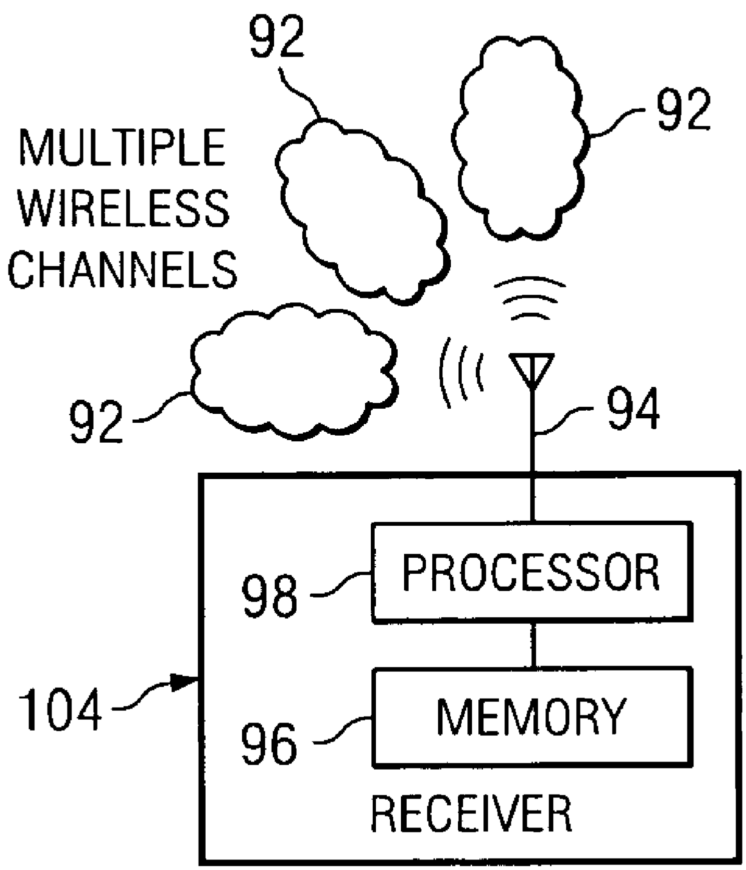
(57) ABSTRACT

A method comprising encoding a plurality of signals according to a predetermined negation scheme and transmitting the plurality of signals, wherein each signal is transmitted by way of a wireless channel. The method further comprises receiving a signal, wherein the received signal is a combination of the plurality of transmitted signals, and interpolating between data in the received signal to generate a plurality of systems of equations. The method further comprises solving the plurality of systems of equations to determine a gain and phase shift applied to each of the plurality of transmitted signals by a corresponding wireless channel.



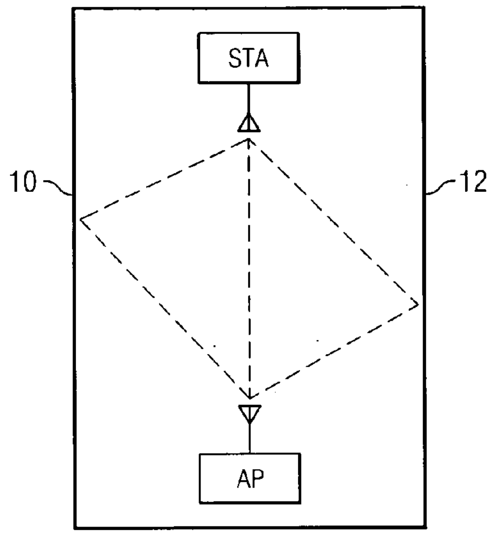


FIG. 1a

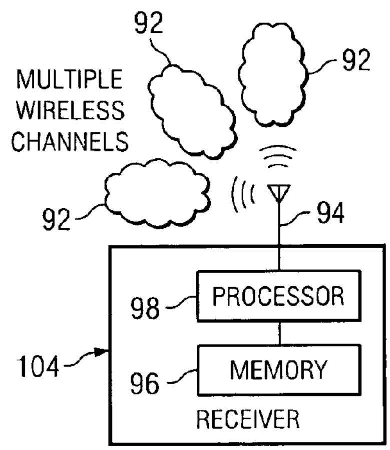


FIG. 1b

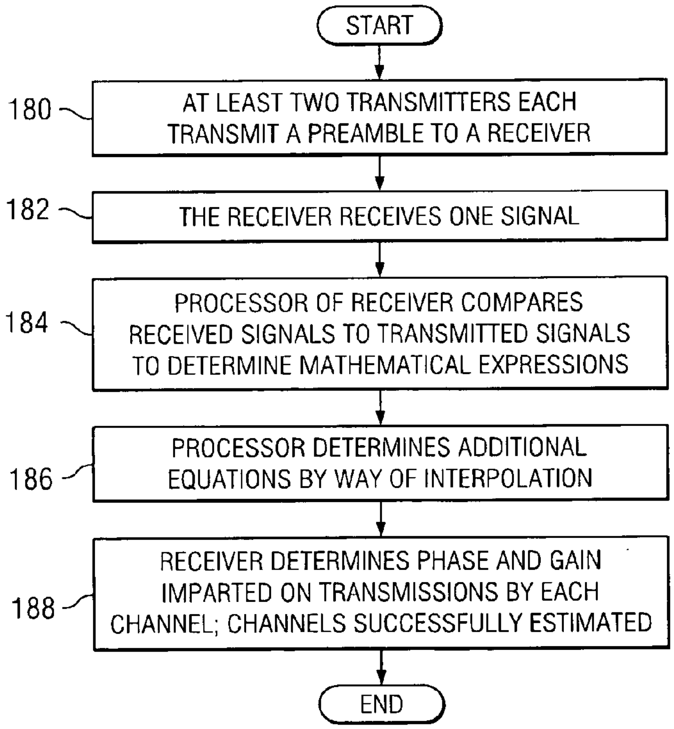


FIG. 1c

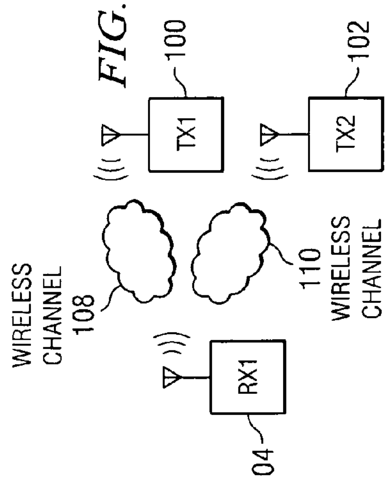


FIG. 1d

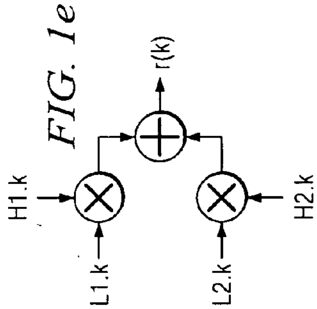


FIG. 1e

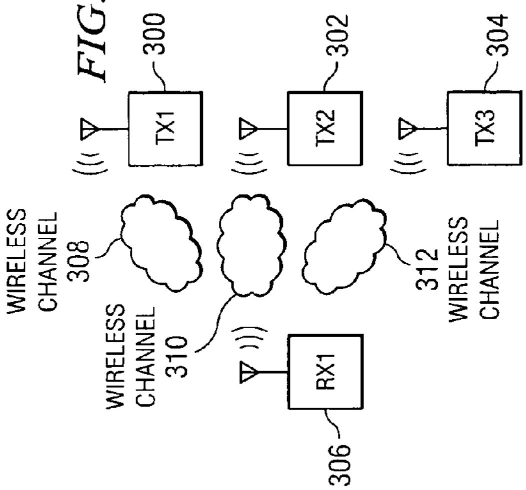


FIG. 3

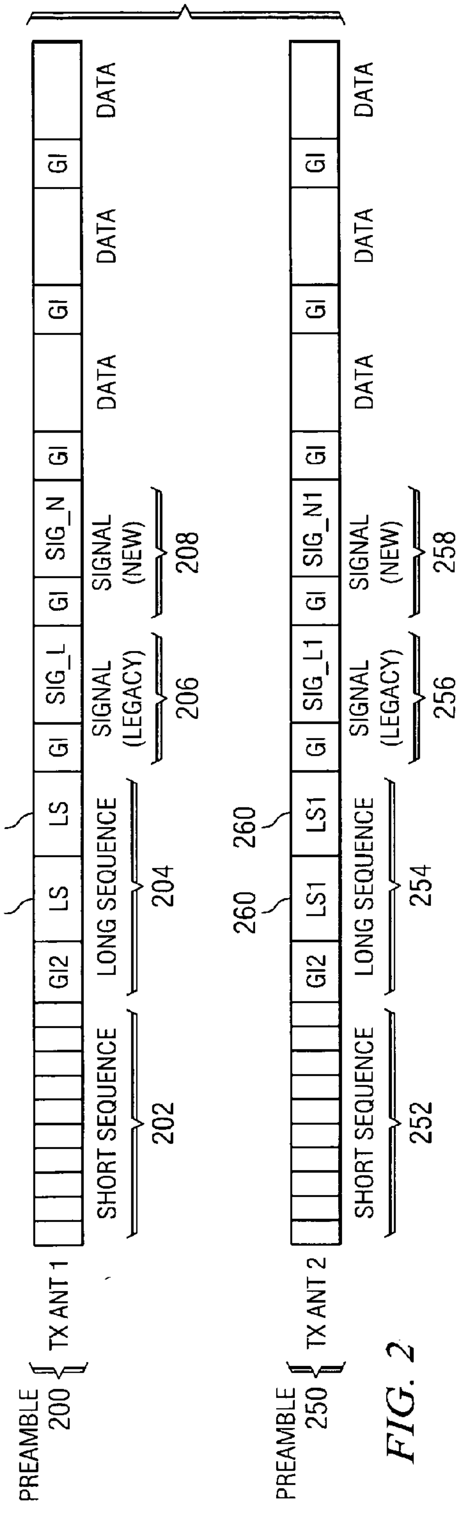
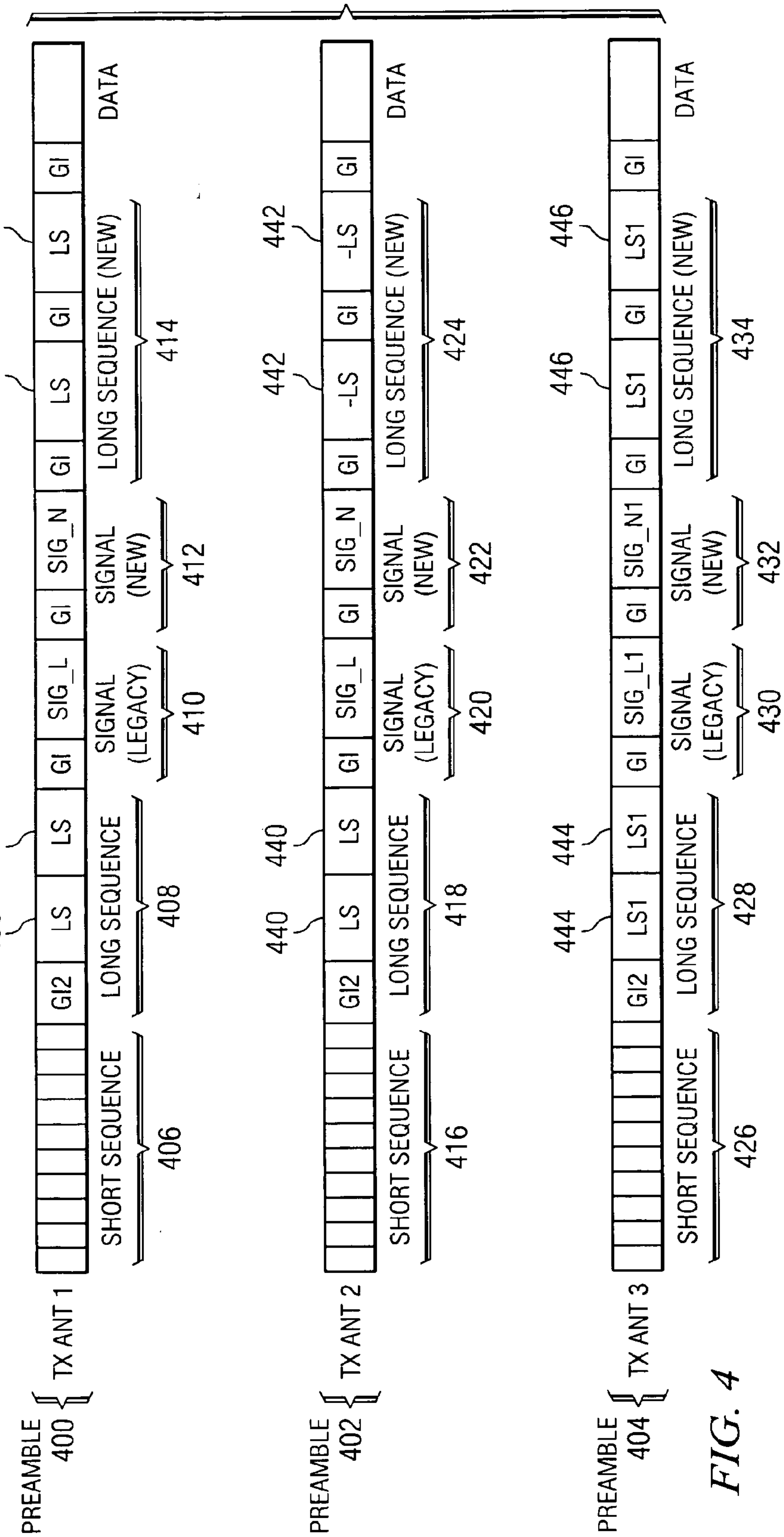


FIG. 2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SIG_N
SIG_N1
SIGNAL (NEW)
412
422
432
-LS
LONG SEQUENCE (NEW)
414
424
434
438
442
446
DATA

FIG. 4

SCALABLE AND BACKWARDS COMPATIBLE PREAMBLE FOR OFDM SYSTEMS

PRIORITY CLAIM

[0001] This application claims priority to U.S. Patent Application Ser. No. 60/500,438, filed on Sep. 5, 2003, entitled "SCALABLE AND BACKWARDS COMPATIBLE PREAMBLE FOR 11n," incorporated herein by reference.

BACKGROUND

[0002] Wireless local area networks ("WLAN") allow electronic devices, such as computers, to have network connectivity without the use of wires. Network connections may be established via, for example, radio signals. A wireless access point ("AP") may comprise a wired Internet or Ethernet connection and radio communication circuitry capable of transmitting data to and receiving data from any compatible wireless device. The AP may provide Internet and/or network connectivity to such wireless devices (e.g., portable computers) called receiver stations ("STA") by transmitting and receiving data via radio signals.

[0003] Architects of WLAN systems and devices must take various factors into account. One such factor is multipath interference. In multipath interference, a signal transmitted from a source (e.g., an AP) may take multiple paths through a wireless medium and thus reach the intended destination as more than one version of the same signal. **FIG. 1***a* illustrates this phenomenon, in which a signal from an AP is transmitted directly to a STA and also bounces off the walls **10**, **12** before reaching the STA. The lengths of the different paths may vary, thereby causing a phase/time difference in the received signals. Accordingly, multipath interference may cause distortion in the signal. Thus, the signal received by the STA may be a distorted version of the signal that was originally transmitted by the AP. The technique of "channel estimation" may be implemented in a STA or AP receiver to eliminate such distortion and generate a version of the signal which is nearly identical to the signal that was originally transmitted by the AP.

[0004] Channel estimation comprises transmitting a predetermined signal (described below) from a transmitter to a receiver, where the transmitted predetermined signal is known to both the transmitter and the receiver prior to transmission. Due to multipath interference, the predetermined signal received by the receiver will generally be different from the predetermined signal transmitted by the transmitter. Upon receiving the signal, the receiver may compare the received signal to the transmitted signal to determine how multipath interference has distorted the signal. The receiver may use such information to synchronize the receiver to the transmitter(s) and eliminate distortion present in future received signals.

[0005] A signal used specifically for channel estimation comprises a preamble. A preamble comprises, among other things, a short sequence of data and a long sequence of data. The short sequence may be used to perform basic synchronization, including determining whether a packet is en route to the receiver, estimating frequency offset, and other various synchronization operations. The long sequence is the sequence actually used in channel estimation. Standard single input, single output ("SISO") systems. Thus, in a system comprising a single transmitter and a single receiver, the receiver is able to successfully estimate the channel between the transmitter and the receiver, thereby eliminating distortions present in a received signal. However, multiple-input, multiple-output ("MIMO") signaling systems comprising a plurality of transmitters and receivers present unique problems for existing channel estimation techniques.

[0006] In a MIMO system, the rate at which data is transferred ("data rate") between a transmitter and a receiver may be raised by increasing the number of antennas associated with each wireless device in the system. For instance, a system comprising a transmitter with multiple antennas and a receiver with multiple antennas may have a higher data rate than a system comprising a transmitter with a single antenna and a receiver with a single antenna. The MIMO antennas are part of a design that attempts to achieve a linear increase in data rate as the number of transmitting and receiving antennas linearly increases.

[0007] MIMO systems present unique problems for existing channel estimation techniques due to difficulties introduced by signal overlapping, wherein a receiver receives a mixture of signals instead of a single signal. For example, in a system comprising two transmitters and two receivers, each receiver receives a signal that is a combination of the signals transmitted by each of the transmitters. In order to estimate the four channels (i.e., one channel from a first transmitter to a first receiver, a second channel from a first transmitter to a second receiver, a third channel from a second transmitter to a first receiver, a fourth channel from a second transmitter to a second receiver), a receiver must mathematically analyze the received signal to determine a plurality of equations describing distortion imparted by each channel on a signal transmitted through the channel. Each receiver then may successfully estimate all four channels. Channel estimation information subsequently may be used by a receiver to eliminate distortion present in future signals. Thus, a technique to separate mixed signals and eliminate signal distortion in MIMO systems is desirable.

BRIEF SUMMARY

[0008] The problems noted above are solved in large part by a method and apparatus for efficiently estimating channels in a MIMO system and using the channel estimations to eliminate signal distortion. One exemplary embodiment may comprise encoding a plurality of signals according to a predetermined negation scheme and transmitting the plurality of signals, wherein each signal is transmitted by way of a wireless channel. The method further comprises receiving a signal, wherein the received signal is a combination of the plurality of transmitted signals, and interpolating between data in the received signal to generate a plurality of systems of equations. The method also comprises solving the plurality of systems of equations to determine a gain and phase shift applied to each of the plurality of transmitted signals by a corresponding wireless channel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] For a detailed description of the preferred embodiments of the invention, reference will now be made to the accompanying drawings in which:

[0010] **FIG. 1***a* illustrates a block diagram describing the

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