System and Method for Semi-Orthogonal Multiple Access

BACKGROUND

[0003] A common goal of successive generation of radio frequency communications systems is to increase the amount of information transmitted in a given communications band. As an example, NTT Docomo has proposed Non-Orthogonal Multiple Access (NOMA) as a candidate for a Fifth Generation (5G) radio access technology. NOMA combines power optimization on a per user equipment (UE) basis and superposition coding. A detailed description of NOMA is provided in document Saito, et al, "Non-Orthogonal Multiple Access (NOMA) for Cellular Future Radio Access," VTC'13, June 2013, which is hereby incorporated herein by reference.

SUMMARY

[0004] Example aspects of the present disclosure which provide a system and method for semi-orthogonal multiple access (SOMA).

[0005] In accordance with an example aspect of the present disclosure, a method for operating a transmitting device using semi-orthogonal multiple access (SOMA) is provided. The method includes determining, by the transmitting device, power allocations, sub-quadrature amplitude modulation (sub-QAM) allocations, and coding rates for a first receiving device and a second receiving device in accordance with channel information associated with the first receiving device and the second receiving device, and transmitting, by the transmitting device, information about a first power allocation for the first receiving device, and a first sub-QAM allocation for the first receiving device to the first receiving device.

[0006] In accordance with another example aspect of the present disclosure, a method for operating a first receiving device operating in a semi-orthogonal multiple access (SOMA) communications system is provided. The method includes determining, by the first receiving device, power allocations, sub-quadrature amplitude modulation (sub-QAM) allocations, and coding rates of the first receiving device and a second receiving device, wherein one of the first receiving device and a second receiving device has a higher signal to noise ratio (SNR) channel with a transmitting device than the other one of the first receiving device and the second receiving device, and receiving, by the first receiving device, a QAM symbol. The method also comprises demapping, by the first receiving device, the QAM symbol in accordance with the sub-QAM allocation of the first receiving device, thereby producing encoded data, decoding, by the first receiving device, the encoded data in accordance with the coding rate of the first receiving device, thereby producing decoded data, and processing, by the first receiving device, the decoded data.

[0007] In accordance with another example aspect of the present disclosure, a method for operating a second receiving device operating in a semi-orthogonal multiple access (SOMA) communications system is provided. The method includes determining, by the second receiving device, a constellation map of a first receiving device and the second receiving device, wherein a first channel between a transmitting device and the first receiving device is a high signal to noise ratio (SNR) channel and a second channel between the transmitting device and the second receiving device is a low SNR channel, and receiving, by the second receiving device, a QAM symbol. The method also includes demapping, by the second receiving device, the QAM symbol in accordance with the constellation map, thereby producing encoded data, decoding, by the second receiving device, the encoded data in accordance with a coding rate of the second receiving device, thereby producing decoded data, and processing, by the second receiving device, the decoded data.

[0008] In accordance with another example aspect of the present disclosure, a transmitting device is provided. The transmitting device includes a processor, and a transmitter operatively coupled to the processor. The processor determines power allocations and sub-quadrature amplitude modulation (sub-QAM) allocations for a first receiving device and a second receiving device in accordance with channel information associated with the first receiving device and the second receiving device. The transmitter transmits information about a first power allocation for the first receiving device, and a first sub-QAM allocation for the first receiving device to the first receiving device.

[0009] One advantage of an aspect of the present disclosure is that decoding requirements are simple and leverages interference structure for communicating devices operating in a low signal to noise ratio environment.

[0010] A further advantage of an aspect of the present disclosure is that a uniform control signaling format is utilized for all communicating devices, thereby simplifying control signaling.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] For a more complete understanding of the present disclosure, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawing, in which:

[0012] Figure 1 illustrates an example communications system according to example embodiments described herein;

[0013] Figure 2a illustrates an example communications system highlighting an arrangement of UEs according to example embodiments described herein;

[0014] Figure 2b illustrates an example bandwidth and data rate allocation for communications system in an orthogonal frequency division multiple access (OFDMA) communications system;

[0015] Figure 2c illustrates an example bandwidth and data rate allocation for communications system in a NOMA communications system;

[0016] Figure 3 illustrates a first example PMDMA (or SOMA) constellation according to example embodiments described herein;

[0017] Figure 4 illustrates a second example PMDMA (or SOMA) constellation according to example embodiments described herein;

[0018] Figure 5 illustrates a third example PMDMA (or SOMA) constellation according to example embodiments described herein;

[0019] Figure 6 illustrates a flow diagram of example operations occurring in a transmitting device as the transmitting device adjusts PMDMA (or SOMA) configuration according to example embodiments described herein;

[0031] Figure 15b illustrates a flow diagram of third example operations occurring in a receiving device receiving implicit signaling of a power offset according to example embodiments described herein;

[0032] Figure 16 illustrates a computing platform that may be used for implementing, for example, the devices and methods described herein, according to example embodiments;

[0033] Figure 17 illustrates an example first communications device according to example embodiments described herein; and

[0034] Figure 18 illustrates an example second communications device according to example embodiments described herein.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0035] The operating of the current example embodiments and the structure thereof are discussed in detail below. It should be appreciated, however, that the present disclosure can be embodied in a wide variety of specific contexts. The specific embodiments discussed are merely illustrative of specific structures of the disclosure and ways to operate the disclosure, and do not limit the scope of the disclosure.

[0036] The present disclosure will be described with respect to example embodiments in a specific context, namely communications systems that use advanced multiple access techniques to improve performance for communicating devices while maintaining a uniform level of control information across communicating devices and reducing decoding complexity. The disclosure may be applied to standards compliant communications systems, such as those that are compliant with Third Generation Partnership Project (3GPP), IEEE 802.11, and the like, technical standards, and non-standards compliant communications systems, that use advanced multiple access techniques.

[0037] Figure 1 illustrates an example communications system 100. Communications system 100 includes an evolved NodeB (eNB) 105 that may serve a plurality of UE, such as UE 110, UE 112, UE 114, UE 116, and UE 120. eNB 105 may schedule transmission opportunities for the UEs and signal information regarding the transmission opportunities to the UEs. Based on the type of the transmission opportunity, the UEs may receive transmissions or make transmissions in accordance with the scheduled transmission opportunities. eNB 105, as well as a subset of the UEs, may implement example embodiments presented herein, namely, power and modulation domain multiple access, also known as semi-orthogonal multiple access (SOMA).

QAM layers. In practice, the PMDMA constellations may be partitioned into 2 or more sub-QAMs, wherein QAM layers are examples of sub-QAMs with each QAM layer being associated with 2 bits, depending on the number of UEs being served, for example. Furthermore, the number of bits assigned to each sub-QAM (e.g., QAM layer) may be the same or different. As an illustrative example, a QAM layer comprises two bits of the same LLR properties. As an illustrative example, a PMDMA constellation of 6-bits may be partitioned into 3 QAM layers, with 2 bits being assigned to a first QAM layer, 2 bits being assigned to a second QAM layer, and 2 bits being assigned to a third QAM layer. In this example, each QAM layer is a sub-QAM, however, a sub-QAM may include 1 or more QAM layers. As discussed previously, a UE may be assigned at least one QAM layer. A maximum number of UEs per constellation map may be achieved when each UE is assigned one QAM layer, i.e., the maximum number of UEs per constellation map is equal to the number of QAM layers in the constellation map. Therefore, the illustrative examples of 4-bit and 6-bit PMDMA constellations being partitioned into 2 and 3 QAM layers should not be construed as being limiting to scope of the example embodiments.

[0052] According to an example embodiment, the UEs do not need to decode transmissions of other UEs, therefore, successive interference cancellation (SIC) is not needed in the decoding process. As an illustrative example, consider the communications system as shown in Figure 2a, decoding by UE1 does not need to decode transmissions of UE2. Furthermore, the UEs may perform accurate QAM soft de-mapping since interference from other UEs are structured. As another illustrative example, consider the communications system as shown in Figure 2a, UE2 can perform accurate QAM soft de-mapping since interference from transmissions to UE1is structured.

[0053] According to an example embodiment, a shared demodulation reference signal (DMRS) may be used for channel estimation. The shared DMRS may be designed for UE2 (i.e., the UE with the lower quality channel). According to another example embodiment, the power offset (or the power allocation) for UE1 (i.e., the UE with the higher quality channel) is provided to the UEs. The power offset may also be used by UE2 to improve its QAM de-mapping performance. Since the power offsets are already signaled to the UEs, no additional signaling is needed. According to another example embodiment, the control information is more uniform for both UEs, with the control information comprising the power offset of UE1 and the MCS and QAM layer of each UE. The power offset (or the power allocation) may be explicitly signaled to the UEs. Alternatively, the power offset (or the power allocation) may be implicitly signaled to the UEs. Examples of explicit signaling and implicit signaling are provided below. Hence, the

maps may be dependent on selection criterion such as support for the non-legacy constellation maps, device compatibility, signaling overhead constraints, power offset, and the like. As an illustrative example, the transmitting device may select a legacy constellation map or a non-legacy constellation map with an inherent power offset that most closely matches the power offset or meets the selection criterion. The transmitting device may transmit an index corresponding to the selected constellation map to the receiving devices. The receiving devices may be able to determine the power offset by referencing the selected constellation map using the index received from the transmitting device.

[0080] Figure 15a illustrates a flow diagram of third example operations 1500 occurring in a transmitting device implicitly signaling a power offset to a receiving device. Operations 1500 may be indicative of operations occurring in a transmitting device as the transmitting device implicitly signals a power offset to a receiving device. The transmitting device may be an eNB, for example.

[0081] Operations 1500 may begin with the transmitting device determining a power offset for receiving devices (block 1505). The transmitting device may determine the power offset by jointly determining a first power allocation for a first receiving device with a high quality channel between itself and the transmitting device and a second power allocation for a second receiving device with a low quality channel between itself and the transmitting device. The transmitting device may select one of a plurality of legacy constellation maps and non-legacy constellation maps with an inherent power offset that most closely matches the power offset (block 1510). As an illustrative example, the inherent power offset of the selected constellation map (either legacy constellation map or non-legacy constellation map) may be the closest to the power offset determined for the receiving devices. As another illustrative example, the inherent power offset of the selected constellation map (either legacy constellation map or non-legacy constellation map) may be the smallest power offset greater than the power offset determined for the receiving devices. As another illustrative example, the inherent power offset of the selected legacy constellation map is the closest to the power offset but is not a close as some of the non-legacy constellation maps, however, the receiving devices do not support non-legacy constellation maps, so the legacy constellation map is selected. The transmitting device may select the legacy constellation map or the non-legacy constellation based on a selection criterion, including support for the non-legacy constellation maps, device compatibility, signaling overhead constraints, power offset, and the like. The transmitting device may send the indication of the selected constellation map to the receiving devices (block 1515). The transmitting device may also send other information to the receiving devices, including QAM layer allocation, coding rate, and the like.

encode data utilizing the constellation map assigned to communications device 1800. Data processing unit 1822 is configured to generate QAM symbols utilizing the constellation map assigned to communications device 1800. Data processing unit 1822 is configured to process received data. A channel information processing unit 1824 is configured to make measurements of communications channels and to generate channel information, such as channel state information, channel quality indicators, and the like, to reflect the measurements. A memory 1830 is configured to store constellation maps (legacy and non-legacy constellation maps), channel information, power allocations (or power offsets), QAM layer assignments, coding rates, constellation map assignments, received data, data to be transmitted, and the like.

[0095] The elements of communications device 1800 may be implemented as specific hardware logic blocks. In an alternative, the elements of communications device 1800 may be implemented as software executing in a processor, controller, application specific integrated circuit, or so on. In yet another alternative, the elements of communications device 1800 may be implemented as a combination of software and/or hardware.

[0096] As an example, receiver 1810 and transmitter 1805 may be implemented as a specific hardware block, while constellation processing unit 1820, data processing unit 1822, and channel information processing unit 1824 may be software modules executing in a microprocessor (such as processor 1815) or a custom circuit or a custom compiled logic array of a field programmable logic array. Constellation processing unit 1820, data processing unit 1822, and channel information processing unit 1824 may be modules stored in memory 1830.

[0097] In accordance with various embodiments of the present invention, example methods for operating a transmitting or receiving device, and example transmitting or receiving devices are disclosed as follows.

Example 1. A method for operating a transmitting device using semi-orthogonal multiple access (SOMA), the method comprising:

determining, by the transmitting device, power allocations, sub-quadrature amplitude

modulation (sub-QAM) allocations, and coding rates for a first receiving device and a second receiving device in accordance with channel information associated with the first receiving device and the second receiving device; and

transmitting, by the transmitting device, information about a first power allocation for the first receiving device, and a first sub-QAM allocation for the first receiving device to the first receiving device.

Example 2. The method of Example 1, wherein the coding rates for the first receiving device and the second receiving device are determined in accordance with the power allocations and the sub-QAM allocations.

Example 3. The method of Example 2, wherein the information includes information about the coding rates.

Example 4. The method of Example 1, wherein a sub-QAM comprises one or more QAM layers and is a subset of a total number of QAM layers in a constellation map associated with the first receiving device and the second receiving device.

Example 5. The method of Example 1, wherein the power allocations are performed jointly in accordance with the channel information associated with the first receiving device and the second receiving device.

Example 6. The method of Example 1, further comprising transmitting information about a second sub-QAM allocation for the second receiving device to the second receiving device.

Example 7. The method of Example 1, further comprising transmitting information about a second power allocation for the second receiving device and a second sub-QAM allocation for the second receiving device to the second receiving device.

Example 8. The method of Example 1, wherein transmitting the information comprises:

selecting a constellation map out of a plurality of constellation maps, wherein the constellation map is selected in accordance with the power allocations for the first receiving device and the second receiving device; and

transmitting an indicator of the selected constellation map to the first receiving device.

Example 9. The method of Example 8, wherein the plurality of constellation maps comprises constellation maps with different inherent power offsets, and wherein selecting the constellation map comprises selecting the constellation map with an inherent power offset in accordance with a selection criterion.

Example 10. The method of Example 9, wherein the selection criterion comprises at least one of support for non-legacy constellation maps, receiving device compatibility, power offsets, power allocations, and signaling overhead constraints.

Example 11. The method of Example 8, wherein the plurality of constellation maps comprises legacy constellation maps specified by a technical standard.

Example 12. The method of Example 8, wherein the plurality of constellation maps comprises legacy constellation maps specified by a technical standard and non-legacy constellation maps with different inherent power offsets.

Example 13. The method of Example 1, further comprising:

deriving effective channel information from the power allocations and the sub-QAM allocations, wherein the coding rates are determined in accordance with the effective channel information.

Example 14. The method of Example 1, wherein the channel information comprises a channel quality indicator (CQI).

Example 15. The method of Example 1, wherein a first channel between the transmitting device and the first receiving device has a high signal to noise ratio (SNR), and wherein a second channel between the transmitting device and the second receiving device has a low SNR.

Example 16. The method of Example 1, further comprising:

receiving the channel information from the first receiving device and the second receiving device.

Example 17. The method of Example 1, further comprising:

receiving data for the first receiving device and the second receiving device;

encoding data for the first receiving device in accordance with a first coding rate for the first receiving device, thereby producing first encoded data;

encoding data for the second receiving device in accordance with a second coding rate for the second receiving device, thereby producing second encoded data;

modulating the first encoded data in accordance with a first sub-QAM allocation for the first receiving device and the second encoded data in accordance with a second sub-QAM allocation for the second receiving device, thereby producing a QAM symbol; and

transmitting the QAM symbol.

Example 18. The method of Example 17, wherein the QAM symbol is transmitted to the first receiving device and the second receiving device.

Example 19. The method of Example 17, wherein modulating the first encoded data in accordance with the first sub-QAM allocation for the first receiving device and the second encoded data in accordance with the second sub-QAM allocation for the second receiving device comprises:

generating a constellation map in accordance with the power allocations, and the sub-QAM allocations; and

modulating the first encoded data and the second encoded data in accordance with the constellation map, thereby producing the QAM symbol.

Example 20. A method for operating a first receiving device operating in a semi-orthogonal multiple access (SOMA) communications system, the method comprising:

determining, by the first receiving device, power allocations, sub-quadrature amplitude modulation (sub-QAM) allocations, and coding rates of the first receiving device and a second receiving device, wherein one of the first receiving device and a second receiving device has a higher signal to noise ratio (SNR) channel with a transmitting device than the other one of the first receiving device and the second receiving device;

receiving, by the first receiving device, a QAM symbol;

demapping, by the first receiving device, the QAM symbol in accordance with the sub-QAM allocation of the first receiving device, thereby producing encoded data;

decoding, by the first receiving device, the encoded data in accordance with the coding rate of the first receiving device, thereby producing decoded data; and

processing, by the first receiving device, the decoded data.

Example 21. The method of Example 20, wherein demapping the QAM symbol comprises demapping the QAM symbol further in accordance with the sub-QAM allocation of the second

receiving device when the second receiving device has a lower SNR channel with the transmitting device.

Example 22. The method of Example 20, wherein determining the power allocations, the sub-QAM allocations, and the coding rates comprises receiving a message including the power allocations, the sub-QAM allocations, and the coding rates.

Example 23. The method of Example 20, wherein determining the power allocations, the sub-QAM allocations, and the coding rates comprises:

receiving an indicator of a selected constellation map; and

determining the power allocations and the sub-QAM allocations in accordance with the indicator of the selected constellation map.

Example 24. The method of Example 23, further comprising receiving a message including information about the coding rates.

Example 25. The method of Example 23, further comprising determining the coding rates by using blind detection with candidate coding rates.

Example 26. A method for operating a second receiving device operating in a semi-orthogonal multiple access (SOMA) communications system, the method comprising:

determining, by the second receiving device, a constellation map of a first receiving device and the second receiving device, wherein a first channel between a transmitting device and the first receiving device is a high signal to noise ratio (SNR) channel and a second channel between the transmitting device and the second receiving device is a low SNR channel;

receiving, by the second receiving device, a QAM symbol;

demapping, by the second receiving device, the QAM symbol in accordance with the constellation map, thereby producing encoded data;

decoding, by the second receiving device, the encoded data in accordance with a coding rate of the second receiving device, thereby producing decoded data; and

processing, by the second receiving device, the decoded data.

Example 27. The method of Example 26, further comprising determining the coding rate of the second receiving device by using blind detection with candidate coding rates.

Example 28. A transmitting device comprising:

a processor configured to determine power allocations and sub-quadrature amplitude modulation (sub-QAM) allocations for a first receiving device and a second receiving device in accordance with channel information associated with the first receiving device and the second receiving device; and

a transmitter operatively coupled to the processor, the transmitter configured to transmit information about a first power allocation for the first receiving device, and a first sub-QAM allocation for the first receiving device to the first receiving device.

Example 29. The transmitting device of Example 28, wherein the processor is configured to determine coding rates for the first receiving device and the second receiving device in accordance with the power allocations and the sub-QAM allocation.

Example 30. The transmitting device of Example 28, wherein the transmitter is configured to transmit information about a second sub-QAM allocation for the second receiving device to the second receiving device.

Example 31. The transmitting device of Example 28, wherein the transmitter is configured to transmit information about a second power allocation for the second receiving device and a second sub-QAM allocation for the second receiving device to the second receiving device.

Example 32. The transmitting device of Example 28, wherein the transmitter is configured to transmit a message including the information to the first receiving device.

Example 33. The transmitting device of Example 28, wherein the processor is configured to select a constellation map out of a plurality of constellation maps, wherein the constellation map is selected in accordance with the power allocations for the first receiving device and the second receiving device, and the transmitter is configured to transmit an indicator of the selected constellation map to the first receiving device.

Example 34. The transmitting device of Example 33, wherein the plurality of constellation maps comprises constellation maps with different inherent power offsets.

Example 35. The transmitting device of Example 33, wherein the plurality of constellation maps comprises legacy constellation maps specified by a technical standard.

Example 36. The transmitting device of Example 33, wherein the plurality of constellation maps comprises legacy constellation maps specified by a technical standard and non-legacy constellation maps with different inherent power offsets.

Example 37. The transmitting device of Example 33, wherein the processor is configured to select the constellation map with an inherent power offset in accordance with a selection criterion.

Example 38. The transmitting device of Example 28, wherein the processor is configure to derive effective channel information from the power allocations and the sub-QAM allocations, wherein the coding rates are determined in accordance with the effective channel information.

Example 39. The transmitting device of Example 28, wherein a first channel between the transmitting device and the first receiving device has a high signal to noise ratio (SNR), and wherein a second channel between the transmitting device and the second receiving device has a low SNR.

Example 40. The transmitting device of Example 28, further comprising a receiver operatively coupled to the processor, the receiver configured to receive the channel information from the first receiving device and the second receiving device.

Example 41. The transmitting device of Example 28, further comprising a receiver operatively coupled to the processor, the receiver configured to receive data for the first receiving device and the second receiving device, wherein the processor is configured to encode data for the first receiving device in accordance with a first coding rate for the first receiving device, thereby producing first encoded data, to encode data for the second receiving device in accordance with a second coding rate for the second receiving device, thereby producing second encoded data, and to modulate the first encoded data in accordance with a first sub-QAM allocation for the first receiving device and the second encoded data in accordance with a second sub-QAM allocation for the second receiving device, thereby producing a QAM symbol, and wherein the transmitter is configured to transmit the QAM symbol.

Example 42. The transmitting device of Example 41, wherein the processor is configured to generate a constellation map in accordance with the power allocations, and the sub-QAM

allocations, and to modulate the first encoded data and the second encoded data in accordance with the constellation map, thereby producing the QAM symbol.

[0098] While this invention 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 the invention, 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 operating a transmitting device using semi-orthogonal multiple access (SOMA), the method comprising:

determining, by the transmitting device, a first power allocation for a first receiving device, and a joint Gray code mapping in a composite quadrature amplitude modulation (QAM) constellation of signals for the first receiving device and a second receiving device, the composite QAM constellation comprising a first constellation map for the first receiving device and a second constellation map for the second receiving device; and

transmitting, by the transmitting device, information about the first power allocation for the first receiving device, and information about the first constellation map for the first receiving device, to the first receiving device.

2. The method of claim 1, wherein the first power allocation and the joint Gray code mapping are determined in accordance with channel information associated with the first and second receiving devices.

3. The method of claim 1 or claim 2, further comprising determining coding rates for the first receiving device and the second receiving device in accordance with the first power allocation and the joint Gray code mapping in the composite QAM constellation.

4. The method of any one of claim 1 to claim 3, wherein each one of the first and second constellation maps comprises one or more QAM layers and is a subset of a total number of QAM layers in the composite QAM constellation associated with the first receiving device and the second receiving device.

5. The method of any one of claim 1 to claim 4, further comprising:

selecting the composite QAM constellation out of a plurality of constellation maps, wherein the composite QAM constellation is selected in accordance with the first power allocation for the first receiving device and a second power allocation for the second receiving device; and

transmitting an indicator of the selected composite QAM constellation to the first receiving device.

6. The method of claim 5, wherein the plurality of constellation maps comprises constellation maps with different inherent power offsets, and wherein selecting the composite

QAM constellation comprises selecting the composite QAM constellation with an inherent power offset in accordance with a selection criterion.

7. The method of claim 6, wherein the selection criterion comprises at least one of: support for non-legacy constellation maps, receiving device compatibility, power offsets, the first and second power allocations, and signaling overhead constraints.

8. The method of claim 5, wherein the plurality of constellation maps comprises at least one of: legacy constellation maps specified by a technical standard; and non-legacy constellation maps with different inherent power offsets.

9. The method of claim 2, further comprising:

deriving the channel information from the first power allocation and joint Gray code mapping in the composite QAM constellation; and

determining coding rates in accordance with the channel information.

10. The method of any one of claim 1 to claim 9, wherein the channel information comprises a channel quality indicator (CQI).

11. The method of any one of claim 1 to claim 9, wherein a first channel between the transmitting device and the first receiving device has a high signal to noise ratio (SNR), and wherein a second channel between the transmitting device and the second receiving device has a low SNR.

12. The method of claim 1 or claim 2, further comprising:

receiving data for the first receiving device and the second receiving device;

encoding data for the first receiving device in accordance with a first coding rate for the first receiving device, thereby producing first encoded data;

encoding data for the second receiving device in accordance with a second coding rate for the second receiving device, thereby producing second encoded data;

modulating the first encoded data in accordance with the first constellation map for the first receiving device and the second encoded data in accordance with the second constellation map for the second receiving device, thereby producing a QAM symbol; and

transmitting the QAM symbol to the first receiving device and the second receiving device.

13. A method for operating a first receiving device operating in a semi-orthogonal multiple access (SOMA) communications system, the method comprising:

determining, by the first receiving device, power allocations, sub-quadrature amplitude modulation (sub-QAM) allocations, and coding rates of the first receiving device and a second receiving device, wherein one of the first receiving device and a second receiving device has a higher signal to noise ratio (SNR) channel with a transmitting device than the other one of the first receiving device and the second receiving device;

receiving, by the first receiving device, a QAM symbol;

demapping, by the first receiving device, the QAM symbol in accordance with the sub-QAM allocation of the first receiving device, thereby producing encoded data;

decoding, by the first receiving device, the encoded data in accordance with the coding rate of the first receiving device, thereby producing decoded data; and

processing, by the first receiving device, the decoded data.

14. The method of claim 13, wherein demapping the QAM symbol comprises demapping the QAM symbol further in accordance with the sub-QAM allocation of the second receiving device when the second receiving device has a lower SNR channel with the transmitting device.

15. The method of claim 13 or claim 14, wherein determining the power allocations, the sub-QAM allocations, and the coding rates comprises receiving a message including the power allocations, the sub-QAM allocations, and the coding rates.

16. The method of claim 13 or claim 14, wherein determining the power allocations, the sub-QAM allocations, and the coding rates comprises:

receiving an indicator of a selected constellation map; and

determining the power allocations and the sub-QAM allocations in accordance with the indicator of the selected constellation map.

17. The method of claim 16, further comprising receiving a message including information about the coding rates.

18. The method of claim 16, further comprising determining the coding rates by using blind detection with candidate coding rates.

19. A method for operating a second receiving device operating in a semi-orthogonal multiple access (SOMA) communications system, the method comprising:

determining, by the second receiving device, a constellation map of a first receiving device and the second receiving device, wherein a first channel between a transmitting device and the first receiving device is a high signal to noise ratio (SNR) channel and a second channel between the transmitting device and the second receiving device is a low SNR channel;

receiving, by the second receiving device, a QAM symbol;

demapping, by the second receiving device, the QAM symbol in accordance with the constellation map, thereby producing encoded data;

decoding, by the second receiving device, the encoded data in accordance with a coding rate of the second receiving device, thereby producing decoded data; and

processing, by the second receiving device, the decoded data.

20. The method of claim 19, further comprising determining the coding rate of the second receiving device by using blind detection with candidate coding rates.

21. A transmitting device comprising means configured to implement a method in accordance with any one of claims 1 to 12.

22. A method for operating a receiving device in accordance with semi-orthogonal multiple access (SOMA), the method comprising:

receiving, by the receiving device, information about a first power allocation for the receiving device, and information about a first constellation map of a composite quadrature amplitude modulation (QAM) constellation of signals, the composite QAM constellation comprising a first constellation map for the receiving device, and a second constellation map for a second receiving device.

23. The method of claim 22, wherein the composite QAM constellation comprises joint Gray code mapping.

24. The method of claim 22 or claim 23, wherein the composite QAM constellation is selected out of a plurality of constellation maps, wherein the composite QAM constellation is selected in accordance with the first power allocation for the first receiving device and a second power allocation for the second receiving device, the method further comprising receiving by the first receiving device an indicator of the selected composite QAM constellation.

25. A receiving device comprising means configured to implement a method in accordance with any one of claims 22 to 24.