

CLAIMS

1. A method, in a user equipment, for receiving control information in a radio communications network, the method comprising
 - receiving (2010) a downlink signal comprising an enhanced control region consisting of at least two sets of physical resource block, PRB, pairs, each PRB pair consisting of a group of non-overlapping physical layer building blocks;
 wherein the method further comprises:
 - forming (2020) one or more distributed enhanced control-channel elements, eCCEs, from a first set of PRB pairs by aggregating physical layer building blocks from multiple PRB pairs to form each distributed eCCE;
 - forming (2030) one or more localized eCCEs from a second set of PRB pairs by aggregating physical layer building blocks such that each of the localized eCCEs is formed from physical layer building blocks from within a single PRB pair of the second set;
 - forming (2050) first control channel message candidates from the distributed eCCEs and second control channel message candidates from the localized eCCEs; and
 - decoding (2060) each of the first and second control channel message candidates to search for a valid control channel message;
 and wherein said physical layer building blocks are enhanced Resource Element Groups, eREGs, each eREG consisting of eight or nine resource elements.

2. The method of claim 1, wherein said radio communications network is a Long-Term Evolution, LTE, radio network.

3. The method of claim 1 or 2, wherein forming (2020, 2030) the first and second control channel message candidates comprises forming at least some of the control channel message candidates by aggregating two or more of the localized eCCEs or two or more of the distributed eCCEs, or both.

4. The method of any of claims 1 to 3, further comprising receiving Radio Resource Control, RRC, signalling that indicates a division of the PRB pairs into the first and second sets of PRB pairs.

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

forming (2040) one or more additional distributed eCCEs from a third set of PRB pairs by aggregating physical layer building blocks from multiple PRB pairs to form each additional distributed eCCE;

forming (2040) one or more additional localized eCCEs from the third set of PRB pairs by aggregating physical layer building blocks such that each additional localized eCCE is formed from physical layer building blocks from within a single PRB pair of the third set;

forming one or more third control channel message candidates from the additional distributed eCCEs and one or more fourth control channel message candidates from the additional localized eCCEs; and

decoding each of the third and fourth control channel message candidates to search for a valid control channel message.

6. The method of claim 5, further comprising receiving Radio Resource Control, RRC, signalling that indicates a division point in the third set of PRB pairs, the division point splitting the third set into a first portion used to form the additional localized eCCEs and a second portion used to form the additional distributed eCCEs.

7. The method of any of claims 1 to 6, wherein forming (225) the first control channel message candidates from the distributed eCCEs and the second control channel message candidates from the localized eCCEs comprises determining a starting eCCE position within the enhanced control region, such that the starting eCCE position varies according to a subframe number for the downlink signal and a Radio Network Temporary Identifier, RNTI, for the user equipment, and forming a number of control channel message candidates from eCCEs beginning at the starting eCCE position.

8. The method of claim 7, wherein said determining a starting eCCE position and said forming a number of control channel message candidates is performed independently for each of the localized eCCEs and the distributed eCCEs.

9. The method of claim 8, wherein the starting eCCE position for the localized eCCEs and the starting point for the distributed eCCEs are at or near opposite ends of a range of numbered eCCEs, such that the second control channel messages are formed by traversing the numbered eCCEs in a reverse order from that used for forming the first control channel messages.

10. The method of any preceding claim, wherein the first set of PRB pairs and the second set of PRB pairs are separate.

101. A method, in a radio network node, for sending control information in a radio communications network in which a plurality of user equipment are served in a cell controlled by the radio network node, the method comprising

transmitting a downlink signal comprising an enhanced control region consisting of at least two sets of physical resource block, PRB, pairs, each PRB pair consisting of a group of non-overlapping physical layer building blocks;

wherein the method further comprises:

mapping (2110) one or more first control channel messages to distributed enhanced control-channel elements, eCCEs, in a first set of PRB pairs, where each distributed eCCE consists of an aggregation of physical layer building blocks from multiple PRB pairs;

mapping (2120) one or more second control channel messages to localized eCCEs in a second set of PRB pairs, where each localized eCCE consists of an aggregation of physical layer building blocks from within a single PRB pair;
and

transmitting (2140) the first control channel messages and the second control channel messages in a subframe of the downlink signal;

and wherein said physical layer building blocks are enhanced Resource Element Groups, eREGs, each eREG consisting of eight or nine resource elements.

142. The method of claim 101, wherein said radio communications network is a Long-Term Evolution, LTE, radio network.

123. The method of claim 101 or 142, wherein mapping at least some of the first and second control channel messages to the distributed eCCEs and the localized eCCEs comprises mapping a control channel message to an aggregation of two or more localized eCCEs or two or more distributed eCCEs.

134. The method of any of claims 101 to 123, further comprising transmitting Radio Resource Control, RRC, signalling that indicates a division of the PRB pairs into the first and second sets of PRB pairs.

145. The method of any of claims 101 to 134, further comprising:

mapping (2130) one or more third control channel messages to distributed enhanced control-channel elements, eCCEs, in a third set of PRB pairs, where each distributed eCCE consists of an aggregation of physical layer building blocks from multiple PRB pairs;

mapping (2130) one or more fourth control channel messages to localized eCCEs in the third set of PRB pairs, where each localized eCCE consists of an aggregation of physical layer building blocks from within a single PRB pair; and

transmitting the third control channel messages and the fourth control channel messages in the subframe of the downlink signal.

156. The method of claim 145, further comprising transmitting Radio Resource Control, RRC, signalling that indicates a division point in the third set of PRB pairs, the division point splitting the third set into a first portion used for control channel messages mapped to localized eCCEs and a second portion used for control channel messages mapped to distributed eCCEs.

17. The method of any of claims 11 to 16, wherein the first set of PRB pairs and the second set of PRB pairs are separate.

168. A base station comprising:

a transceiver (2220) adapted for transmitting a downlink signal comprising an enhanced control region consisting of at least two sets of physical resource block, PRB, pairs, each PRB pair consisting of a group of non-overlapping physical layer building blocks; and

a processing circuit (2210);

wherein the processing circuit (2210) is adapted to carry out the method of any of claims 9 11 to 157.

179. A user equipment apparatus comprising:

a transceiver (2220) adapted for receiving a downlink signal comprising an enhanced control region consisting of at least two sets of physical resource block, PRB, pairs, each PRB pair consisting of a group of non-overlapping physical layer building blocks; and

a processing circuit (2210);

wherein the processing circuit (2210) is adapted to carry out the method of any of claims 1 to 910.

1820. A computer program product comprising a non-transitory computer-readable medium (2260), said computer-readable medium (2260) comprising computer program instructions configured for execution by a processor in a user equipment configured for operation in a wireless communication network, the computer program instructions comprising:

program instructions for causing the user equipment to receive a downlink signal comprising an enhanced control region consisting of at least two sets of physical resource block, PRB, pairs, each PRB pair consisting of a group of non-overlapping physical layer building blocks;

wherein the computer program instructions further comprise:

program instructions for causing the user equipment to form one or more distributed enhanced control-channel elements, eCCEs, from a first set of PRB pairs by

aggregating physical layer building blocks from multiple PRB pairs to form each distributed eCCE;

program instructions for causing the user equipment to form one or more localized eCCEs from a second set of PRB pairs by aggregating physical layer building blocks such that each of the localized eCCEs is formed from physical layer building blocks from within a single PRB pair of the second set;

program instructions for causing the user equipment to form first control channel message candidates from the distributed eCCEs and second control channel message candidates from the localized eCCEs; and

program instructions for causing the user equipment to decode each of the first and second control channel message candidates to search for a valid control channel message;

and wherein said physical layer building blocks are enhanced Resource Element Groups, eREGs, each eREG consisting of eight or nine resource elements.

1921. A computer program product comprising a non-transitory computer-readable medium (2260), said computer-readable medium (2260) comprising computer program instructions configured for execution by a processor in a base station apparatus configured for operation in a wireless communication network, the computer program instructions comprising:

program instructions for causing the base station to transmit a downlink signal comprising an enhanced control region consisting of at least two sets of physical resource block, PRB, pairs, each PRB pair consisting of a group of non-overlapping physical layer building blocks;

wherein the computer program instructions further comprise:

program instructions for causing the base station to map one or more first control channel messages to distributed enhanced control-channel elements, eCCEs, in a first set of PRB pairs, where each distributed eCCE consists of an aggregation of physical layer building blocks from multiple PRB pairs;

program instructions for causing the base station to map one or more second control channel messages to localized eCCEs in a second set of PRB pairs, where each localized eCCE consists of an aggregation of physical layer building blocks from within a single PRB pair; and

program instructions for causing the base station to transmit the first control channel messages and the second control channel messages in a subframe of the downlink signal;

and wherein said physical layer building blocks are enhanced Resource Element Groups, eREGs, each eREG consisting of eight or nine resource elements.