

CLAIMS

1. A system comprising:

a multiple antenna system (MAS) with multi-user (MU) transmissions ("MU-
5 MAS") comprising:

a plurality of wireless user devices;

a plurality of cooperative distributed antennas or wireless transceiver devices
communicatively coupled to the wireless user devices and with overlapping coverage at
locations of the wireless user devices;

10 a spatial processing logic employing spatial processing to exploit inter-cell
interference for creating a plurality of concurrent non-interfering downlink or uplink
data links with the user devices within the same frequency band;

wherein power transmitted from the distributed antennas is not constrained to
any particular power level, resulting in the intentional creation of inter-cell interference
15 throughout the cell, the inter-cell interference exploited to increase capacity of the
wireless communications network.

2. A system comprising:

a multiple antenna system (MAS) with multi-user (MU) transmissions ("MU-
20 MAS") comprising:

a plurality of wireless user devices;

a plurality of cooperative distributed antennas or wireless transceiver devices communicatively coupled to the wireless user devices and with overlapping coverage at locations of the wireless user devices;

5 a spatial processing logic employing spatial processing to exploit inter-cell interference for creating a plurality of concurrent non-interfering downlink or uplink data links with the user devices within the same frequency band;

wherein the wireless communications network is a cellular network such as the LTE network;

10 wherein closed-loop precoding methods are employed to send simultaneous non-interfering data streams from the BTSs to the UEs over the downlink (DL) channel; and

wherein every UE uses the cell-specific reference signal (CRS) to estimate the channel state information (CSI) from all BTSs or from only the BTSs within its own user-cluster, wherein the user-cluster is defined as the set of BTSs that are reachable from the UE location.

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3. The system as in claim 2 wherein the CP estimates the time and frequency selectivity of the channel and dynamically re-allocates the CRS for different BTSs to different resource elements.

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4. A system comprising:

a multiple antenna system (MAS) with multi-user (MU) transmissions ("MU-MAS") comprising:

a plurality of wireless user devices;

a plurality of cooperative distributed antennas or wireless transceiver devices communicatively coupled to the wireless user devices and with overlapping coverage at locations of the wireless user devices;

a spatial processing logic employing spatial processing to exploit inter-cell
5 interference for creating a plurality of concurrent non-interfering downlink or uplink data links with the user devices within the same frequency band;

wherein the wireless communications network is a cellular network such as the LTE network;

wherein closed-loop precoding methods are employed to send simultaneous non-
10 interfering data streams from the BTSs to the UEs over the downlink (DL) channel; and

wherein every UE uses the CSI reference signal (CSI-RS) or the demodulation reference signal (DM-RS) or combination of both to estimate the CSI from all BTSs or from only the BTSs within its own user-cluster.

15 5. The system as in claim 4 wherein the transmit power from the BTSs is decreased to reduce the number of BTSs in the user-cluster below the maximum number of antennas supported by the CSI-RS scheme in the LTE standard.

 6. The system as in claim 4 wherein the BTSs within the user-cluster are
20 divided into subsets and the CSI-RS is sent from one subset of BTSs at a time with given periodicity.

7. The system as in claim 6 wherein the periodicity of the CSI-RS for different subsets is determined based on the channel coherence time of the UE as well as the periodicity values supported by the LTE standard.

5 8. The system as in claim 4 wherein different patterns and periodicities than in the LTE standard are allowed for the CSI-RS to enable higher number of BTSs in the system.

9. A system comprising:

10 a multiple antenna system (MAS) with multi-user (MU) transmissions ("MU-MAS") comprising:

a plurality of wireless user devices;

a plurality of cooperative distributed antennas or wireless transceiver devices communicatively coupled to the wireless user devices and with overlapping coverage at

15 locations of the wireless user devices;

a spatial processing logic employing spatial processing to exploit inter-cell interference for creating a plurality of concurrent non-interfering downlink or uplink data links with the user devices within the same frequency band;

wherein the wireless communications network is a cellular network such as the

20 LTE network;

wherein closed-loop precoding methods are employed to send simultaneous non-interfering data streams from the BTSs to the UEs over the downlink (DL) channel; and

wherein the UE reports the RI, PMI and CQI to the CP via the PUCCH.

10. A system comprising:
- a multiple antenna system (MAS) with multi-user (MU) transmissions ("MU-MAS") comprising:
- 5 a plurality of wireless user devices;
- a plurality of cooperative distributed antennas or wireless transceiver devices communicatively coupled to the wireless user devices and with overlapping coverage at locations of the wireless user devices;
- a spatial processing logic employing spatial processing to exploit inter-cell
- 10 interference for creating a plurality of concurrent non-interfering downlink or uplink data links with the user devices within the same frequency band;
- wherein the wireless communications network is a cellular network such as the LTE network;
- wherein closed-loop precoding methods are employed to send simultaneous non-
- 15 interfering data streams from the BTSs to the UEs over the downlink (DL) channel;
- wherein the UE reports the RI, PMI and CQI to the CP via the PUSCH.
11. The system as in claim 10 wherein the system estimates the channel frequency-selectivity and dynamically adjusts the PMI to support larger number of
- 20 BTSs for the same available uplink (UL) resource.

12. A system comprising:

a multiple antenna system (MAS) with multi-user (MU) transmissions ("MU-MAS") comprising:

a plurality of wireless user devices;

a plurality of cooperative distributed antennas or wireless transceiver devices
5 communicatively coupled to the wireless user devices and with overlapping coverage at
locations of the wireless user devices;

a spatial processing logic employing spatial processing to exploit inter-cell
interference for creating a plurality of concurrent non-interfering downlink or uplink
data links with the user devices within the same frequency band;

10 wherein the wireless communications network is a cellular network such as the
LTE network;

wherein open-loop precoding methods are employed to send simultaneous non-
interfering data streams from the BTSs to the UEs over the DL channel.

15 13. A system comprising:

a multiple antenna system (MAS) with multi-user (MU) transmissions ("MU-MAS") comprising:

a plurality of wireless user devices;

a plurality of cooperative distributed antennas or wireless transceiver devices
20 communicatively coupled to the wireless user devices and with overlapping coverage at
locations of the wireless user devices;

a spatial processing logic employing spatial processing to exploit inter-cell interference for creating a plurality of concurrent non-interfering downlink or uplink data links with the user devices within the same frequency band;

wherein the wireless communications network is a cellular network such as the
5 LTE network;

wherein open-loop methods are employed to receive simultaneous non-interfering data streams from the UEs to the BTSs over the UL channel.

14. The system as in claim 12 wherein the SRS or DMRS is used to estimate
10 the channel impulse response from all UEs to the BTSs.

15. The system as in claim 14 wherein different SRSs or DMRSs are assigned to different antennas of every UE.

15 16. The system as in claim 14 wherein different SRSs or DMRSs are assigned to different subsets of BTSs to reduce interference between non-cooperative BTSs.

17. The system as in claim 14 wherein the SRS or DMRS are assigned based
20 on frequency hopping patterns to exploit channel frequency diversity.

18. The system as in claim 14 wherein the active UEs are divided into groups and the same set of SRSs or DMRSs is assigned to each group over consecutive time slots.

5 19. The system as in claim 18 wherein the shortest channel coherence time is estimated for all active UEs, and the maximum number of UE groups as well as the periodicity of the SRS or DMRS time multiplexing scheme is calculated based on that information.

10 20. The system as in claim 13 wherein time and frequency synchronization among UEs is achieved by exploiting DL signaling information.

21. The system as in claim 20 wherein the BTSs are synchronized to the same reference clock via direct wiring to the same physical clock or sharing a common
15 time and frequency reference through global positioning system disciplined oscillators (GPSDOs).

22. The system as in claim 20 wherein the relative propagation delays between UEs are avoided by processing the UL frames only for those UEs linked to the
20 same set of BTSs, thereby guaranteeing time synchronization between UEs.

23. The system as in claim 20 wherein the relative propagation delays between UEs are pre-compensated at the UE side before UL transmission to guarantee time synchronization of the UEs at the BTS receivers.

5 24. The system as in claim 13 wherein the open-loop methods comprise of non-linear spatial filters, including maximum likelihood (ML), decision feedback equalization (DFE) or successive interference cancellation (SIC) receivers.

25. The system as in claim 13 wherein the open-loop methods comprise of
10 linear spatial filters, including zero-forcing (ZF) or minimum mean squared error (MMSE) receivers.

26. The system as in claim 13 wherein SC-FMDA is used to multiplex the UEs in the frequency domain.

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27. The system as in claim 12 wherein RF calibration is used to convert UL CSI into DL CSI thereby exploiting UL/DL channel reciprocity.

28. The system as in claim 13 wherein the SRS or DMRS is used to estimate
20 the channel impulse response from all UEs to the BTSs.