CLAIMS

1. An apparatus for wireless communications, comprising:

a processing system configured to generate a plurality of transmit beamforming refinement frames for a sector sweep, each transmit beamforming refinement frame comprising a preamble, a data field, at least one beamforming training field, and an indication of whether the transmit beamforming refinement frame is a last transmit beamforming refinement frame in the sector sweep;

a first interface configured to output the transmit beamforming refinement frames for transmission using a first transmit beamforming sector for the preambles and data fields and using one or more of second transmit beamforming sectors for each beamforming training field; and

a second interface configured to obtain a first feedback frame from a wireless node, after the last transmit beamforming refinement frame in the sector sweep was output for transmission, the first feedback frame indicating one or more of the second transmit beamforming sectors, wherein the apparatus is configured to select at least one of the indicated one or more of the second transmit beamforming sectors for communication with the wireless node.

2. The apparatus of claim 1, wherein the first interface is configured to output the beamforming training fields for transmission via different sets of the second transmit beamforming sectors.

3. The apparatus of claim 1, wherein the indication of whether the transmit beamforming refinement frame is the last transmit beamforming refinement frame in the sector sweep is provided via a single bit.

4. The apparatus of claim 1, wherein the indication of whether the transmit beamforming refinement frame is the last transmit beamforming refinement frame in the sector sweep is provided via a plurality of bits, wherein the plurality of bits also indicate whether a corresponding transmit beamforming frame is at a start of the sector sweep or is a continuation of the sector sweep.

5. The apparatus of claim 1, wherein the indication of whether the transmit beamforming refinement frame is the last transmit beamforming refinement frame in the sector sweep is provided by a counter of the transmit beamforming refinement frames.

6. The apparatus of claim 1, wherein:

the processing system is configured to generate one or more data frames; and

the first interface is further configured to output the data frames for transmission, wherein each data frame is output for transmission between at least two of the transmit beamforming refinement frames.

7. The apparatus of claim 1, wherein:

the second interface is further configured to obtain one or more first acknowledgment frames from the wireless node, each acknowledging one of the transmit beamforming refinement frames;

the processing system is configured to generate a subsequent transmit beamforming refinement frame after obtaining the one or more first acknowledgement frames; and

the first interface is further configured to output the subsequent transmit beamforming refinement frame for transmission.

8. The apparatus of claim 1, wherein:

the first feedback frame also has an indication of a receive signal quality of each of the indicated second transmit beamforming sectors; and

the selection is based on corresponding receive signal quality.

9. The apparatus of claim 1, wherein:

the first feedback frame also includes a request for a receive beamforming training phase;

the processing system is further configured to generate, in response to the request, a plurality of receive beamforming refinement frames, each receive beamforming refinement frame comprising a preamble, a data field, at least one beamforming training field, and an indication of whether the receive beamforming refinement frame is a last receive beamforming refinement frame in the receive beamforming refinement phase; and

the first interface is further configured to output the receive beamforming refinement frames for transmission using at least one of the first transmit beamforming sector or one of the second transmit beamforming sectors indicated in the first feedback frame.

10. The apparatus of claim 9, wherein:

the second interface is further configured to obtain a second acknowledgement frame from the wireless node, after the last receive beamforming refinement frame in the receive beamforming refinement phase is output for transmission; and

the apparatus is configured to communicate with the wireless node using one of the second transmit beamforming sectors indicated in the first feedback frame after obtaining the second acknowledgment frame.

11. The apparatus of claim 9, wherein:

the first feedback frame also indicates a requested number of training fields for the receive beamforming refinement phase; and

the processing system is configured to include the requested number of training fields, in the receive beamforming refinement frames.

12. The apparatus of claim 9, wherein the first interface is configured to output each of the receive beamforming refinement frames using a different third transmit beamforming sector.

13. The apparatus of claim 12, wherein the different third transmit beamforming sectors are selected from the second transmit beamforming sectors indicated in the first feedback frame.

14. The apparatus of claim 12, wherein:

the second interface is further configured to obtain a second acknowledgement frame from the wireless node, after the last receive beamforming refinement frame in the receive beamforming refinement phase was output for transmission, the second acknowledgment frame indicating one of the third transmit beamforming sectors; and

the apparatus is configured to communicate with the wireless node using the indicated third transmit beamforming sector after obtaining the second acknowledgment frame.

15. The apparatus of claim 9, wherein:

the processing system is configured to generate one or more data frames; and

the first interface is further configured to output the data frames for transmission, wherein each data frame is output for transmission between at least two of the receive beamforming refinement frames.

16. An apparatus for wireless communications, comprising:

a processing system configured to generate a plurality of receive beamforming refinement frames, each receive beamforming refinement frame comprising a preamble, a data field, at least one beamforming training field, and an indication of whether the receive beamforming refinement frame is a last receive beamforming refinement frame in a receive beamforming refinement phase; and

a first interface is configured to output the receive beamforming refinement frames for transmission using at least one first transmit beamforming sector.

17. The apparatus of claim 16, further comprising:

a second interface configured to obtain a first acknowledgement frame from a wireless node, after the last receive beamforming refinement frame in the receive beamforming refinement phase was output for transmission; and

the apparatus is configured to communicate with the wireless node using a second transmit beamforming sector after obtaining the first acknowledgment frame.

18. The apparatus of claim 16, wherein the indication of whether the receive beamforming refinement frame is the last receive beamforming refinement frame in the receive beamforming refinement phase is provided via a single bit.

19. The apparatus of claim 16, wherein the indication of whether the receive beamforming refinement frame is the last receive beamforming refinement frame in the receive beamforming refinement phase is provided via a plurality of bits, wherein the plurality of bits also indicate whether a corresponding receive beamforming frame is at a start of the receive beamforming refinement phase or is a continuation of the receive beamforming refinement phase.

20. The apparatus of claim 16, wherein the indication of whether the receive beamforming refinement frame is the last receive beamforming refinement frame in the receive beamforming refinement phase is provided by a counter of the receive beamforming refinement frames.

21. The apparatus of claim 16, wherein:

the processing system is configured to generate one or more data frames; and

the first interface is further configured to output the data frames for wherein each data frame is output for transmission between at least two of the receive beamforming frames.

22. The apparatus of claim 16, further comprising:

a second interface configured to obtain a first feedback frame including a requested number of training fields for the receive beamforming refinement phase, wherein the processing system is configured to include the requested number of training fields, collectively, in the receive beamforming refinement frames.

23. An apparatus for wireless communications, comprising:

a first interface configured to obtain a plurality of transmit beamforming refinement frames during a sector sweep, wherein

a first portion of each transmit beamforming refinement frame is obtained via a first receive beamforming sector,

training fields of the transmit beamforming refinement frames are obtained while the apparatus is in an omnidirectional receive antenna mode,

each transmit beamforming refinement frame has an indication of whether the transmit beamforming refinement frame is a last transmit beamforming refinement frame in the sector sweep, and

a processing system configured to

determine the sector sweep is over after identifying the last transmit beamforming refinement frame based on the indication contained therein,

in response to the determination,

select at least one first transmit beamforming sector that was used to transmit one of the training fields, based on received signal quality of the one of the training fields, and

generate a first feedback frame indicating the selected at least one first transmit beamforming sector; and

a second interface configured to output the first feedback frame for transmission.

24. The apparatus of claim 23, wherein the first interface is configured to obtain the indication of each beamforming refinement frame via a single bit.

25. The apparatus of claim 23, wherein the first interface is configured to obtain the indication of each beamforming refinement frame via a plurality of bits, wherein the plurality of bits also indicates whether a corresponding transmit beamforming frame is at a start of the sector sweep or is a continuation of the sector sweep.

26. The apparatus of claim 23, wherein the first interface is configured to obtain the indication of each beamforming refinement frame via a counter of the transmit beamforming refinement frames.

27. The apparatus of claim 23, wherein:

the first interface is further configured to obtain one or more data frames, each data frame being obtained between two of the transmit beamforming refinement frames; and

the processing system is further configured to process the data frames.

28. The apparatus of claim 23, wherein:

the processing system is further configured to generate one or more first acknowledgment frames, each first acknowledgment frame acknowledging one of the transmit beamforming refinement frames; and

the second interface is further configured to output the first acknowledgment frames for transmission.

29. The apparatus of claim 23, wherein the first feedback frame also has an indication of a receive signal quality of each of the selected at least one first transmit beamforming sector.

30. The apparatus of claim 23, wherein:

the first feedback frame also includes a request for a receive beamforming training phase; the first interface is further configured to obtain, in response to the request, a plurality of receive beamforming refinement frames, each receive beamforming refinement frame comprising a first portion obtained via the first receive beamforming sector, at least one beamforming training field obtained via one or more second receive beamforming sectors, and an indication of whether the receive beamforming refinement frame is a last receive beamforming refinement frame in the receive beamforming refinement phase; and

the processing system is configured to process the training fields to select one or more of the second receive beamforming sectors for use in communication with a wireless node.

31. The apparatus of claim 30, wherein:

the processing system is further configured generate a second acknowledgement frame, after obtaining the last receive beamforming refinement frame in the receive beamforming refinement phase;

the second interface is further configured to output the second acknowledgment frame for transmission; and

the apparatus is configured to communicate with the wireless node using one of the selected second receive beamforming sectors after obtaining the second acknowledgment frame.

32. The apparatus of claim 30, wherein:

the first feedback frame also indicates a requested number of training fields for the receive beamforming refinement phase; and

the processing system is configured to process the requested number of training fields obtained, collectively, in the receive beamforming refinement frames, using different receive beamforming sectors.

33. The apparatus of claim 30, wherein:

the processing system is further configured to generate a second acknowledgement frame, after obtaining the last receive beamforming refinement frame in the receive beamforming refinement phase, the second acknowledgment frame indicating at least one beamforming sector that was used to transmit one of the receive beamforming refinement frames; and

the second interface is configured to output the second acknowledgment frame for transmission.

34. The apparatus of claim 30, wherein:

the first interface is further configured to obtain one or more data frames, wherein each data frame is obtained between two receive beamforming refinement frames; and

the processing system is further configured to process the data frames.

35. An apparatus for wireless communications, comprising:

a first interface configured to obtain from a wireless node, during a receive beamforming phase, a plurality of receive beamforming refinement frames, each receive beamforming refinement frame comprising a first portion obtained via a receive beamforming sector, at least one of the plurality of beamforming training frames being obtained via a different receive beamforming sector than at least another of the plurality of beamforming training frames, and wherein each of the plurality of receive beamforming refinement frames comprises an indication of whether the receive beamforming refinement frame is a last receive beamforming refinement frame in the receive beamforming refinement phase; and

a processing system configured to process the plurality of beamforming training frames to select one of the different receive beamforming sectors for use in communication with the wireless node.

36. The apparatus of claim 35, wherein:

the processing system is further configured to generate a first acknowledgement frame, after obtaining the last receive beamforming refinement frame in the receive beamforming refinement phase; and

the apparatus further comprises a second interface configured to output the first acknowledgment frame for transmission.

37. The apparatus of claim 35, wherein the first interface is configured to obtain the indication of whether the receive beamforming refinement frame is the last receive beamforming refinement frame in the receive beamforming refinement phase via a single bit.

38. The apparatus of claim 35, wherein the first interface is configured to obtain the indication of whether the receive beamforming refinement frame is the last receive beamforming refinement frame in the receive beamforming refinement phase via a plurality of bits, wherein the plurality of bits also indicate whether a corresponding receive beamforming frame is at a start of the receive beamforming refinement phase or is a continuation of the receive beamforming refinement phase.

39. The apparatus of claim 35, wherein the first interface is configured to obtain the indication of each beamforming refinement frame via a counter of the receive beamforming refinement frames.

40. The apparatus of claim 35, wherein:

the first interface is further configured to obtain one or more data frames, each data frame being obtained between two of the receive beamforming refinement frames; and

the processing system is further configured to process the data frames.

41. The apparatus of claim 35, wherein:

the processing system is further configured to generate a first feedback frame, the first feedback frame including a requested number of training fields for the receive beamforming refinement phase;

the apparatus further comprises a second interface configured to output the first feedback frame for transmission to the wireless node; and

the processing system is configured to evaluate the receive beamforming sectors by processing the requested number of training fields obtained, in the receive beamforming refinement frames.

42. The apparatus of claim 35, wherein:

the processing system is further configured to generate a first acknowledgement frame, after obtaining the last receive beamforming refinement frame in the receive beamforming refinement phase, the first acknowledgment frame indicating at least one beamforming sector that was used by the wireless node to transmit one of the receive beamforming refinement frames; and

the apparatus further comprises a second interface further configured to output the first acknowledgment frame for transmission to a wireless device.