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(54) **LOW COMPLEXITY BLIND DETECTION OF TRANSMISSION PARAMETERS OF INTERFERERS**

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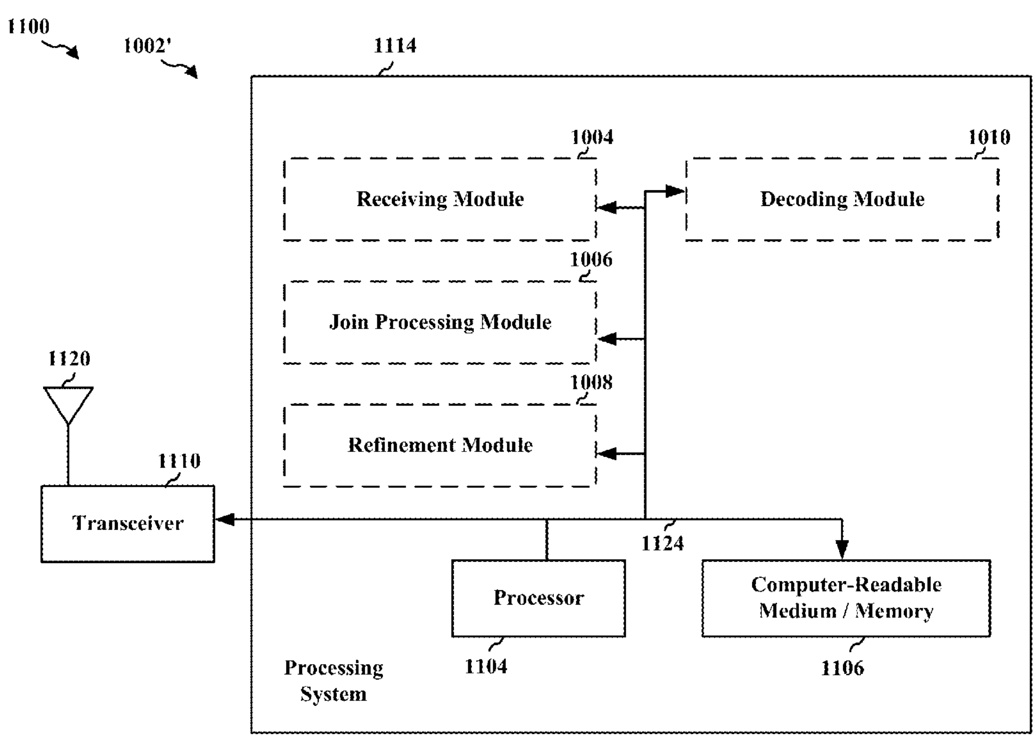
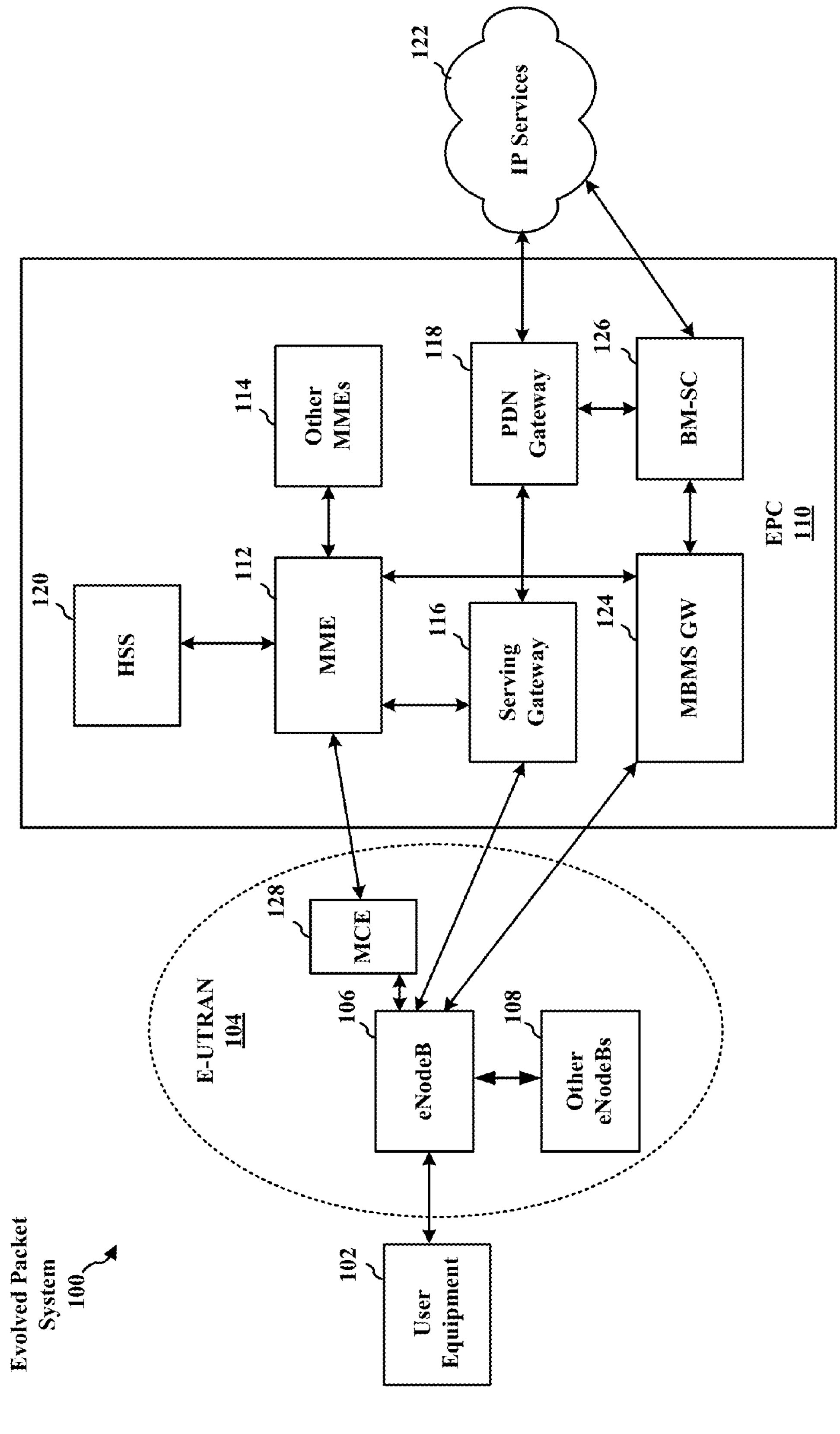
USPC **370/329**

(57) **ABSTRACT**

A method, an apparatus, and a computer program product for wireless communication are provided. The apparatus reduces inference in a received signal. The apparatus receives a signal including transmissions from a plurality of cells. The apparatus determines transmission parameter hypotheses associated with the plurality of cells. Each transmission parameter hypothesis from the transmission parameter hypotheses includes a set of transmission parameters associated with all the cells from the plurality cells. The apparatus selects at least one transmission parameter hypothesis based on a first metric applied to each hypothesis. The apparatus refines transmission parameters associated with at least one cell from the plurality of cells. The refining includes improving an accuracy of the transmission parameters associated with the at least one cell based on a second metric associated with each cell individually.





Evolved Packet System 100
User Equipment
102
E-UTRAN
104
eNodeB
106
Other eNodeBs
108
MCE
128
EPC
110
HSS
120
MME
112
Other MMEs
114
Serving Gateway
116
PDN Gateway
118
MBMS GW
124
BM-SC
126
IP Services
122

FIG. 1

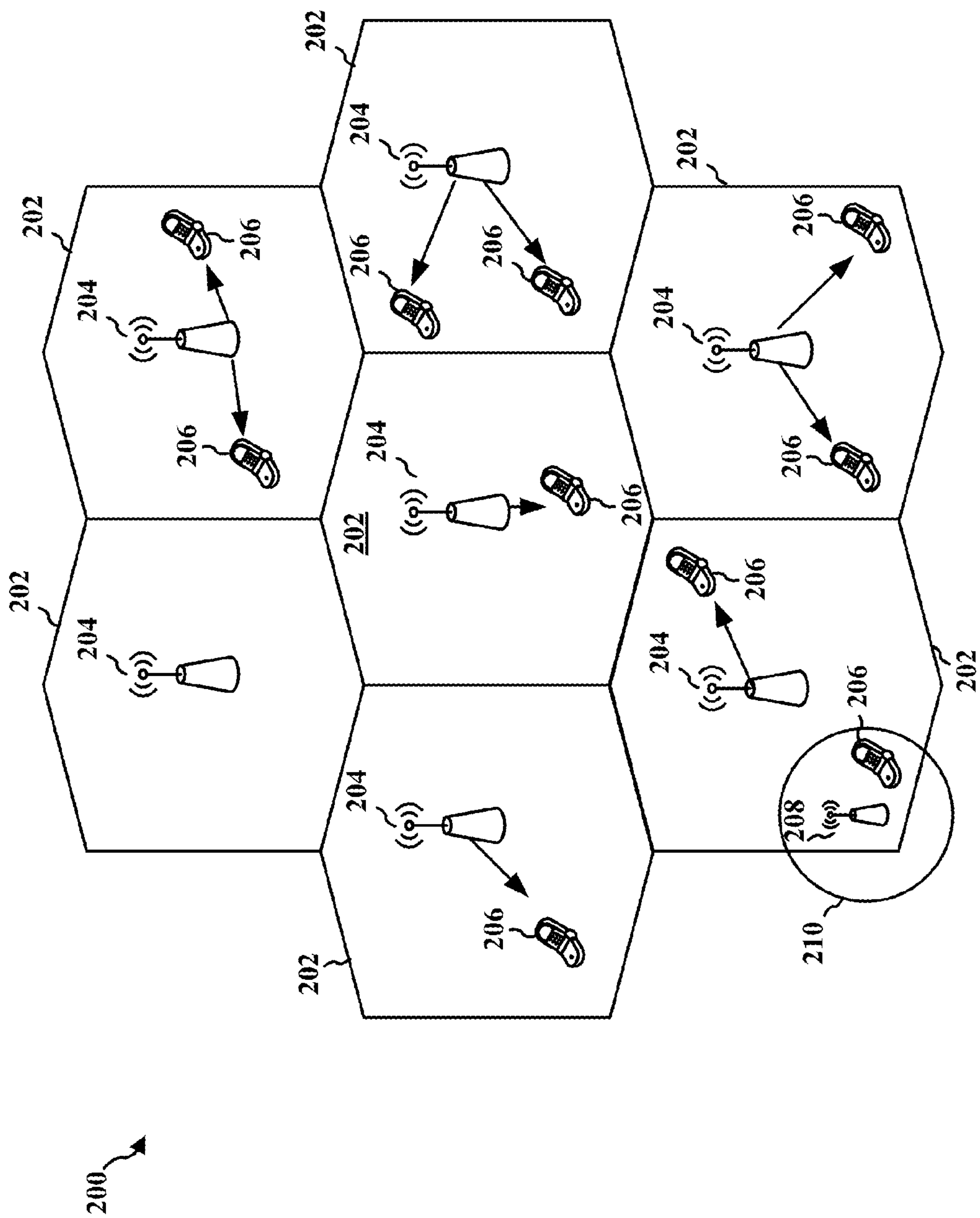


FIG. 2

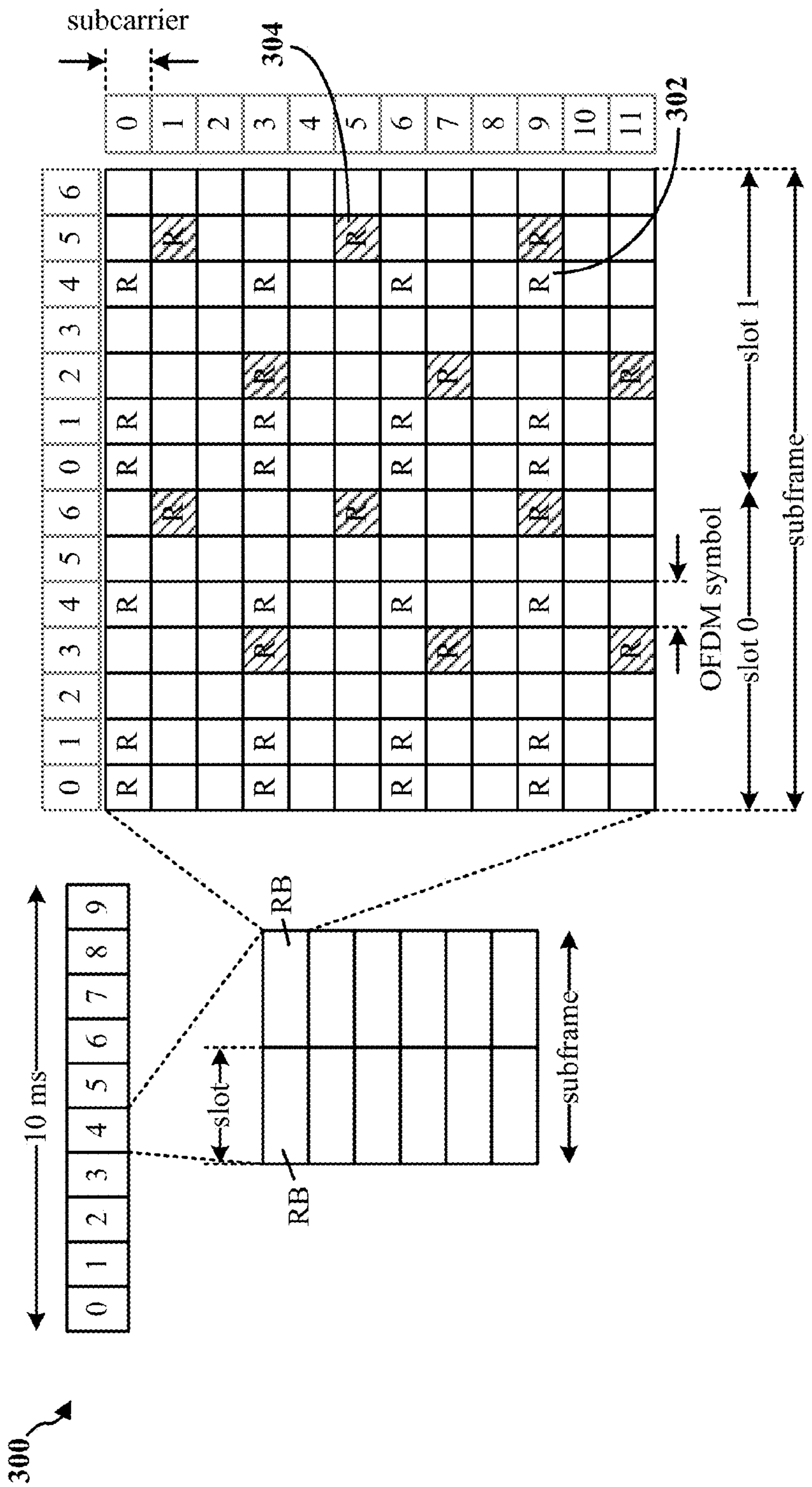

subcarrier
304
302
OFDM symbol
slot 0
slot 1
subframe
10 ms
slot
RB
RB
subframe
300

FIG. 3

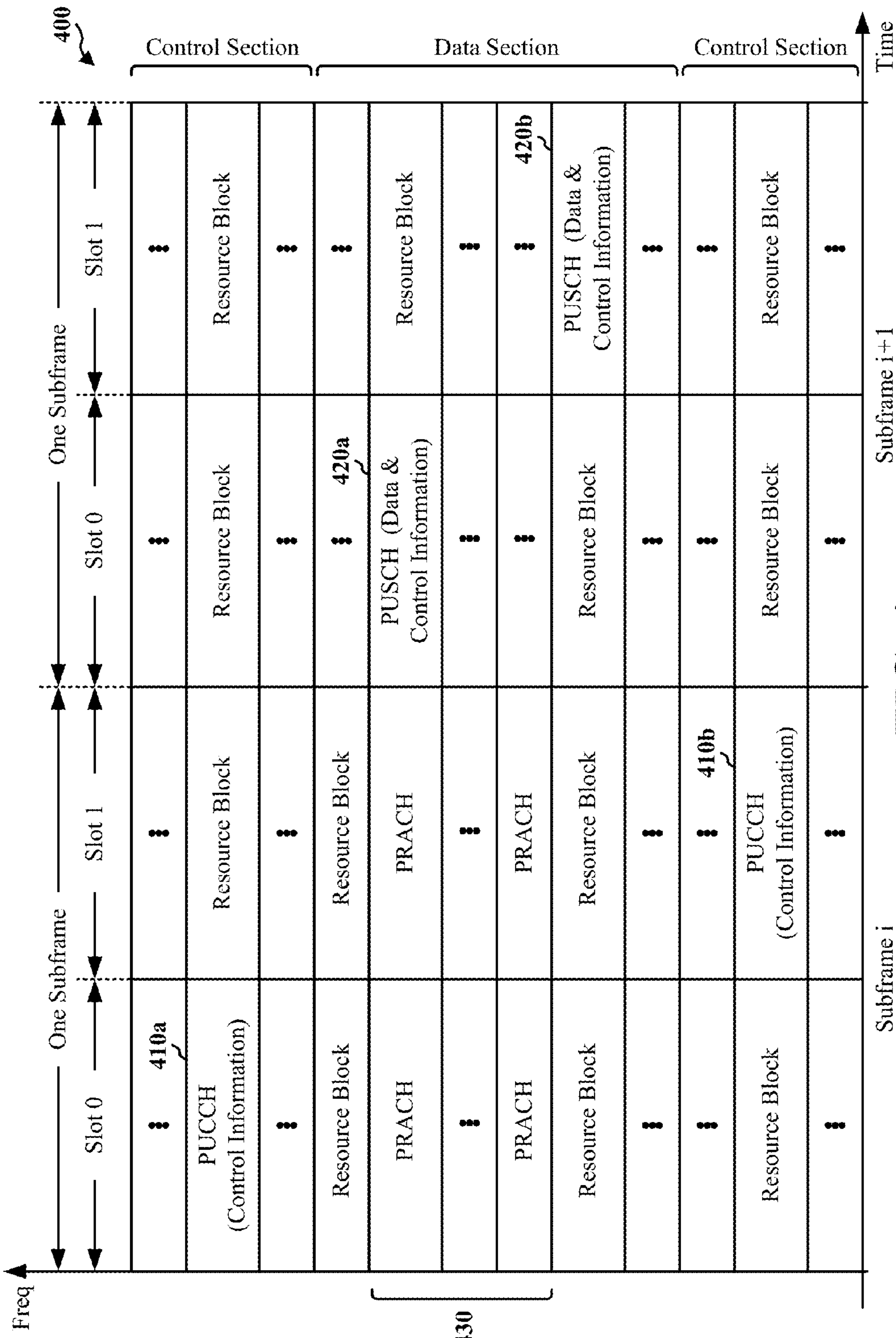

400
Control Section
Data Section
Control Section
Time
Freq
One Subframe
One Subframe
Slot 0
Slot 1
Slot 0
Slot 1
PUCCH (Control Information)
410a
410b
PUCCH (Control Information)
Resource Block
PRACH
PRACH
420a
PUSCH (Data & Control Information)
420b
PUSCH (Data & Control Information)
430
Subframe i
Subframe i+1

FIG. 4

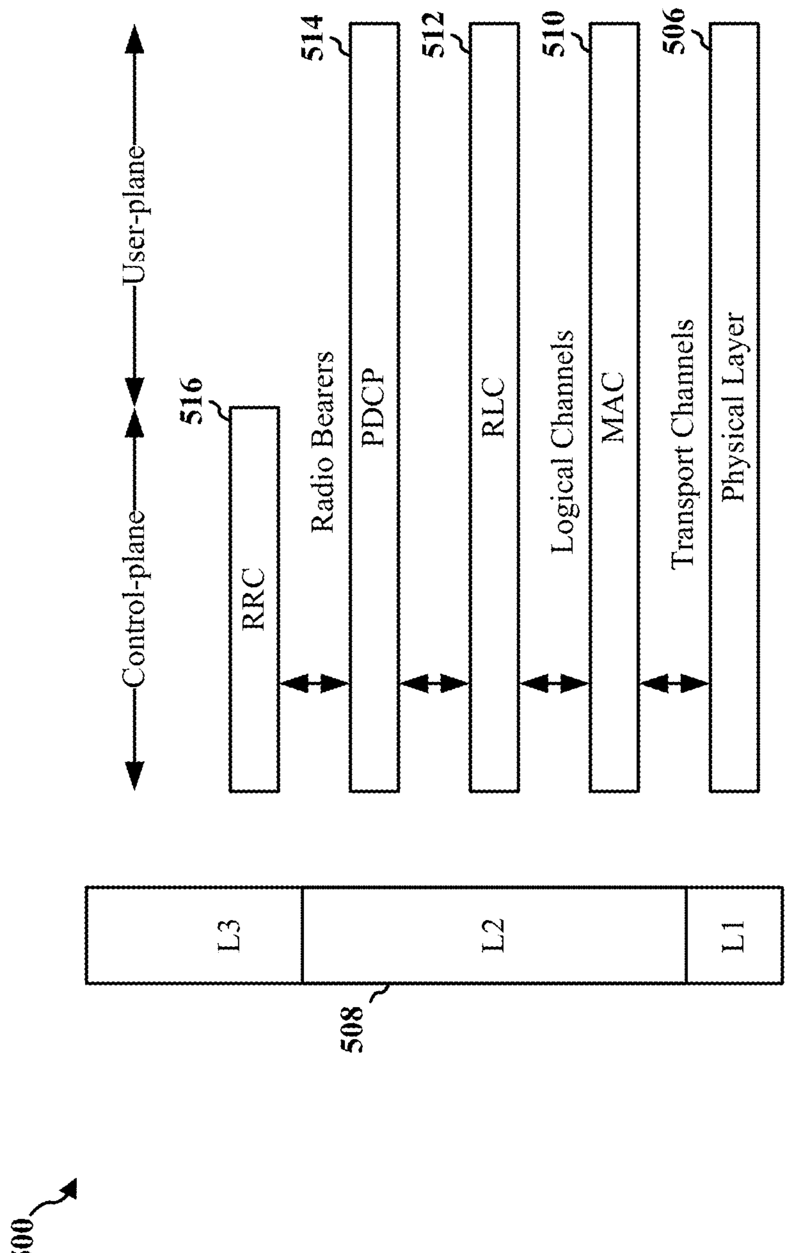

500
508
L3
L2
L1
Control-plane
User-plane
516
RRC
Radio Bearers
514
PDCP
512
RLC
Logical Channels
510
MAC
Transport Channels
506
Physical Layer

FIG. 5

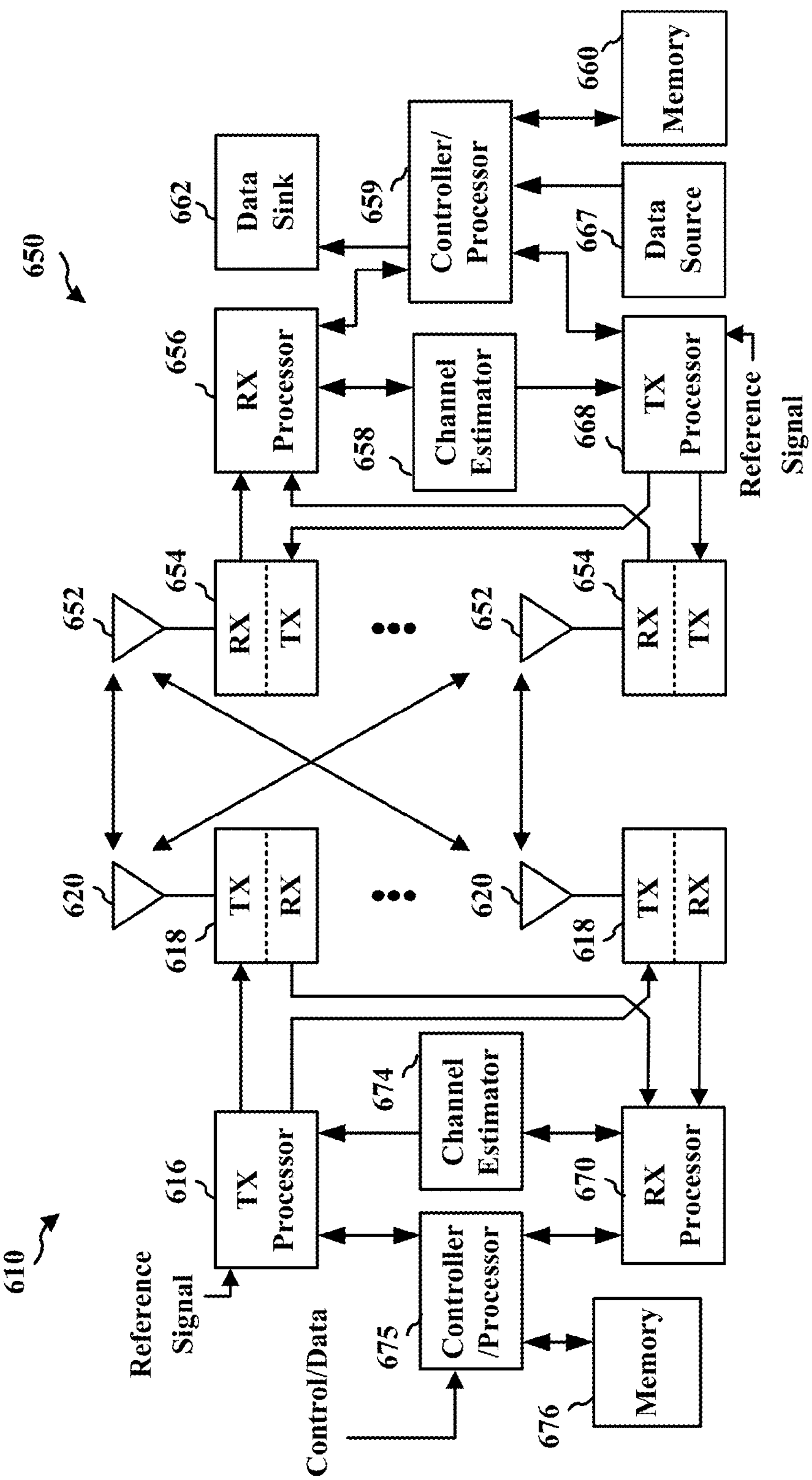

650
610
Data Sink
662
Controller/ Processor
659
Memory
660
Data Source
667
RX Processor
656
Channel Estimator
658
TX Processor
668
Reference Signal
652
654
RX
TX
620
618
TX Processor
616
Channel Estimator
674
RX Processor
670
Controller /Processor
675
Memory
676
Reference Signal
Control/Data

FIG. 6

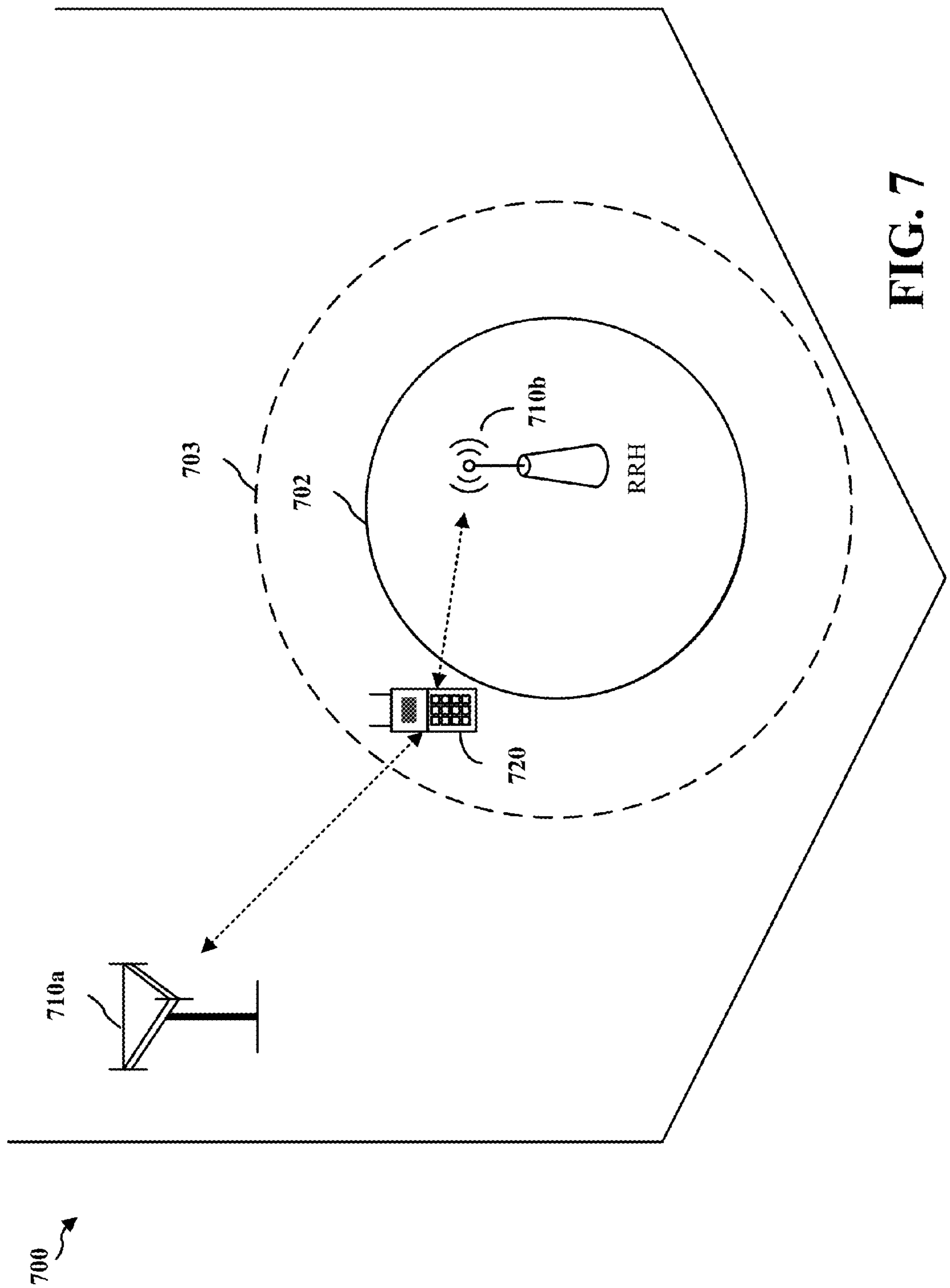


FIG. 7

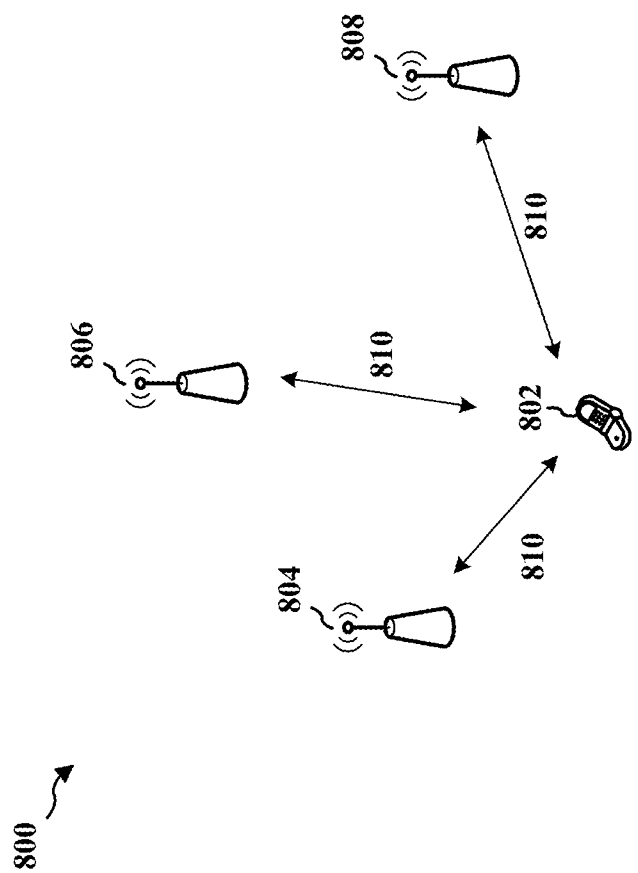


FIG. 8

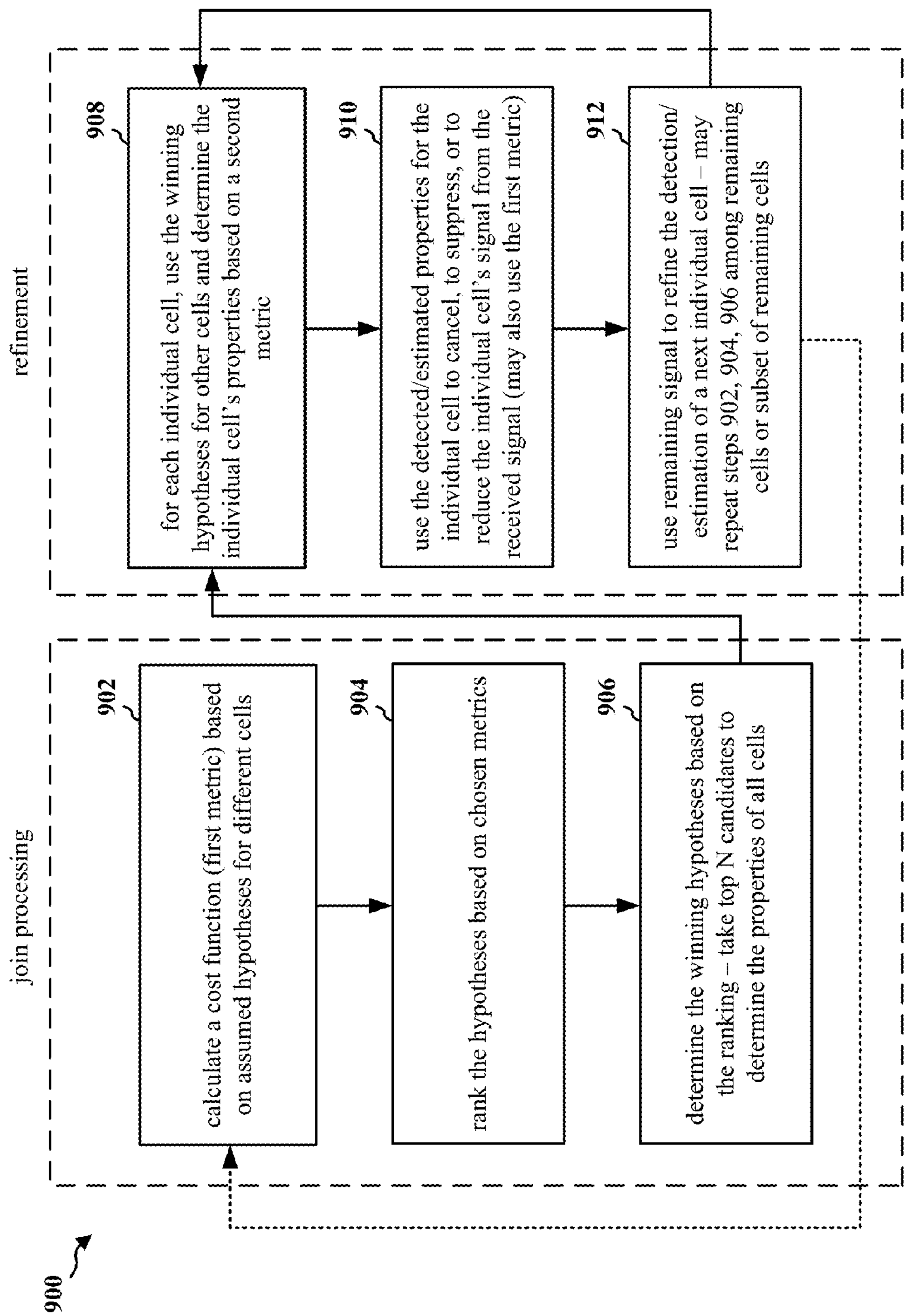

900
join processing
902
calculate a cost function (first metric) based on assumed hypotheses for different cells
904
rank the hypotheses based on chosen metrics
906
determine the winning hypotheses based on the ranking – take top N candidates to determine the properties of all cells
refinement
908
for each individual cell, use the winning hypotheses for other cells and determine the individual cell's properties based on a second metric
910
use the detected/estimated properties for the individual cell to cancel, to suppress, or to reduce the individual cell's signal from the received signal (may also use the first metric)
912
use remaining signal to refine the detection/ estimation of a next individual cell – may repeat steps 902, 904, 906 among remaining cells or subset of remaining cells

FIG. 9

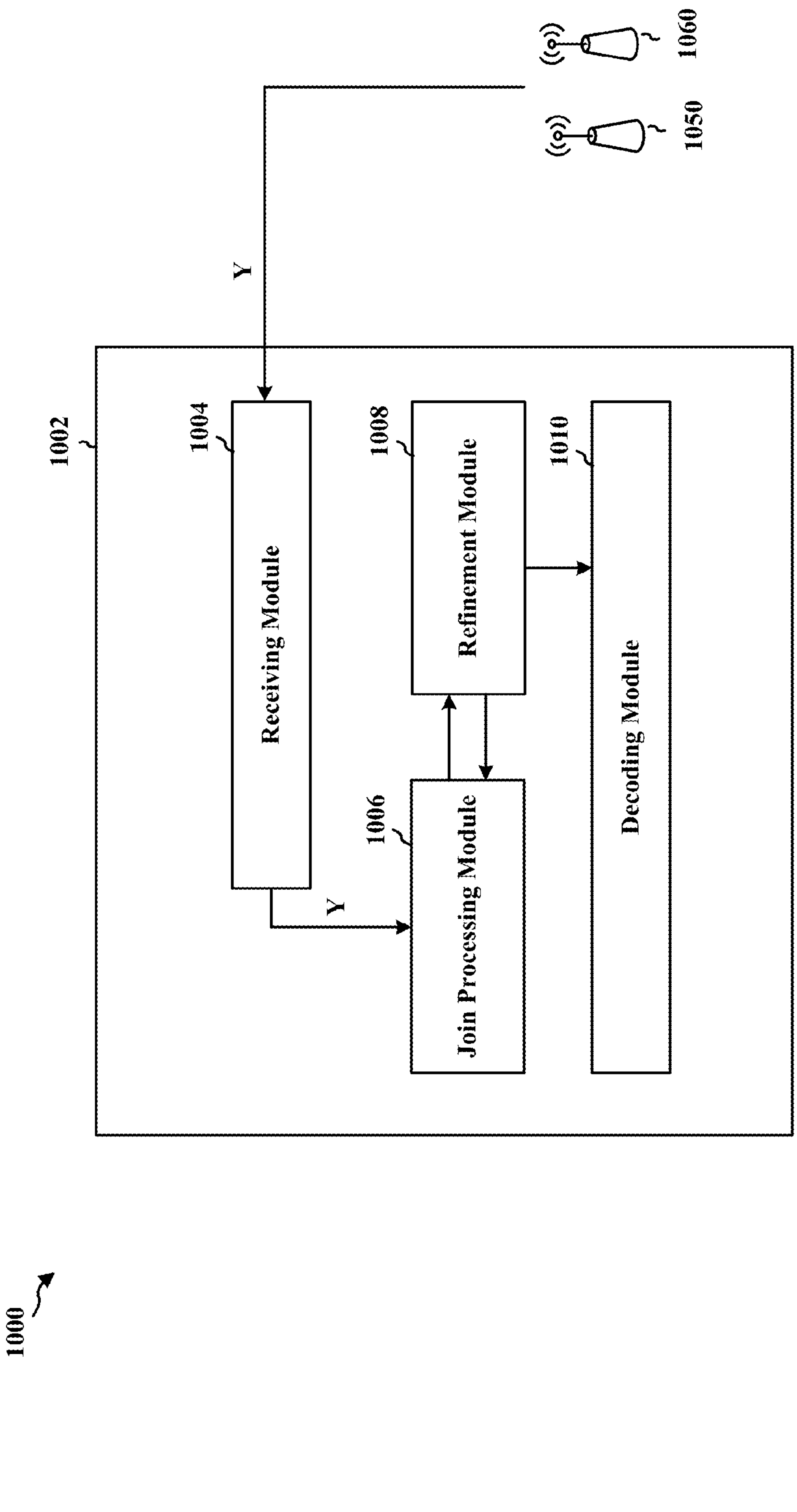

1060
1050
Y
1002
1004
Receiving Module
1008
Refinement Module
1010
Decoding Module
1006
Join Processing Module
Y
1000

FIG. 10

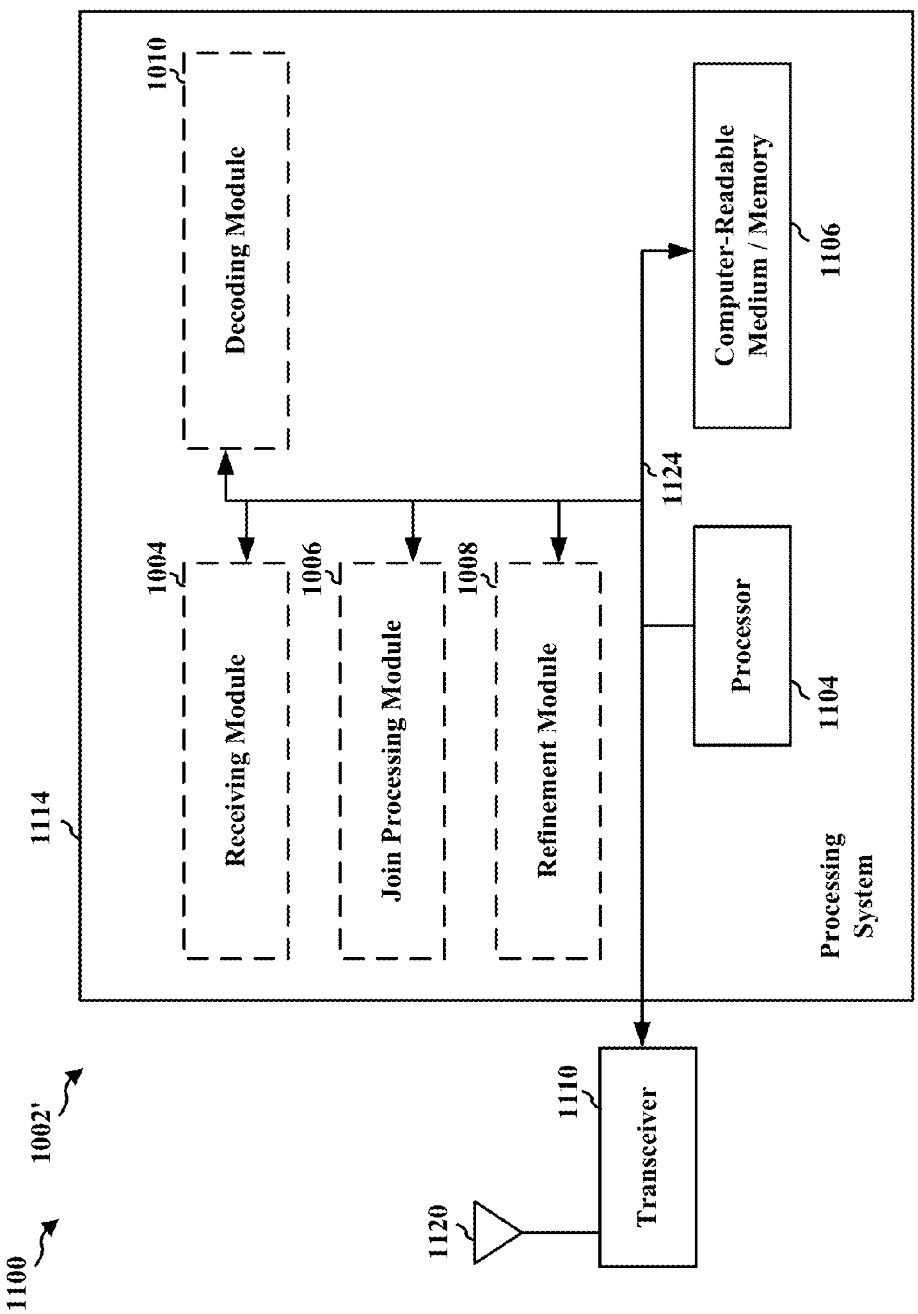

1100
1002'
1114
1010
Decoding Module
1004
Receiving Module
1006
Join Processing Module
1008
Refinement Module
1124
Computer-Readable Medium / Memory
1106
Processor
1104
Processing System
1110
Transceiver
1120

FIG. 11

LOW COMPLEXITY BLIND DETECTION OF TRANSMISSION PARAMETERS OF INTERFERERS

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims the benefit of U.S. Provisional Application Ser. No. 61/809,828, entitled "LOW COMPLEXITY BLIND DETECTION OF TRANSMISSION PARAMETERS OF LTE INTERFERERS" and filed on Apr. 8, 2013, which is expressly incorporated by reference herein in its entirety.

BACKGROUND

[0002] 1. Field

[0003] The present disclosure relates generally to communication systems, and more particularly, to low complexity blind detection of transmission parameters of Long Term Evolution (LTE) interferers.

[0004] 2. Background

[0005] Wireless communication systems are widely deployed to provide various telecommunication services such as telephony, video, data, messaging, and broadcasts. Typical wireless communication systems may employ multiple-access technologies capable of supporting communication with multiple users by sharing available system resources (e.g., bandwidth, transmit power). Examples of such multiple-access technologies include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, orthogonal frequency division multiple access (OFDMA) systems, single-carrier frequency division multiple access (SC-FDMA) systems, and time division synchronous code division multiple access (TD-SCDMA) systems.

[0006] These multiple access technologies have been adopted in various telecommunication standards to provide a common protocol that enables different wireless devices to communicate on a municipal, national, regional, and even global level. An example of an emerging telecommunication standard is LTE. LTE is a set of enhancements to the Universal Mobile Telecommunications System (UMTS) mobile standard promulgated by Third Generation Partnership Project (3GPP). LTE is designed to better support mobile broadband Internet access by improving spectral efficiency, lowering costs, improving services, making use of new spectrum, and better integrating with other open standards using OFDMA on the downlink (DL), SC-FDMA on the uplink (UL), and multiple-input multiple-output (MIMO) antenna technology. However, as the demand for mobile broadband access continues to increase, there exists a need for further improvements in LTE technology. Preferably, these improvements should be applicable to other multi-access technologies and the telecommunication standards that employ these technologies.

SUMMARY

[0007] In an aspect of the disclosure, a method, a computer program product, and an apparatus are provided. The apparatus reduces inference in a received signal. The apparatus receives a signal, which includes transmissions from a plurality of cells. The apparatus determines transmission parameter hypotheses associated with the plurality of cells. Each transmission parameter hypothesis includes a set of transmission parameters associated with all the cells from the plurality cells. Furthermore, each transmission parameter hypothesis is associated with a first metric. The apparatus selects at least one transmission parameter hypothesis based on the first metric associated with each hypothesis. The apparatus then refines the transmission parameters associated with at least one cell from the plurality of cells based on at least one selected transmission parameter hypothesis. The apparatus refines the parameters by improving the accuracy of the transmission parameters associated with the at least one cell based on a second metric.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a diagram illustrating an example of a network architecture.

[0009] FIG. **2** is a diagram illustrating an example of an access network.

[0010] FIG. **3** is a diagram illustrating an example of a DL frame structure in LTE.

[0011] FIG. **4** is a diagram illustrating an example of an UL frame structure in LTE.

[0012] FIG. **5** is a diagram illustrating an example of a radio protocol architecture for the user and control planes.

[0013] FIG. **6** is a diagram illustrating an example of an evolved Node B and user equipment in an access network.

[0014] FIG. **7** is a diagram illustrating a range expanded cellular region in a heterogeneous network.

[0015] FIG. **8** is a diagram for illustrating an exemplary method.

[0016] FIG. **9** is a flow chart of a method of reducing inference in a received signal.

[0017] FIG. **10** is a conceptual data flow diagram illustrating the data flow between different modules/means/components in an exemplary apparatus.

[0018] FIG. **11** is a diagram illustrating an example of a hardware implementation for an apparatus employing a processing system.

DETAILED DESCRIPTION

[0019] The detailed description set forth below in connection with the appended drawings is intended as a description of various configurations and is not intended to represent the only configurations in which the concepts described herein may be practiced. The detailed description includes specific details for the purpose of providing a thorough understanding of various concepts. However, it will be apparent to those skilled in the art that these concepts may be practiced without these specific details. In some instances, well known structures and components are shown in block diagram form in order to avoid obscuring such concepts.

[0020] Several aspects of telecommunication systems will now be presented with reference to various apparatus and methods. These apparatus and methods will be described in the following detailed description and illustrated in the accompanying drawings by various blocks, modules, components, circuits, steps, processes, algorithms, etc. (collectively referred to as "elements"). These elements may be implemented using electronic hardware, computer software, or any combination thereof. Whether such elements are implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system.

[0021] By way of example, an element, or any portion of an element, or any combination of elements may be implemented with a "processing system" that includes one or more processors. Examples of processors include microprocessors, microcontrollers, digital signal processors (DSPs), field programmable gate arrays (FPGAs), programmable logic devices (PLDs), state machines, gated logic, discrete hardware circuits, and other suitable hardware configured to perform the various functionality described throughout this disclosure. One or more processors in the processing system may execute software. Software shall be construed broadly to mean instructions, instruction sets, code, code segments, program code, programs, subprograms, software modules, applications, software applications, software packages, routines, subroutines, objects, executables, threads of execution, procedures, functions, etc., whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise.

[0022] Accordingly, in one or more exemplary embodiments, the functions described may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions may be stored on or encoded as one or more instructions or code on a computer-readable medium. Computer-readable media includes computer storage media. Storage media may be any available media that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can comprise a random-access memory (RAM), a read-only memory (ROM), an electrically erasable programmable ROM (EEPROM), compact disk ROM (CD-ROM) or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code in the form of instructions or data structures and that can be accessed by a computer. Combinations of the above should also be included within the scope of computer-readable media.

[0023] FIG. **1** is a diagram illustrating an LTE network architecture **100**. The LTE network architecture **100** may be referred to as an Evolved Packet System (EPS) **100**. The EPS **100** may include one or more user equipment (UE) **102**, an Evolved UMTS Terrestrial Radio Access Network (E-UTRAN) **104**, an Evolved Packet Core (EPC) **110**, and an Operator's Internet Protocol (IP) Services **122**. The EPS can interconnect with other access networks, but for simplicity those entities/interfaces are not shown. As shown, the EPS provides packet-switched services, however, as those skilled in the art will readily appreciate, the various concepts presented throughout this disclosure may be extended to networks providing circuit-switched services.

[0024] The E-UTRAN includes the evolved Node B (eNB) **106** and other eNBs **108**, and may include a Multicast Coordination Entity (MCE) **128**. The eNB **106** provides user and control planes protocol terminations toward the UE **102**. The eNB **106** may be connected to the other eNBs **108** via a backhaul (e.g., an X2 interface). The MCE **128** allocates time/frequency radio resources for evolved Multimedia Broadcast Multicast Service (MBMS) (eMBMS), and determines the radio configuration (e.g., a modulation and coding scheme (MCS)) for the eMBMS. The MCE **128** may be a separate entity or part of the eNB **106**. The eNB **106** may also be referred to as a base station, a Node B, an access point, a base transceiver station, a radio base station, a radio transceiver, a transceiver function, a basic service set (BSS), an extended service set (ESS), or some other suitable terminology. The eNB **106** provides an access point to the EPC **110** for a UE **102**. Examples of UEs **102** include a cellular phone, a smart phone, a session initiation protocol (SIP) phone, a laptop, a personal digital assistant (PDA), a satellite radio, a global positioning system, a multimedia device, a video device, a digital audio player (e.g., MP3 player), a camera, a game console, a tablet, or any other similar functioning device. The UE **102** may also be referred to by those skilled in the art as a mobile station, a subscriber station, a mobile unit, a subscriber unit, a wireless unit, a remote unit, a mobile device, a wireless device, a wireless communications device, a remote device, a mobile subscriber station, an access terminal, a mobile terminal, a wireless terminal, a remote terminal, a handset, a user agent, a mobile client, a client, or some other suitable terminology.

[0025] The eNB **106** is connected to the EPC **110**. The EPC **110** may include a Mobility Management Entity (MME) **112**, a Home Subscriber Server (HSS) **120**, other MMEs **114**, a Serving Gateway **116**, a Multimedia Broadcast Multicast Service (MBMS) Gateway **124**, a Broadcast Multicast Service Center (BM-SC) **126**, and a Packet Data Network (PDN) Gateway **118**. The MME **112** is the control node that processes the signaling between the UE **102** and the EPC **110**. Generally, the MME **112** provides bearer and connection management. All user IP packets are transferred through the Serving Gateway **116**, which itself is connected to the PDN Gateway **118**. The PDN Gateway **118** provides UE IP address allocation as well as other functions. The PDN Gateway **118** and the BM-SC **126** are connected to the IP Services **122**. The IP Services **122** may include the Internet, an intranet, an IP Multimedia Subsystem (IMS), a PS Streaming Service (PSS), and/or other IP services. The BM-SC **126** may provide functions for MBMS user service provisioning and delivery. The BM-SC **126** may serve as an entry point for content provider MBMS transmission, may be used to authorize and initiate MBMS Bearer Services within a PLMN, and may be used to schedule and deliver MBMS transmissions. The MBMS Gateway **124** may be used to distribute MBMS traffic to the eNBs (e.g., **106**, **108**) belonging to a Multicast Broadcast Single Frequency Network (MBSFN) area broadcasting a particular service, and may be responsible for session management (start/stop) and for collecting eMBMS related charging information.

[0026] FIG. **2** is a diagram illustrating an example of an access network **200** in an LTE network architecture. In this example, the access network **200** is divided into a number of cellular regions (cells) **202**. One or more lower power class eNBs **208** may have cellular regions **210** that overlap with one or more of the cells **202**. The lower power class eNB **208** may be a femto cell (e.g., home eNB (HeNB)), pico cell, micro cell, or remote radio head (RRH). The macro eNBs **204** are each assigned to a respective cell **202** and are configured to provide an access point to the EPC **110** for all the UEs **206** in the cells **202**. There is no centralized controller in this example of an access network **200**, but a centralized controller may be used in alternative configurations. The eNBs **204** are responsible for all radio related functions including radio bearer control, admission control, mobility control, scheduling, security, and connectivity to the serving gateway **116**. An eNB may support one or multiple (e.g., three) cells (also referred to as a sectors). The term "cell" can refer to the smallest coverage area of an eNB and/or an eNB subsystem serving are particular coverage area. Further, the terms "eNB," "base station," and "cell" may be used interchangeably herein.

[0027] The modulation and multiple access scheme employed by the access network **200** may vary depending on the particular telecommunications standard being deployed. In LTE applications, OFDM is used on the DL and SC-FDMA is used on the UL to support both frequency division duplex (FDD) and time division duplex (TDD). As those skilled in the art will readily appreciate from the detailed description to follow, the various concepts presented herein are well suited for LTE applications. However, these concepts may be readily extended to other telecommunication standards employing other modulation and multiple access techniques. By way of example, these concepts may be extended to Evolution-Data Optimized (EV-DO) or Ultra Mobile Broadband (UMB). EV-DO and UMB are air interface standards promulgated by the 3rd Generation Partnership Project 2 (3GPP2) as part of the CDMA2000 family of standards and employs CDMA to provide broadband Internet access to mobile stations. These concepts may also be extended to Universal Terrestrial Radio Access (UTRA) employing Wideband-CDMA (W-CDMA) and other variants of CDMA, such as TD-SCDMA; Global System for Mobile Communications (GSM) employing TDMA; and Evolved UTRA (E-UTRA), IEEE 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, and Flash-OFDM employing OFDMA. UTRA, E-UTRA, UMTS, LTE and GSM are described in documents from the 3GPP organization. CDMA2000 and UMB are described in documents from the 3GPP2 organization. The actual wireless communication standard and the multiple access technology employed will depend on the specific application and the overall design constraints imposed on the system.

[0028] The eNBs **204** may have multiple antennas supporting MIMO technology. The use of MIMO technology enables the eNBs **204** to exploit the spatial domain to support spatial multiplexing, beamforming, and transmit diversity. Spatial multiplexing may be used to transmit different streams of data simultaneously on the same frequency. The data streams may be transmitted to a single UE **206** to increase the data rate or to multiple UEs **206** to increase the overall system capacity. This is achieved by spatially precoding each data stream (i.e., applying a scaling of an amplitude and a phase) and then transmitting each spatially precoded stream through multiple transmit antennas on the DL. The spatially precoded data streams arrive at the UE(s) **206** with different spatial signatures, which enables each of the UE(s) **206** to recover the one or more data streams destined for that UE **206**. On the UL, each UE **206** transmits a spatially precoded data stream, which enables the eNB **204** to identify the source of each spatially precoded data stream.

[0029] Spatial multiplexing is generally used when channel conditions are good. When channel conditions are less favorable, beamforming may be used to focus the transmission energy in one or more directions. This may be achieved by spatially precoding the data for transmission through multiple antennas. To achieve good coverage at the edges of the cell, a single stream beamforming transmission may be used in combination with transmit diversity.

[0030] In the detailed description that follows, various aspects of an access network will be described with reference to a MIMO system supporting OFDM on the DL. OFDM is a spread-spectrum technique that modulates data over a number of subcarriers within an OFDM symbol. The subcarriers are spaced apart at precise frequencies. The spacing provides "orthogonality" that enables a receiver to recover the data from the subcarriers. In the time domain, a guard interval (e.g., cyclic prefix) may be added to each OFDM symbol to combat inter-OFDM-symbol interference. The UL may use SC-FDMA in the form of a DFT-spread OFDM signal to compensate for high peak-to-average power ratio (PAPR).

[0031] FIG. **3** is a diagram **300** illustrating an example of a DL frame structure in LTE. A frame (10 ms) may be divided into 10 equally sized subframes. Each subframe may include two consecutive time slots. A resource grid may be used to represent two time slots, each time slot including a resource block. The resource grid is divided into multiple resource elements. In LTE, for a normal cyclic prefix, a resource block contains 12 consecutive subcarriers in the frequency domain and 7 consecutive OFDM symbols in the time domain, for a total of 84 resource elements. For an extended cyclic prefix, a resource block contains 12 consecutive subcarriers in the frequency domain and 6 consecutive OFDM symbols in the time domain, for a total of 72 resource elements. Some of the resource elements, indicated as R **302**, **304**, include DL reference signals (DL-RS). The DL-RS include Cell-specific RS (CRS) (also sometimes called common RS) **302** and UE-specific RS (UE-RS) **304**. UE-RS **304** are transmitted only on the resource blocks upon which the corresponding physical DL shared channel (PDSCH) is mapped. The number of bits carried by each resource element depends on the modulation scheme. Thus, the more resource blocks that a UE receives and the higher the modulation scheme, the higher the data rate for the UE.

[0032] FIG. **4** is a diagram **400** illustrating an example of an UL frame structure in LTE. The available resource blocks for the UL may be partitioned into a data section and a control section. The control section may be formed at the two edges of the system bandwidth and may have a configurable size. The resource blocks in the control section may be assigned to UEs for transmission of control information. The data section may include all resource blocks not included in the control section. The UL frame structure results in the data section including contiguous subcarriers, which may allow a single UE to be assigned all of the contiguous subcarriers in the data section.

[0033] A UE may be assigned resource blocks **410*a***, **410*b*** in the control section to transmit control information to an eNB. The UE may also be assigned resource blocks **420*a***, **420*b*** in the data section to transmit data to the eNB. The UE may transmit control information in a physical UL control channel (PUCCH) on the assigned resource blocks in the control section. The UE may transmit only data or both data and control information in a physical UL shared channel (PUSCH) on the assigned resource blocks in the data section. A UL transmission may span both slots of a subframe and may hop across frequency.

[0034] A set of resource blocks may be used to perform initial system access and achieve UL synchronization in a physical random access channel (PRACH) **430**. The PRACH **430** carries a random sequence and cannot carry any UL data/signaling. Each random access preamble occupies a bandwidth corresponding to six consecutive resource blocks. The starting frequency is specified by the network. That is, the transmission of the random access preamble is restricted to certain time and frequency resources. There is no frequency hopping for the PRACH. The PRACH attempt is carried in a single subframe (1 ms) or in a sequence of few contiguous subframes and a UE can make only a single PRACH attempt per frame (10 ms).

[0035] FIG. **5** is a diagram **500** illustrating an example of a radio protocol architecture for the user and control planes in LTE. The radio protocol architecture for the UE and the eNB is shown with three layers: Layer 1, Layer 2, and Layer 3. Layer 1 (L1 layer) is the lowest layer and implements various physical layer signal processing functions. The L1 layer will be referred to herein as the physical layer **506**. Layer 2 (L2 layer) **508** is above the physical layer **506** and is responsible for the link between the UE and eNB over the physical layer **506**.

[0036] In the user plane, the L2 layer **508** includes a media access control (MAC) sublayer **510**, a radio link control (RLC) sublayer **512**, and a packet data convergence protocol (PDCP) **514** sublayer, which are terminated at the eNB on the network side. Although not shown, the UE may have several upper layers above the L2 layer **508** including a network layer (e.g., IP layer) that is terminated at the PDN gateway **118** on the network side, and an application layer that is terminated at the other end of the connection (e.g., far end UE, server, etc.).

[0037] The PDCP sublayer **514** provides multiplexing between different radio bearers and logical channels. The PDCP sublayer **514** also provides header compression for upper layer data packets to reduce radio transmission overhead, security by ciphering the data packets, and handover support for UEs between eNBs. The RLC sublayer **512** provides segmentation and reassembly of upper layer data packets, retransmission of lost data packets, and reordering of data packets to compensate for out-of-order reception due to hybrid automatic repeat request (HARQ). The MAC sublayer **510** provides multiplexing between logical and transport channels. The MAC sublayer **510** is also responsible for allocating the various radio resources (e.g., resource blocks) in one cell among the UEs. The MAC sublayer **510** is also responsible for HARQ operations.

[0038] In the control plane, the radio protocol architecture for the UE and eNB is substantially the same for the physical layer **506** and the L2 layer **508** with the exception that there is no header compression function for the control plane. The control plane also includes a radio resource control (RRC) sublayer **516** in Layer 3 (L3 layer). The RRC sublayer **516** is responsible for obtaining radio resources (e.g., radio bearers) and for configuring the lower layers using RRC signaling between the eNB and the UE.

[0039] FIG. **6** is a block diagram of an eNB **610** in communication with a UE **650** in an access network. In the DL, upper layer packets from the core network are provided to a controller/processor **675**. The controller/processor **675** implements the functionality of the L2 layer. In the DL, the controller/processor **675** provides header compression, ciphering, packet segmentation and reordering, multiplexing between logical and transport channels, and radio resource allocations to the UE **650** based on various priority metrics. The controller/processor **675** is also responsible for HARQ operations, retransmission of lost packets, and signaling to the UE **650**.

[0040] The transmit (TX) processor **616** implements various signal processing functions for the L1 layer (i.e., physical layer). The signal processing functions include coding and interleaving to facilitate forward error correction (FEC) at the UE **650** and mapping to signal constellations based on various modulation schemes (e.g., binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), M-phase-shift keying (M-PSK), M-quadrature amplitude modulation (M-QAM)). The coded and modulated symbols are then split into parallel streams. Each stream is then mapped to an OFDM subcarrier, multiplexed with a reference signal (e.g., pilot) in the time and/or frequency domain, and then combined together using an Inverse Fast Fourier Transform (IFFT) to produce a physical channel carrying a time domain OFDM symbol stream. The OFDM stream is spatially precoded to produce multiple spatial streams. Channel estimates from a channel estimator **674** may be used to determine the coding and modulation scheme, as well as for spatial processing. The channel estimate may be derived from a reference signal and/or channel condition feedback transmitted by the UE **650**. Each spatial stream may then be provided to a different antenna **620** via a separate transmitter **618**TX. Each transmitter **618**TX may modulate an RF carrier with a respective spatial stream for transmission.

[0041] At the UE **650**, each receiver **654**RX receives a signal through its respective antenna **652**. Each receiver **654**RX recovers information modulated onto an RF carrier and provides the information to the receive (RX) processor **656**. The RX processor **656** implements various signal processing functions of the L1 layer. The RX processor **656** may perform spatial processing on the information to recover any spatial streams destined for the UE **650**. If multiple spatial streams are destined for the UE **650**, they may be combined by the RX processor **656** into a single OFDM symbol stream. The RX processor **656** then converts the OFDM symbol stream from the time-domain to the frequency domain using a Fast Fourier Transform (FFT). The frequency domain signal comprises a separate OFDM symbol stream for each subcarrier of the OFDM signal. The symbols on each subcarrier, and the reference signal, are recovered and demodulated by determining the most likely signal constellation points transmitted by the eNB **610**. These soft decisions may be based on channel estimates computed by the channel estimator **658**. The soft decisions are then decoded and deinterleaved to recover the data and control signals that were originally transmitted by the eNB **610** on the physical channel. The data and control signals are then provided to the controller/processor **659**.

[0042] The controller/processor **659** implements the L2 layer. The controller/processor can be associated with a memory **660** that stores program codes and data. The memory **660** may be referred to as a computer-readable medium. In the UL, the controller/processor **659** provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, control signal processing to recover upper layer packets from the core network. The upper layer packets are then provided to a data sink **662**, which represents all the protocol layers above the L2 layer. Various control signals may also be provided to the data sink **662** for L3 processing. The controller/processor **659** is also responsible for error detection using an acknowledgement (ACK) and/or negative acknowledgement (NACK) protocol to support HARQ operations.

[0043] In the UL, a data source **667** is used to provide upper layer packets to the controller/processor **659**. The data source **667** represents all protocol layers above the L2 layer. Similar to the functionality described in connection with the DL transmission by the eNB **610**, the controller/processor **659** implements the L2 layer for the user plane and the control plane by providing header compression, ciphering, packet segmentation and reordering, and multiplexing between logical and transport channels based on radio resource allocations by the eNB **610**. The controller/processor **659** is also responsible for HARQ operations, retransmission of lost packets, and signaling to the eNB **610**.

[0044] Channel estimates derived by a channel estimator **658** from a reference signal or feedback transmitted by the eNB **610** may be used by the TX processor **668** to select the appropriate coding and modulation schemes, and to facilitate spatial processing. The spatial streams generated by the TX processor **668** may be provided to different antenna **652** via separate transmitters **654**TX. Each transmitter **654**TX may modulate an RF carrier with a respective spatial stream for transmission.

[0045] The UL transmission is processed at the eNB **610** in a manner similar to that described in connection with the receiver function at the UE **650**. Each receiver **618**RX receives a signal through its respective antenna **620**. Each receiver **618**RX recovers information modulated onto an RF carrier and provides the information to a RX processor **670**. The RX processor **670** may implement the L1 layer.

[0046] The controller/processor **675** implements the L2 layer. The controller/processor **675** can be associated with a memory **676** that stores program codes and data. The memory **676** may be referred to as a computer-readable medium. In the UL, the control/processor **675** provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, control signal processing to recover upper layer packets from the UE **650**. Upper layer packets from the controller/processor **675** may be provided to the core network. The controller/processor **675** is also responsible for error detection using an ACK and/or NACK protocol to support HARQ operations.

[0047] FIG. **7** is a diagram **700** illustrating a range expanded cellular region in a heterogeneous network. A lower power class eNB such as the RRH **710***b* may have a range expanded cellular region **703** that is expanded from the cellular region **702** through enhanced inter-cell interference coordination between the RRH **710***b* and the macro eNB **710***a* and through interference cancelation performed by the UE **720**. In enhanced inter-cell interference coordination, the RRH **710***b* receives information from the macro eNB **710***a* regarding an interference condition of the UE **720**. The information allows the RRH **710***b* to serve the UE **720** in the range expanded cellular region **703** and to accept a handoff of the UE **720** from the macro eNB **710***a* as the UE **720** enters the range expanded cellular region **703**.

[0048] Reliability of serving cell decoding can be enhanced by interference handling at a UE. Interference handling includes interference suppression (IS) and interference cancelation (IC). If a UE is aware of transmission properties of an interfering cell, the UE can more effectively cancel, suppress, or otherwise reduce interference from the interfering cell. Transmission properties may include whether an interfering cell is transmitting, spatial schemes, a traffic to pilot ratio (TPR), a modulation order, and other transmission properties. Whether an interfering cell is transmitting may be true or false (on or off). Spatial schemes may include a CRS based transmission or a UE-RS based transmission. The CRS based transmission may be a space frequency block code (SFBC) transmission, a rank 1 transmission, a rank 2 transmission or a higher rank transmission, or another type of transmission. The UE-RS based transmission may be transmission rank information. The TPR may be one of several possible values (e.g., −5 dB, −3 dB, 0 dB, 3 dB, 5 dB). Whether an interfering cell is transmitting may be grouped into the TPR. As such, the TPR may include the value −∞ for when an interfering cell is not transmitting. The modulation order may be one of several possible values (e.g., BPSK, QPSK, M-QAM for various M). The transmission properties may differ for data and control channels. The granularity of a variation in interference properties may depend on several parameters such as a transmission mode, resource allocation type, etc. There is a need in both homogeneous and heterogeneous networks to reduce interference from one or more cells while receiving interference from multiple cells. Methods for reducing interference in a received signal are provided infra with respect to FIG. **8** and FIG. **9**.

[0049] FIG. **8** is a diagram illustrating an exemplary method **800**. In FIG. **8**, a UE **802** receives a signal **810**, which includes transmissions from cells **804**, **806**, **808**. One cell may be a serving cell and the remaining cells may be interfering cells. For example, cell **804** may be a serving cell and cells **806**, **808** may be interfering cells. The UE **802** efficiently detects/estimates transmission properties from the interfering cells **806**, **808** by performing two steps: (1) a join-processing step, and (2) a refinement step.

[0050] In the join-processing step, the UE **802** determines transmission parameter hypotheses associated with cells **806**, **808**. Each transmission parameter hypothesis from the transmission parameter hypotheses includes a set of possible transmission parameters associated with cells **806**, **808**. The UE **802** determines a first probability metric to each hypothesis based on the confidence associated with each transmission parameter hypothesis. Thereafter, the UE selects at least one transmission parameter hypothesis, from the different transmission parameter hypotheses, based on the first probability metric associated with each hypothesis. Based on the implementation, the UE may select a single hypothesis having the highest first metric value, corresponding to a likely accurate hypothesis. Alternatively, the UE may select a plurality of the highest first metric value hypotheses.

[0051] For example, assume the UE **802** needs to determine the TPR and the spatial scheme for interfering cells **806**, **808**. The UE **802** may determine that there are three possible values of TPR for the cell **806** (e.g., TPR_{1_eNB1}, TPR_{2_eNB1}, TPR_{3_eNB1}), two possible values of TPR for the cell **808** (e.g., TPR_{1_eNB2}, TPR_{2_eNB2}), and two possible values for the spatial scheme for each of the cells **806** (e.g., SS_{1_eNB1}, SS_{2_eNB1}), **808** (e.g., SS_{1_eNB2}, SS_{2_eNB2}). As such, there are 24 different combinations of transmission parameters for the cells **806**, **808**, corresponding to the total number of possible combinations of values for cells **806**, **808** (3 TPR_{eNB1} values×2 TPR_{eNB2} values×2 SS_{eNB1} values×2 SS_{eNB2} values). The UE **802** applies a first probability metric to each hypothesis, each hypothesis being representable as $\{TPR_{eNB1}, TPR_{eNB2}, SS_{eNB1}, SS_{eNB2}\}$. Thereafter, the UE selects at least one transmission parameter hypothesis, of the 24 different transmission parameter hypotheses, based on a first probability metric associated with each hypothesis. Based on the implementation, the UE may select a single hypothesis having the highest first metric value, corresponding to a likely accurate hypothesis. Alternatively, the UE may select a plurality of the highest first metric value hypotheses.

[0052] For another example, assume the UE **802** needs to determine the TPR for interfering cells **806**, **808**. Assume also that the UE **802** determines that the interfering cell **806** may have four possible TPR values: 3 dB, 0 dB, −3 dB, and −∞ dB (or an extreme negative value, corresponding to no interference from the interfering cell **806** due to the interfering cell **806** not transmitting), and that the interfering cell **808** may have four possible TPR values: 6 dB, 0 dB, −6 dB, and −∞ dB (or an extreme negative value, corresponding to no interference from the interfering cell **806** due to the interfering cell **806** not transmitting). The UE **802** receives signal Y from the serving cell **804** and one or more of the interfering cells **806**, **808**. The received signal $Y=f(TPR)S+f_1(TPR_1)I_1+f_2(TPR_2)I_2$, where S is the received signal from the serving cell, I_1 is the received signal from the interfering cell **806**, I_2 is the received signal from the interfering cell **808**, TPR_1 may have one of four possible values, for example, 3 dB, 0 dB, −3 dB, and −∞ dB, and TPR_2 may have one of four possible values, for example, 6 dB, 0 dB, −6 dB, and −∞ dB. Accordingly, the UE **802** determines that there are 16 possible combinations of TPR for the interfering cells **806**, **808**. The UE **802** applies a first probability metric p_1 to each of the hypothesis to obtain a plurality of probabilities $p_{1,i}$ for each i^{th} hypothesis of the 16 possible hypotheses:

I_1 - TPR	I_2 - TPR	Probability
3 dB	6 dB	$p_{1,1}$
3 dB	0 dB	$p_{1,2}$
3 dB	−6 dB	$p_{1,3}$
3 dB	−∞ dB	$p_{1,4}$
0 dB	6 dB	$p_{1,5}$
0 dB	0 dB	$p_{1,6}$
0 dB	−6 dB	$p_{1,7}$
0 dB	−∞ dB	$p_{1,8}$
−3 dB	6 dB	$p_{1,9}$
−3 dB	0 dB	$p_{1,10}$
−3 dB	−6 dB	$p_{1,11}$
−3 dB	−∞ dB	$p_{1,12}$
−∞ dB	6 dB	$p_{1,13}$
−∞ dB	0 dB	$p_{1,14}$
−∞ dB	−6 dB	$p_{1,15}$
−∞ dB	−∞ dB	$p_{1,16}$

[0053] The first probability metric p_1 may be a function of the received signal Y, TPR_1, and TPR_2. For example, the probability $p_{1,1}$ may be determined based on the received signal Y and assumptions that TPR_1=3 dB and that TPR_2=6 dB. The first probability metric p_1 may be a function of additional parameters. Upon determining the probabilities $p_{1,i}$ for each i^{th} hypothesis of the 16 possible hypotheses, the UE **802** may rank the hypotheses and select the hypothesis with the highest rank (i.e., highest probability $p_{1,i}$), or may select a set of hypotheses with the highest rank (e.g., probabilities $p_{1,i}$ greater than a threshold T, or n hypothesis with the highest rank).

[0054] In the refinement step, the UE **802** refines transmission parameters associated with at least one cell of the cells **806**, **808**. The UE **802** may perform the refining step by improving an accuracy of the transmission parameters associated with the at least one cell based on a second probability metric. During the refinement step, the second probability metric is determined for each cell individually. This second metric may be the same or similar to the first metric, but is applied to individual cell analysis. Alternatively, the second metric may vary significantly from the first metric, being designed to evaluate the accuracy of individual cell parameters.

[0055] For example, assume that the UE **802** selects the hypothesis associated with the probabilities $p_{1,3}$, $p_{1,4}$, and $p_{1,7}$ as being most likely. In the refinement step, the UE **802** may apply a second probability metric p_2 to determine whether the TPR for the interfering cell **806** is 3 dB or 0 dB. If based on the second metric, the UE **802** determines that the TPR for the interfering cell **806** is 3 dB. The UE **802** may then subtract (e.g., cancel or suppress) I_1 from the received signal Y based on an assumed TPR_1 of 3 dB to obtain a refined (interference subtracted or interference reduced) signal Y_2. When subtracting the signal I_1 from the received signal Y, the UE **802** may use the TPR_1 of 3 dB.

[0056] Subsequent to the refinement step, the UE may return to the join-processing step or further refine the other interferer values. In one configuration, the UE **802** performs join processing again with the signal Y_2 in order to estimate TPR_2 associated with the interfering cell **808**. When performing join processing again, the UE **802** may determine a new set of possible values for TPR_2. Upon determining a set of likely hypotheses for TPR_2, the UE **802** may perform the refinement step again in order to determine a likely value for TPR_2 and to subtract I_2 from the received signal Y_2 based on the likely value for TPR_2 to generate a received signal Y_3, where Y_3 excludes signal hand signal I_2.

[0057] As discussed supra, the UE **802** estimates/detects transmission properties of the interfering cells **806**, **808**. If the UE **802** does not know the transmission parameters of the serving cell **804**, the UE **802** may also estimate/detect the transmission properties of the serving cell **804**. Accordingly, the UE **802** may perform the join-processing and refining steps on all of the cells **804**, **806**, **808**, not just the interfering cells **806**, **808**.

[0058] FIG. **9** is a flow chart **900** of a method of reducing inference in a received signal. The method is performed by a UE, such as the UE **802**.

[0059] In step **902**, a UE calculates a cost function (i.e., a first probability metric) based on assumed hypotheses for different cells. The cost function may be a function of a received signal and the transmission properties of interfering cells. As discussed supra, the transmission properties may include a TPR, on/off transmission, a spatial scheme, a modulation order, and other transmission properties. The on/off transmission may be part of the TPR, assuming −∞ dB (or similar) is an off transmission and a value other than −∞ dB is an on transmission. A subset of the transmission properties can be chosen for each cell. A finite number of possible values are chosen for each transmission parameter in the subset. A different range of parameters values may be guessed/estimated for each cell. All or a subset of all possible hypotheses for each individual cell are taken into account. For example, in the case where the set of all possible hypotheses would be prohibitive, the UE may exclude highly unlikely hypothesis having improbable parameters.

[0060] In step **904**, the UE ranks the hypotheses based on the cost function. However, this step may be skipped for implementations where the UE would pick the top candidate, or top N candidates, where N is a relatively small number or ranking or sorting is cost prohibitive.

[0061] In step **906**, the UE determines the winning hypotheses based on the ranking in step **904**, or similar method. In step **906**, the UE may select the top N (N≥1) candidates to determine the properties for the cells.

[0062] In steps **908**, **910**, **912**, the UE uses the results from step **906** to refine the detection/estimation for each individual cell. In step **908**, for each individual cell, the UE uses the winning hypotheses for other cells and determines the individual cell's properties based on a second probability metric. The second probability metric and the first probability metric may be different or the same.

[0063] In step **910**, the UE uses the detected/estimated properties for the individual cell to cancel, to suppress, or otherwise to reduce the individual cell's signal from the received signal. The UE may additionally use the first metric when performing step **910**.

[0064] In step **912**, the UE uses the remaining signal to refine the detection/estimation of a next individual cell. The UE may repeat steps **902**, **904**, **906** among remaining cells or a subset of remaining cells.

[0065] Accordingly, a UE may receive a signal including transmissions from a plurality of cells. The UE may determine transmission parameter hypotheses associated with the plurality of cells. Each transmission parameter hypothesis from the transmission parameter hypotheses may include a set of transmission parameters associated with all the cells from the plurality cells. The UE may select at least one transmission parameter hypothesis based on a first probability metric applied to each hypothesis. The UE may refine transmission parameters associated with at least one cell from the plurality of cells. The UE may refine by improving an accuracy of the transmission parameters associated with the at least one cell based on a second probability metric associated with each cell individually.

[0066] The UE may select the at least one transmission parameter hypothesis based on a ranking of transmission parameter hypotheses based on the first probability metric associated with each hypothesis. The UE may refine transmission parameters by subtracting a transmission associated with a cell from the received signal to obtain a refined signal. The subtracted transmission may be determined based on at least one of the first probability metric or the second probability metric. Each transmission parameter hypothesis may include cell-specific transmission parameters for each cell from the plurality of cells. The UE may refine transmission parameters by determining the second probability metric for each cell from the plurality of cells. In addition, the UE may subtract a transmission associated with a cell from the received signal to obtain a reduced received signal. The subtracted transmission may be determined based on a cell from the plurality of cells having a highest second probability metric. In addition, the UE may determine updated cell-specific transmission parameters for one or more cells based on the refined signal. Furthermore, the UE may determine an updated second probability metric for the one or more cells. The UE may repeat the steps of determining, selecting, and refining iteratively. Each subsequent repetition of the determining step may use the results of the previous refining step.

[0067] The transmission parameters may include at least one of a modulation order, a TPR, a spatial scheme, or whether there is an interfering transmission. The spatial scheme may include one a CRS based transmission or a UE-RS based transmission. The CRS based transmission may include one of an SFBC transmission, a rank 1 transmission, a rank 2 transmission, or a higher rank transmission. The UE-RS based transmission may be transmission rank information. The UE may determine the transmission parameter hypotheses for the plurality of cells by determining a transmission parameter hypothesis for each of the plurality of cells, determining the first probability metric for each transmission parameter hypothesis, and ranking the plurality of transmission parameter hypotheses based on the first probability metric associated with each transmission parameter hypothesis.

[0068] FIG. **10** is a conceptual data flow diagram **1000** illustrating the data flow between different modules/means/components in an exemplary apparatus **1002**. The apparatus may be a UE. The apparatus includes a receiving module **1004** that is configured to receive a signal Y including transmissions from a plurality of cells **1050**, **1060**. The plurality of cells including a serving cell **1050** and one or more interfering cells **1060**. The apparatus further includes a join processing module **1006** that is configured to determine transmission parameter hypotheses associated with the plurality of cells. Each transmission parameter hypothesis from the transmission parameter hypotheses includes a set of transmission parameters associated with all the cells from the plurality cells. The join processing module **1006** is further configured to select at least one transmission parameter hypothesis based on a first probability metric applied to each hypothesis. The apparatus further includes a refinement module **1008** that is configured to refine transmission parameters associated with at least one cell from the plurality of cells. The refinement module **1008** is configured to refine by improving an accuracy of the transmission parameters associated with the at least one cell based on a second probability metric associated with each cell individually.

[0069] The join processing module **1006** may be configured to select based on a ranking of transmission parameter hypotheses based on the first probability metric associated with each hypothesis. The refinement module **1008** may be configured to refine by subtracting a transmission associated with a cell from the received signal to obtain a refined signal. The subtracted transmission may be determined based on at least one of the first probability metric or the second probability metric. In one configuration, each transmission parameter hypothesis includes cell-specific transmission parameters for each cell from the plurality of cells, and the refinement module **1008** is configured to refine by determining the second probability metric for each cell from the plurality of cells; subtracting a transmission associated with a cell from the received signal to obtain a reduced received signal, the subtracted transmission being determined based on a cell from the plurality of cells having a highest second probability metric; determining updated cell-specific transmission parameters for one or more cells based on the refined signal; and determining an updated second probability metric for the one or more cells. The apparatus may repeat the steps of determining, selecting, and refining iteratively. Each subsequent repetition of the determining step may use the results of the previous refining step.

[0070] The transmission parameters may include at least one of a modulation order, a TPR, a spatial scheme, or whether there is an interfering transmission. The spatial scheme may be one of a CRS based transmission or a UE-RS based transmission. The CRS based transmission may be one of an SFBC transmission, a rank 1 transmission, a rank 2 transmission, or a higher rank transmission. The UE-RS based transmission may be transmission rank information. The join processing module **1006** may be configured to determine the transmission parameter hypotheses for the plurality of cells by determining a transmission parameter hypothesis for each of the plurality of cells, determining the first probability metric for each transmission parameter hypothesis, and ranking the plurality of transmission parameter hypotheses based on the first probability metric associated with each transmission parameter hypothesis. The join processing module **1006** may determine the transmission parameter hypotheses for the transmission parameters for each of the plurality cells by determining a set of hypotheses. The set of hypotheses may include a hypothesis for each combination of possible values for n transmission parameters.

[0071] The apparatus may include additional modules that perform each of the steps of the algorithm in the aforementioned flow chart of FIG. **9**. As such, each step in the aforementioned flow chart of FIG. **9** may be performed by a module and the apparatus may include one or more of those modules. The modules may be one or more hardware components specifically configured to carry out the stated processes/algorithm, implemented by a processor configured to perform the stated processes/algorithm, stored within a computer-readable medium for implementation by a processor, or some combination thereof.

[0072] FIG. **11** is a diagram **1100** illustrating an example of a hardware implementation for an apparatus **1002'** employing a processing system **1114**. The processing system **1114** may be implemented with a bus architecture, represented generally by the bus **1124**. The bus **1124** may include any number of interconnecting buses and bridges depending on the specific application of the processing system **1114** and the overall design constraints. The bus **1124** links together various circuits including one or more processors and/or hardware modules, represented by the processor **1104**, the modules **1004**, **1006**, **1008**, **1010** and the computer-readable medium/memory **1106**. The bus **1124** may also link various other circuits such as timing sources, peripherals, voltage regulators, and power management circuits, which are well known in the art, and therefore, will not be described any further.

[0073] The processing system **1114** may be coupled to a transceiver **1110**. The transceiver **1110** is coupled to one or more antennas **1120**. The transceiver **1110** provides a means for communicating with various other apparatus over a transmission medium. The transceiver **1110** receives a signal from the one or more antennas **1120**, extracts information from the received signal, and provides the extracted information to the processing system **1114**. In addition, the transceiver **1110** receives information from the processing system **1114**, and based on the received information, generates a signal to be applied to the one or more antennas **1120**. The processing system **1114** includes a processor **1104** coupled to a computer-readable medium/memory **1106**. The processor **1104** is responsible for general processing, including the execution of software stored on the computer-readable medium/memory **1106**. The software, when executed by the processor **1104**, causes the processing system **1114** to perform the various functions described supra for any particular apparatus. The computer-readable medium/memory **1106** may also be used for storing data that is manipulated by the processor **1104** when executing software. The processing system further includes at least one of the modules **1004**, **1006**, **1008**, and **1010**. The modules may be software modules running in the processor **1104**, resident/stored in the computer readable medium/memory **1106**, one or more hardware modules coupled to the processor **1104**, or some combination thereof. The processing system **1114** may be a component of the UE **650** and may include the memory **660** and/or at least one of the TX processor **668**, the RX processor **656**, and the controller/processor **659**.

[0074] In one configuration, the apparatus **1002/1002'** for wireless communication reduces interference in a received signal. The apparatus includes means for receiving a signal including transmissions from a plurality of cells. The apparatus further includes means for determining transmission parameter hypotheses associated with the plurality of cells. Each transmission parameter hypothesis from the transmission parameter hypotheses includes a set of transmission parameters associated with all the cells from the plurality cells. The apparatus further includes means for selecting at least one transmission parameter hypothesis based on a first probability metric applied to each hypothesis. The apparatus further includes means for refining transmission parameters associated with at least one cell from the plurality of cells. The refining includes improving an accuracy of the transmission parameters associated with the at least one cell based on a second probability metric associated with each cell individually.

[0075] In one configuration, the means for selecting performs the selecting based on a ranking of transmission parameter hypotheses based on the first probability metric associated with each hypothesis. In one configuration, the means for refining is configured to refine by subtracting a transmission associated with a cell from the received signal to obtain a refined signal. The subtracted transmission may be determined based on at least one of the first probability metric or the second probability metric. In one configuration, each transmission parameter hypothesis includes cell-specific transmission parameters for each cell from the plurality of cells, and the means for refining is configured to determine the second probability metric for each cell from the plurality of cells; subtract a transmission associated with a cell from the received signal to obtain a reduced received signal, the subtracted transmission being determined based on a cell from the plurality of cells having a highest second probability metric; determine updated cell-specific transmission parameters for one or more cells based on the refined signal; and determine an updated second probability metric for the one or more cells. In one configuration, the apparatus further includes means for repeating the steps of determining, selecting, and refining iteratively. In such a configuration, each subsequent repetition of the determining step uses the results of the previous refining step. In one configuration, the means for determining the transmission parameter hypotheses for the plurality of cells is configured to determine a transmission parameter hypothesis for each of the plurality of cells, to determine the first probability metric for each transmission parameter hypothesis, and to rank the plurality of transmission parameter hypotheses based on the first probability metric associated with each transmission parameter hypothesis. The means for determining the transmission parameter hypotheses for the transmission parameters for each of the plurality cells may be configured to determine a set of hypotheses. The set of hypotheses may include a hypothesis for each combination of possible values for n transmission parameters.

[0076] The aforementioned means may be one or more of the aforementioned modules of the apparatus **1002** and/or the processing system **1114** of the apparatus **1002'** configured to perform the functions recited by the aforementioned means. As described supra, the processing system **1114** may include the TX Processor **668**, the RX Processor **656**, and the controller/processor **659**. As such, in one configuration, the aforementioned means may be the TX Processor **668**, the RX

Processor **656**, and the controller/processor **659** configured to perform the functions recited by the aforementioned means.

[0077] It is understood that the specific order or hierarchy of steps in the processes/flow charts disclosed is an illustration of exemplary approaches. Based upon design preferences, it is understood that the specific order or hierarchy of steps in the processes/flow charts may be rearranged. Further, some steps may be combined or omitted. The accompanying method claims present elements of the various steps in a sample order, and are not meant to be limited to the specific order or hierarchy presented.

[0078] The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. Various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects. Thus, the claims are not intended to be limited to the aspects shown herein, but is to be accorded the full scope consistent with the language claims, wherein reference to an element in the singular is not intended to mean "one and only one" unless specifically so stated, but rather "one or more." The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any aspect described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects." Unless specifically stated otherwise, the term "some" refers to one or more. Combinations such as "at least one of A, B, or C," "at least one of A, B, and C," and "A, B, C, or any combination thereof" include any combination of A, B, and/or C, and may include multiples of A, multiples of B, or multiples of C. Specifically, combinations such as "at least one of A, B, or C," "at least one of A, B, and C," and "A, B, C, or any combination thereof" may be A only, B only, C only, A and B, A and C, B and C, or A and B and C, where any such combinations may contain one or more member or members of A, B, or C. All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. No claim element is to be construed as a means plus function unless the element is expressly recited using the phrase "means for."

What is claimed is:

1. A method of reducing inference in a received signal, comprising:

receiving a signal including transmissions from a plurality of cells;

determining transmission parameter hypotheses associated with the plurality of cells, each transmission parameter hypothesis from the transmission parameter hypotheses including a set of transmission parameters associated with all the cells from the plurality cells;

selecting at least one transmission parameter hypothesis based on a first metric applied to each hypothesis; and

refining transmission parameters associated with at least one cell from the plurality of cells, the refining including improving an accuracy of the transmission parameters associated with the at least one cell based on a second metric associated with each cell individually.

2. The method of claim **1**, wherein the selecting is based on a ranking of transmission parameter hypotheses based on the first metric associated with each hypothesis.

3. The method of claim **1**, wherein the refining further comprises subtracting a transmission associated with a cell from the received signal to obtain a refined signal, the subtracted transmission being determined based on at least one of the first metric or the second metric.

4. The method of claim **1**, wherein each transmission parameter hypothesis includes cell-specific transmission parameters for each cell from the plurality of cells, and the refining further comprises:

determining the second metric for each cell from the plurality of cells;

subtracting a transmission associated with a cell from the received signal to obtain a reduced received signal, the subtracted transmission being determined based on a cell from the plurality of cells having a highest second metric;

determining updated cell-specific transmission parameters for one or more cells based on the refined signal; and

determining an updated second metric for the one or more cells.

5. The method of claim **1**, further comprising repeating the steps of determining, selecting, and refining iteratively, wherein each subsequent repetition of the determining uses the results of the previous refining step.

6. The method of claim **1**, wherein the transmission parameters comprise at least one of a modulation order, a traffic to pilot ratio (TPR), a spatial scheme, or whether there is an interfering transmission.

7. The method of claim **6**, wherein the spatial scheme comprises one of a cell-specific reference signal (CRS) based transmission or a user equipment (UE) specific reference signal (UE-RS) based transmission.

8. The method of claim **7**, wherein the CRS based transmission comprises one of a space frequency block code (SFBC) transmission, a rank 1 transmission, a rank 2 transmission, or a higher rank transmission.

9. The method of claim **7**, wherein the UE-RS based transmission comprises transmission rank information.

10. The method of claim **1**, wherein the determining the transmission parameter hypotheses for the plurality of cells comprises:

determining a transmission parameter hypothesis for each of the plurality of cells;

determining the first metric for each transmission parameter hypothesis; and

ranking the plurality of transmission parameter hypotheses based on the first metric associated with each transmission parameter hypothesis.

11. The method of claim **10**, wherein the determining the transmission parameter hypotheses for the transmission parameters for each of the plurality cells comprises determining a set of hypotheses, the set of hypotheses including a hypothesis for each combination of possible values for n transmission parameters.

12. An apparatus for reducing inference in a received signal, comprising:

means for receiving a signal including transmissions from a plurality of cells;

means for determining transmission parameter hypotheses associated with the plurality of cells, each transmission parameter hypothesis from the transmission parameter

hypotheses including a set of transmission parameters associated with all the cells from the plurality cells;
means for selecting at least one transmission parameter hypothesis based on a first metric applied to each hypothesis; and
means for refining transmission parameters associated with at least one cell from the plurality of cells, the refining including improving an accuracy of the transmission parameters associated with the at least one cell based on a second metric associated with each cell individually.

13. The apparatus of claim **12**, wherein the means for selecting is configured to select the at least one transmission parameter hypothesis based on a ranking of transmission parameter hypotheses based on the first metric associated with each hypothesis.

14. The apparatus of claim **12**, wherein the means for refining is configured to subtract a transmission associated with a cell from the received signal to obtain a refined signal, the subtracted transmission being determined based on at least one of the first metric or the second metric.

15. The apparatus of claim **12**, wherein each transmission parameter hypothesis includes cell-specific transmission parameters for each cell from the plurality of cells, and the means for refining is configured to:
determine the second metric for each cell from the plurality of cells;
subtract a transmission associated with a cell from the received signal to obtain a reduced received signal, the subtracted transmission being determined based on a cell from the plurality of cells having a highest second metric;
determine updated cell-specific transmission parameters for one or more cells based on the refined signal; and
determine an updated second metric for the one or more cells.

16. The apparatus of claim **12**, further comprising means for repeating the steps of determining, selecting, and refining iteratively, wherein each subsequent repetition of the determining uses the results of the previous refining step.

17. The apparatus of claim **12**, wherein the transmission parameters comprise at least one of a modulation order, a traffic to pilot ratio (TPR), a spatial scheme, or whether there is an interfering transmission.

18. The apparatus of claim **17**, wherein the spatial scheme comprises one of a cell-specific reference signal (CRS) based transmission or a user equipment (UE) specific reference signal (UE-RS) based transmission.

19. The apparatus of claim **18**, wherein the CRS based transmission comprises one of a space frequency block code (SFBC) transmission, a rank 1 transmission, a rank 2 transmission, or a higher rank transmission.

20. The apparatus of claim **18**, wherein the UE-RS based transmission comprises transmission rank information.

21. The apparatus of claim **12**, wherein the means for determining the transmission parameter hypotheses for the plurality of cells is configured to:
determine a transmission parameter hypothesis for each of the plurality of cells;
determine the first metric for each transmission parameter hypothesis; and
rank the plurality of transmission parameter hypotheses based on the first metric associated with each transmission parameter hypothesis.

22. The apparatus of claim **21**, wherein the means for determining the transmission parameter hypotheses for the transmission parameters for each of the plurality cells is configured to determine a set of hypotheses, the set of hypotheses including a hypothesis for each combination of possible values for n transmission parameters.

23. An apparatus for reducing inference in a received signal, comprising:
a memory; and
at least one processor coupled to the memory and configured to:
receive a signal including transmissions from a plurality of cells;
determine transmission parameter hypotheses associated with the plurality of cells, each transmission parameter hypothesis from the transmission parameter hypotheses including a set of transmission parameters associated with all the cells from the plurality cells;
select at least one transmission parameter hypothesis based on a first metric applied to each hypothesis; and
refine transmission parameters associated with at least one cell from the plurality of cells by improving an accuracy of the transmission parameters associated with the at least one cell based on a second metric associated with each cell individually.

24. The apparatus of claim **23**, wherein the at least one processor is configured to select the at least one transmission parameter hypothesis based on a ranking of transmission parameter hypotheses based on the first metric associated with each hypothesis.

25. The apparatus of claim **23**, wherein the at least one processor is configured to refine the transmission parameters by subtracting a transmission associated with a cell from the received signal to obtain a refined signal, the subtracted transmission being determined based on at least one of the first metric or the second metric.

26. The apparatus of claim **23**, wherein each transmission parameter hypothesis includes cell-specific transmission parameters for each cell from the plurality of cells, and the at least one processor is configured to refine the transmission parameters by:
determining the second metric for each cell from the plurality of cells;
subtracting a transmission associated with a cell from the received signal to obtain a reduced received signal, the subtracted transmission being determined based on a cell from the plurality of cells having a highest second metric;
determining updated cell-specific transmission parameters for one or more cells based on the refined signal; and
determining an updated second metric for the one or more cells.

27. The apparatus of claim **23**, wherein the at least one processor is further configured to repeat the steps of determining, selecting, and refining iteratively, wherein each subsequent repetition of the determining uses the results of the previous refining step.

28. The apparatus of claim **23**, wherein the transmission parameters comprise at least one of a modulation order, a traffic to pilot ratio (TPR), a spatial scheme, or whether there is an interfering transmission.

29. The apparatus of claim **23**, wherein the at least one processor is configured to determine the transmission parameter hypotheses for the plurality of cells by:

determining a transmission parameter hypothesis for each of the plurality of cells;

determining the first metric for each transmission parameter hypothesis; and

ranking the plurality of transmission parameter hypotheses based on the first metric associated with each transmission parameter hypothesis.

30. A computer program product for reducing inference in a received signal, comprising:

a computer-readable medium comprising code for:

receiving a signal including transmissions from a plurality of cells;

determining transmission parameter hypotheses associated with the plurality of cells, each transmission parameter hypothesis from the transmission parameter hypotheses including a set of transmission parameters associated with all the cells from the plurality cells;

selecting at least one transmission parameter hypothesis based on a first metric applied to each hypothesis; and

refining transmission parameters associated with at least one cell from the plurality of cells, the refining including improving an accuracy of the transmission parameters associated with the at least one cell based on a second metric associated with each cell individually.

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