an entry of the TBS table which contains a transport block size depending in the number of allocated RBs. Each TBS index corresponds therefore a certain spectral efficiency in terms of bits transmitted per RB.

The current Release-11 MCS table is shown in Figure 6. It can be seen that the table contains three entries without TBS index. These MCS indices are used for retransmissions of erroneous transport blocks. The indication of the transport block size is not required in this case since the size is known from the initial transmission. Each MCS index corresponds to a certain SINR level at which the combination of modulation scheme and code rate that is determined by the transport block size can be used without exceeding a certain block error probability. Assuming a block error probability of 0.1, the current Release-11 table approximately covers the SINR range between -7 dB and 20 dB; the MCS table supports 27 TBS indices, and increasing the TBS index by one corresponds approximately to an SINR level difference of 1 dB.

Figure 8 shows the RB SINR level distributions of two typical UE within a heterogeneous network deployment as evaluated during performance studies for Release-11. The results have been achieved by means of system level distributions and the curves correspond to a cell-center UE with very high average SINR level and a cell-edge UE with very low average SINR level. From Figure 8 it can be seen that a large fraction of SINR samples of the cell-center UE is not covered by the current Rel-11 MCS table.

SUMMARY OF THE INVENTION

In view of the above mentioned problems with the prior art, embodiments of the present invention provide an efficient and robust approach for covering, with the modulation and coding schemes of the adaptive modulation and coding, higher SINR conditions.

It is the particular approach of embodiments of the present invention to provide modulation and coding schemes subdivided into two sets, one of which covers the lower spectral efficiencies and is advantageously applicable for lower SINR levels and the other covering the higher spectral efficiencies which is advantageously applicable to higher SINR levels. These sets have the same length in order to be addressable by the same modulation and coding scheme indicator. The sets differ by the entries of the highest-order modulation. The transmitter and the receiver are able to select between the two (or more) sets.

According to a first aspect of the present invention, there is provided an apparatus for receiving data from a network node or transmitting data to the network node in a communications system, the apparatus including: a control information reception unit for receiving scheduling information specifying resources on which the data are to be transmitted and including a modulation and coding indicator, the control information reception unit receiving a selection indicator; a modulation and coding selection unit capable of selecting modulation and coding from a set of predefined modulation and coding schemes according to the modulation and coding indicator; a set selection unit for selecting, according to the selection indicator, the set of predefined modulation and coding schemes from at least two predefined sets, a a first set and a second set, the first set and the second set having a plurality of modulation and coding schemes in common and differing in that the second set further includes an additional modulation with an order higher than any modulation in the first set, the first set and the second set having the same size, two or more values of the modulation and coding indicator referring to the same modulation and coding schemes with a lowest-order modulation in both of the first set and the second set; and a unit for receiving or transmitting the data on scheduled resources using the selected modulation and coding.

According to a second aspect of the present invention, there is provided an apparatus for transmitting data to a terminal or receiving data from the terminal in a communications system, the apparatus including: a control information transmission unit for transmitting scheduling information specifying resources on which the data are to be transmitted and including a modulation and coding indicator, the control information transmission unit transmitting a selection indicator; a modulation and coding selection unit capable of selecting modulation and coding from a set of predefined modulation and coding schemes according to the modulation and coding indicator; a set selection unit for selecting the set of predefined modulation and coding schemes from at least two predefined sets, a first set and a second set, the first set and the second set having a plurality of modulation and coding schemes in common and differing in that the second set further includes an additional modulation with an order higher than any modulation in the first set, the first set and the second set having the same size, two or more values of the modulation and coding indicator referring to the same modulation and coding schemes with a lowest-order modulation in both of the first set and the second set; and a unit for receiving or transmitting the data on scheduled resources using the selected modulation and coding.

Advantageously, the modulation and coding schemes in each of the sets are associated with the values of modulation and coding indicator, a plurality of the modulation and coding indicator values refer to the respective same modulation and coding schemes in the first and in the second set, and the remaining modulation and coding indicator values refer in the

second set to the highest-order modulation and in the first set to modulation(s) of one or more lowest order(s).

According to an embodiment of the present invention, M lowest values of the modulation and coding indicator, M being an integer, refer to: the modulation and coding schemes with the lowest-order modulation in the first set and the modulation and coding schemes with the highest-order modulation in the second set.

The second set may be constructed in such a way that it does not include modulation with the lowest order included in the first set.

According to an embodiment of the present invention, K values of the modulation and coding indicator, K being an integer, refer to the same modulation and coding schemes with the lowest-order modulation in both the first and the second set, L values refer to the modulation and coding schemes with the lowest-order modulation in the first set and the modulation and coding schemes with the highest-order modulation in the second set, and the remaining values of the modulation and coding indicator refer to the same modulation and coding schemes lower than the highest-order modulation.

Advantageously, the K values correspond to the first K values of the index and the L values are L values immediately following the K values.

According to an embodiment of the present invention, the modulation and coding indicator is associated with a modulation and coding scheme including a modulation order and a size indicator indicating at least one of (i) the number of bits in a transport block which is to be mapped onto physical resources and (ii) retransmission without specific indication of the transport block size.

According to a third aspect of the present invention, there is provided a method for receiving data from a network node or transmitting data to the network node in a communications system, the method including: receiving scheduling information specifying resources on which the data are to be transmitted and including a modulation and coding indicator, and receiving a selection indicator; selecting modulation and coding from a set of predefined modulation and coding schemes according to the modulation and coding indicator; selecting, according to the selection indicator, the set of predefined modulation and coding schemes from at least two predefined sets, a first set and a second set, the first set and the second set having a plurality of modulation and coding schemes in common and differing in that the second set further includes an additional modulation with an order higher than any modulation in the first set, the first set and the second set having the same size, two or more

values of the modulation and coding indicator referring to the same modulation and coding schemes with a lowest-order modulation in both of the first set and the second set; and receiving or transmitting the data on scheduled resources using the selected modulation and coding.

According to a fourth aspect of the present invention, there is provided a method for transmitting data to a terminal or receiving data from the terminal in a communications system, the method including: transmitting scheduling information specifying resources on which the data are to be transmitted and including a modulation and coding indicator, and transmitting a selection indicator; selecting modulation and coding from a set of predefined modulation and coding schemes according to the modulation and coding indicator; selecting the set of predefined modulation and coding schemes from at least two predefined sets , a first set and a second set, the first set and the second set having a plurality of modulation and coding schemes in common and differing in that the second set further includes an additional modulation with an order higher than any modulation in the first set, the first set and the second set having the same size, two or more values of the modulation and coding indicator referring to the same modulation and coding schemes with a lowest-order modulation in both of the first set and the second set; and receiving or transmitting the data on scheduled resources using the selected modulation and coding.

Advantageously, the selection of the set of modulation and coding schemes is performed based on a set selection indicator exchanged between the transmitter and the receiver. In particular, the transmitter of data may perform scheduling for the transmission and/or reception resources and indicate the settings to the receiver of data. In addition, the transmitter may indicate to the receiver also the choice of the set of modulation and coding schemes.

In particular, the set selection indicator may be signaled by means of a higher-layer signaling. For instance, the scheduling information is signaled on physical layer and the set selection indicator is signaled on the MAC (medium access control) or RRC (radio resource control) layer.

Alternatively, the set selection indicator may be signaled on the same layer as the scheduling information, for example on the physical layer. For instance, it may be signaled within the control information which includes the scheduling information. Some fields used for other purposes may be used to signal the set selection indicator. For instance, the redundancy version field used for signaling the version of the redundancy for the hybrid ARQ protocol or new data indicator used for distinguishing between first transmission and retransmission may be used. In particular, some of the values (or a single value) of the RV or NDI may be used

to indicate that a first set is to be used and some values (or a single value) of the RV or NDI may be used to indicate that a second set shall be used.

Alternatively, the selection of the set of modulation and coding schemes is performed by both receiver and transmitter of the data based on the channel conditions of their communication channel. For instance, the transmitter of data receives indication of the channel conditions from the receiver of the data and selects the set accordingly. The receiver also selects the set according to the channel conditions reported to the transmitter. This approach is implicit and does not require any additional signaling. The transmitter and receiver use the same rules to select the set in dependency of the channel conditions reported.

Preferably, the set selection indicator is signaled (transmitted/received) less frequently than the scheduling information.

It is noted that there may be also other differing entries in the different sets than the entries belonging to the new modulation.

According to an embodiment of the present invention a computer-readable medium is provided with a computer-readable program thereon, which, when executed on the computer, implements the steps of the method according to above aspects of the present invention.

According to an advantageous embodiment, the present invention is applied to LTE system (for instance Release-11 of the LTE). In particular, the data transmitter may be the eNodeB and the data receiver may ne the terminal. The data are transmitted over PDSCH and the control information including the scheduling information is transmitted on the PDCCH. The scheduling information may be carried by the DCI. The DCI may include, as is the case in the Release-11 LTE, an MCS index specifying the modulation and coding scheme to be used from among a set of modulation and coding schemes, which are predefined in a so-called MCS table. In compliance with the invention, more than one MCS tables may be defined, from which one is used at a time. The MCS table is selected based on the signaled information at the terminal or based on the channel conditions. The MCS table is chosen by the eNodeB based on channel conditions and the choice may be or does not need to be signaled to the terminal.

The above and other aspects and features of the present invention will become more apparent from the following description and preferred embodiments given in conjunction with the accompanying drawings in which:

CLAIMS

1. An apparatus for receiving data from a network node or transmitting data to the network node in a communications system, the apparatus comprising:

a control information reception unit for receiving scheduling information specifying resources on which the data are to be transmitted and including a modulation and coding indicator, the control information reception unit receiving a selection indicator;

a modulation and coding selection unit capable of selecting modulation and coding from a set of predefined modulation and coding schemes according to the modulation and coding indicator;

a set selection unit for selecting, according to the selection indicator, the set of predefined modulation and coding schemes from at least two predefined sets -- a first set and a second set, the first set and the second set having a plurality of modulation and coding schemes in common and differing in that the second set further includes an additional modulation with an order higher than any modulation in the first set, the first set and the second set having the same size, two or more values of the modulation and coding indicator referring to the same modulation and coding schemes with a lowest-order modulation in both of the first set and the second set; and

a unit for receiving or transmitting the data on scheduled resources using the selected modulation and coding.

2. An apparatus for transmitting data to a terminal or receiving data from the terminal in a communications system, the apparatus comprising:

a control information transmission unit for transmitting scheduling information specifying resources on which the data are to be transmitted and including a modulation and coding indicator, the control information transmission unit transmitting a selection indicator;

a modulation and coding selection unit capable of selecting modulation and coding from a set of predefined modulation and coding schemes according to the modulation and coding indicator;

a set selection unit for selecting the set of predefined modulation and coding schemes from at least two predefined sets -- a first set and a second set, the first set and the second set having a plurality of modulation and coding schemes in common and differing in that the second set further includes an additional modulation with an order higher than any modulation in the first set, the first set and the second set having the same size, two or more values of the modulation and coding indicator referring to the same modulation and coding schemes with a lowest-order modulation in both of the first set and the second set; and

a unit for receiving or transmitting the data on scheduled resources using the selected modulation and coding.

3. The apparatus according to claim 1 or 2, wherein

the modulation and coding schemes in each of the sets are associated with the values of modulation and coding indicator,

a plurality of the modulation and coding indicator values refer to the respective same modulation and coding schemes in the first set and in the second set, and

the remaining modulation and coding indicator values refer in the second set to the highest-order modulation and in the first set to modulation(s) of one or more lowest order(s).

4. The apparatus according to any one of claims 1 to 3, wherein

- K values of the modulation and coding indicator, K being an integer, refer to the same modulation and coding schemes with the lowest-order modulation in both of the first

set and the second set,

- L values refer to the modulation and coding schemes with the lowest-order modulation in the first set and the modulation and coding schemes with the highest-order modulation in the second set, and

- the remaining values of the modulation and coding indicator refer to the same modulation and coding schemes lower than the highest-order modulation.

5. The apparatus according to any one of claims 1 to 4, wherein

the modulation and coding indicator is associated with a modulation and coding scheme including:

- a modulation order and

- a size indicator indicating at least one of (i) the number of bits in a transport block which is to be mapped onto physical resources and (ii) retransmission without specific indication of a size of the transport block.

6. A method for receiving data from a network node or transmitting data to the network node in a communications system, the method comprising:

receiving scheduling information specifying resources on which the data are to be transmitted and including a modulation and coding indicator, and receiving a selection indicator;

selecting modulation and coding from a set of predefined modulation and coding schemes according to the modulation and coding indicator;

selecting, according to the selection indicator, the set of predefined modulation and coding schemes from at least two predefined sets -- a first set and a second set, the first set and the second set having a plurality of modulation and coding schemes in common and differing in that the second set further includes an additional modulation with an order

higher than any modulation in the first set, the first set and the second set having the same size, two or more values of the modulation and coding indicator referring to the same modulation and coding schemes with a lowest-order modulation in both of the first set and the second set; and

receiving or transmitting the data on scheduled resources using the selected modulation and coding.

7. A method for transmitting data to a terminal or receiving data from the terminal in a communications system, the method comprising:

transmitting scheduling information specifying resources on which the data are to be transmitted and including a modulation and coding indicator, and transmitting a selection indicator;

selecting modulation and coding from a set of predefined modulation and coding schemes according to the modulation and coding indicator;

selecting the set of predefined modulation and coding schemes from at least two predefined sets -- a first set and a second set, the first set and the second set having a plurality of modulation and coding schemes in common and differing in that the second set further includes an additional modulation with an order higher than any modulation in the first set, the first set and the second set having the same size, two or more values of the modulation and coding indicator referring to the same modulation and coding schemes with a lowest-order modulation in both of the first set and the second set; and

receiving or transmitting the data on scheduled resources using the selected modulation and coding.

8. The method according to claims 6 or 7, wherein

the modulation and coding schemes in each of the sets are associated with the values

of modulation and coding indicator,

a plurality of the modulation and coding indicator values refer to the respective same modulation and coding schemes in the first set and in the second set, and

the remaining modulation and coding indicator values refer in the second set to the highest-order modulation and in the first set to modulation(s) of one or more lowest order(s).

9. The method according to any one of claims 6 to 8, wherein

- K values of the modulation and coding indicator, K being an integer, refer to the same modulation and coding schemes with the lowest-order modulation in both of the first set and the second set,

- L values refer to the modulation and coding schemes with the lowest-order modulation in the first set and the modulation and coding schemes with the highest-order modulation in the second set, and

- the remaining values of the modulation and coding indicator refer to the same modulation and coding schemes lower than the highest-order modulation.

10. The method according to any one of claims 6 to 9, wherein

the modulation and coding indicator is associated with a modulation and coding scheme including:

- a modulation order and

- a size indicator indicating at least one of (i) the number of bits in a transport block which is to be mapped onto physical resources and (ii) retransmission without specific indication of a size of the transport block.

11. The method according to any one of claims 6 to 10, wherein

- the selection of the set is performed by a network node, signaled to a terminal, and the selection of the set at the terminal is performed according to the signaled choice, wherein the signaling is a higher-layer signaling less frequent than the signaling of the modulation and coding indicator, or

- the selection of the set is performed by a network node, signaled to a terminal, and the selection of the set at the terminal is performed according to the signaled choice, wherein the signaling is carried on the same layer as the signaling of the modulation and coding indicator, but less frequently than the signaling of the modulation and coding indicator.