embodiment, the processing unit is coupled to a local-area network or a wide-area network for data processing and communications with remote devices, such as other processing units, the Internet, remote storage facilities, or the like.

FIG. 31 illustrates a block diagram of an embodiment of a communications device 3100, which may be equivalent to one or more devices (e.g., UEs, NBs, etc.) discussed above. The communications device 3100 may include a processor 3104, a memory 3106, a cellular interface 3110, a supplemental wireless interface 3112, and a supplemental interface 3114, which may (or may not) be arranged as shown in FIG. 31. The processor 3104 may be any component capable of performing computations and/or other processing related tasks, and the memory 3106 may be any component capable of storing programming and/or instructions for the processor 3104. The cellular interface 3110 may be any component or collection of components that allows the communications device 3100 to communicate using a cellular signal, and may be used to receive and/or transmit information over a cellular connection of a cellular network. The supplemental wireless interface 3112 may be any component or collection of components that allows the communications device 3100 to communicate via a non-cellular wireless protocol, such as a Wi-Fi or Bluetooth protocol, or a control protocol. The device 3100 may use the cellular interface 3110 and/or the supplemental wireless interface 3112 to communicate with any wirelessly enabled component, e.g., a base station, relay, mobile device, etc. The supplemental interface 3114 may be any component or collection of components that allows the communications device 3100 to communicate via a supplemental protocol, including wire-line protocols. In embodiments, the supplemental interface 3114 may allow the device 3100 to communicate with another component, such as a backhaul network component.

While embodiments of this disclosure has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications and combinations of the illustrative embodiments, as well as other embodiments of this disclosure, will be apparent to persons skilled in the art upon reference to the description. It

is therefore intended that the appended claims encompass any such modifications or embodiments.

WHAT IS CLAIMED IS:

1. A method for multiplexing data, the method comprising:

receiving a first binary or M-ary data associated with a first multiplexed layer;

encoding the first binary or M-ary data by selecting a first codeword from a first codebook, wherein the first codebook is assigned exclusively to the first multiplexed layer;

multiplexing the first codeword with at least a second codeword from a second codebook to obtain multiplexed codewords, wherein the second codebook is assigned exclusively to a second multiplexed layer; and

transmitting the multiplexed codewords over shared resources of a network.

2. The method of claim 1, wherein encoding the first binary or M-ary data by selecting the first codeword comprises:

selecting the first codeword from a first set of codewords in the first codebook in accordance with a binary or M-ary value of the first binary or M-ary data, wherein each codeword in the first set of codewords is associated with a different binary or M-ary value.

3. The method of claim 2, wherein each codeword in the first set of codewords comprises a low density of non-zero values such that the corresponding codeword can be detected within multiplexed codewords in accordance with a message passing algorithm (MPA).

4. The method of claim 1, wherein the first multiplexed layer is associated with a first user and the second multiplexed layer is associated with a second user.

5. The method of claim 1, wherein the first multiplexed layer and the second multiplexed layer carry separate data streams associated with a common.

6. The method of claim 5, wherein the first multiplexed layer and the second multiplexed layer occupy different multiple-input-multiple-output (MIMO) spatial layers.

7. The method of claim 5, wherein the first multiplexed layer and the second multiplexed layer occupy different Orthogonal Frequency-Division Multiple Access (OFDMA) tones.

8. A transmitter comprising:

a processor; and

a computer readable storage medium storing programming for execution by the processor, the programming including instructions to:

receive a first binary or M-ary data associated with a first multiplexed layer;

encode the first binary or M-ary data by selecting a first codeword from a first codebook, wherein the first codebook is assigned exclusively to the first multiplexed layer;

multiplex the first codeword with at least a second codeword from a second codebook to obtain multiplexed codewords, wherein the second codebook is assigned exclusively to a second multiplexed layer; and

transmit the multiplexed codewords over shared resources of a network.

9. A method for receiving data, the method comprising:

receiving a signal carrying multiplexed codewords, the multiplexed codewords including a plurality of codewords communicated over shared resources of a network, wherein each of the plurality of codewords belongs to a different one of a plurality of codebooks, wherein each of the plurality of codebooks are associated with a different one of a plurality of multiplexed layers;

identifying, by a receiver, a first one of the plurality of codewords within the multiplexed codewords, the first codeword belonging to a first one of the plurality of codebooks assigned exclusively to a first one of the plurality of multiplexed layers, wherein the receiver is associated with the first multiplexed layer; and

decoding the first codeword to obtain a first binary or M-ary data.

10. The method of claim 9, wherein identifying the first codeword within the multiplexed codewords comprises applying a message passing algorithm (MPA) to detect the first codeword amongst the plurality of codewords included within the multiplexed codewords.

11. The method of claim 10, wherein decoding the first codeword to obtain the first binary or M-ary data comprises:

mapping the first codeword directly to a binary or M-ary value of the first binary or M-ary data, wherein each codeword in the first codebook is associated with a different binary or M-ary value.

12. The method of claim 10, wherein different ones of the plurality of multiplexed layers occupy different multiple-input-multiple-output (MIMO) spatial layers.

13. The method of claim 9, wherein different ones of the plurality of multiplexed layers occupy different Orthogonal Frequency-Division Multiple Access (OFDMA) tones.

14. A receiver comprising:

a processor; and

a computer readable storage medium storing programming for execution by the processor, the programming including instructions to:

receive a signal carrying multiplexed codewords, the multiplexed codewords including a plurality of codewords communicated over shared resources of a network, wherein each of the plurality of codewords belongs to a different one of a plurality of codebooks, wherein each of the plurality of codebooks are associated with a different one of a plurality of multiplexed layers;

identify a first one of the plurality of codewords within the multiplexed codewords, the first codeword belonging to a first one of the plurality of codebooks

assigned exclusively to a first one of the plurality of multiplexed layers, wherein the receiver is associated with the first multiplexed layer; and

decode the first codeword to obtain a first binary or M-ary data.

15. A method for designing Sparse Code Multiple Access (SCMA) code, the method comprising:

generating a plurality of multi-dimensional modulation codebooks; and

generating a plurality of sparse codebooks from the plurality of multi-dimensional modulation codebooks.

16. The method of claim 15, wherein each of the plurality of sparse codebooks comprises a plurality of sparse codewords, and wherein different sparse codewords within a sparse codebook are associated with different binary values.

17. The method of claim 15, wherein each codeword in the plurality of sparse codebooks comprise a low density of non-zero values such that the corresponding codeword can be detected within multiplexed codewords in accordance with a message passing algorithm (MPA).

18. The method of claim 15, wherein each of plurality of multi-dimensional modulation codebooks are assigned to a different multiplexed layer.

19. A method for designing Sparse Code Multiple Access (SCMA) code, the method comprising:

generating a plurality of mapping matrices;

generating at least one multi-dimensional constellation;

optimizing one or more of a permutation, a phase operator, and a conjugate operator; and

generating SCMA codewords in accordance with the mapping matrices, the at least one

multi-dimensional constellation, and one or more of the permutation, the phase operator, and the conjugate operator.

20. A method for designing low density signature (LDS) code, the method comprising:

generating a plurality of mapping matrices;

optimizing one or more phase operators; and

generating LDS signatures in accordance with the mapping matrices, the one or more phase operators, and a constellation.

21. The method of claim 20, wherein each of the LDS signatures are assigned to a different multiplexed layer.

embodiment, the processing unit is coupled to a local-area network or a wide-area network for data processing and communications with remote devices, such as other processing units, the Internet, remote storage facilities, or the like.

FIG. 31 illustrates a block diagram of an embodiment of a communications device 3100, which may be equivalent to one or more devices (e.g., UEs, NBs, etc.) discussed above. The communications device 3100 may include a processor 3104, a memory 3106, a cellular interface 3110, a supplemental wireless interface 3112, and a supplemental interface 3114, which may (or may not) be arranged as shown in FIG. 31. The processor 3104 may be any component capable of performing computations and/or other processing related tasks, and the memory 3106 may be any component capable of storing programming and/or instructions for the processor 3104. The cellular interface 3110 may be any component or collection of components that allows the communications device 3100 to communicate using a cellular signal, and may be used to receive and/or transmit information over a cellular connection of a cellular network. The supplemental wireless interface 3112 may be any component or collection of components that allows the communications device 3100 to communicate via a non-cellular wireless protocol, such as a Wi-Fi or Bluetooth protocol, or a control protocol. The device 3100 may use the cellular interface 3110 and/or the supplemental wireless interface 3112 to communicate with any wirelessly enabled component, e.g., a base station, relay, mobile device, etc. The supplemental interface 3114 may be any component or collection of components that allows the communications device 3100 to communicate via a supplemental protocol, including wire-line protocols. In embodiments, the supplemental interface 3114 may allow the device 3100 to communicate with another component, such as a backhaul network component.

The present disclosure also describes following examples

Example 1 A method for designing Sparse Code Multiple Access (SCMA) code, the method comprises:

generating a plurality of multi-dimensional modulation codebooks; and

generating a plurality of sparse codebooks from the plurality of multi-dimensional modulation codebooks.

Example 2 The method of Example 1, wherein each of the plurality of sparse codebooks comprises a plurality of sparse codewords, and wherein different sparse codewords within a sparse codebook are associated with different binary values.

Example 3 The method of Example 1, wherein each codeword in the plurality of sparse codebooks comprise a low density of non-zero values such that the corresponding codeword can be detected within multiplexed codewords in accordance with a message passing algorithm (MPA).

Example 4 The method of Example 1, wherein each of plurality of multi-dimensional modulation codebooks are assigned to a different multiplexed layer.

Example 5 A method for designing Sparse Code Multiple Access (SCMA) code, the method comprises:

generating a plurality of mapping matrices;

generating at least one multi-dimensional constellation;

optimizing one or more of a permutation, a phase operator, and a conjugate operator; and

generating SCMA codewords in accordance with the mapping matrices, the at least one multi-dimensional constellation, and one or more of the permutation, the phase operator, and the conjugate operator.

Example 6 A method for designing low density signature (LDS) code, the method comprising:

generating a plurality of mapping matrices;

optimizing one or more phase operators; and

generating LDS signatures in accordance with the mapping matrices, the one or more phase operators, and a constellation.

Example 7 The method of Example 6, wherein each of the LDS signatures are assigned to a different multiplexed layer.

While embodiments of this disclosure has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications and combinations of the illustrative embodiments, as well as other embodiments of this disclosure, will be apparent to persons skilled in the art upon reference to the description. It is therefore intended that the appended claims encompass any such modifications or embodiments.

WHAT IS CLAIMED IS:

1. A method for multiplexing data, the method comprising:

receiving a first binary or M-ary data associated with a first multiplexed layer;

encoding the first binary or M-ary data by selecting a first codeword from a first codebook, wherein the first codebook is assigned exclusively to the first multiplexed layer;

multiplexing the first codeword with at least a second codeword from a second codebook to obtain multiplexed codewords, wherein the second codebook is assigned exclusively to a second multiplexed layer; and

transmitting the multiplexed codewords over shared resources of a network.

2. The method of claim 1, wherein encoding the first binary or M-ary data by selecting the first codeword comprises:

selecting the first codeword from a first set of codewords in the first codebook in accordance with a binary or M-ary value of the first binary or M-ary data, wherein each codeword in the first set of codewords is associated with a different binary or M-ary value.

3. The method of claim 2, wherein each codeword in the first set of codewords comprises a low density of non-zero values such that the corresponding codeword can be detected within multiplexed codewords in accordance with a message passing algorithm (MPA).

4. The method of claim 1, wherein the first multiplexed layer is associated with a first user and the second multiplexed layer is associated with a second user.

5. The method of claim 1, wherein the first multiplexed layer and the second multiplexed layer carry separate data streams associated with a common.

6. The method of claim 5, wherein the first multiplexed layer and the second multiplexed layer occupy different multiple-input-multiple-output (MIMO) spatial layers.

7. The method of claim 5, wherein the first multiplexed layer and the second multiplexed layer occupy different Orthogonal Frequency-Division Multiple Access (OFDMA) tones.

8. A transmitter comprising:

a processor; and

a computer readable storage medium storing programming for execution by the processor, the programming including instructions to implement actions in a method in accordance with any one of claims 1 to 7.

9. A method for receiving data, the method comprising:

receiving a signal carrying multiplexed codewords, the multiplexed codewords including a plurality of codewords communicated over shared resources of a network, wherein each of the plurality of codewords belongs to a different one of a plurality of codebooks, wherein each of the plurality of codebooks are associated with a different one of a plurality of multiplexed layers;

identifying, by a receiver, a first one of the plurality of codewords within the multiplexed codewords, the first codeword belonging to a first one of the plurality of codebooks assigned exclusively to a first one of the plurality of multiplexed layers, wherein the receiver is associated with the first multiplexed layer; and

decoding the first codeword to obtain a first binary or M-ary data.

10. The method of claim 9, wherein identifying the first codeword within the multiplexed codewords comprises applying a message passing algorithm (MPA) to detect the first codeword amongst the plurality of codewords included within the multiplexed codewords.

11. The method of claim 10, wherein decoding the first codeword to obtain the first binary or M-ary data comprises:

mapping the first codeword directly to a binary or M-ary value of the first binary or M-

ary data, wherein each codeword in the first codebook is associated with a different binary or M-ary value.

12. The method of claim 10, wherein different ones of the plurality of multiplexed layers occupy different multiple-input-multiple-output (MIMO) spatial layers.

13. The method of claim 9, wherein different ones of the plurality of multiplexed layers occupy different Orthogonal Frequency-Division Multiple Access (OFDMA) tones.

14. A receiver comprising:

a processor; and

a computer readable storage medium storing programming for execution by the processor, the programming including instructions to implement actions in a method in accordance with any one of claims 9 to 13.