BLIND DECODING

Radio communication systems typically involve the transmission of downlink control information via radio resources whose precise identity is not known to the intended recipient(s) of the downlink control information. A receiving device finds downlink control information intended for it by repeatedly selecting different candidate sets of radio resources and attempting to successfully decode the signals carried on said sets of radio resources. This is known as blind decoding.

It has been proposed to make such unscheduled transmissions of downlink control information according to an enhanced transmission technique by which gains, such as frequency-domain packet scheduling (FDPS) gain, can be targeted; whilst continuing to also make unscheduled transmissions according to the conventional transmission technique.

There has been identified the challenge of reducing the processing power required by a communication device to perform blind decoding under the above-mentioned proposal.

Summary

According to a first aspect of the invention ~~There~~ there is hereby provided a method, comprising: in a system in which a communication device searches for ~~unscheduled~~ transmissions of downlink control information for said communication device: selecting a combination of search spaces for ~~unscheduled~~ transmissions of downlink control information for a communication device by a plurality of transmission tech-

niques: wherein the communication device applies blind decoding in finding the downlink control information for the communication device and transmitting an indication of the result of the selected combination to said communication device.

According to a second aspect, there is a method comprising in a system in which a radio access network transmits indications of the results of selections of combinations of search spaces for transmissions by a plurality of transmission techniques of downlink control information for one or more communication devices, wherein the communication device applies blind decoding in finding the downlink control information for the one or more communication devices: searching at a first communication device for transmissions of downlink control information for said communication device; wherein said searching is performed either: (a) on the basis of a transmitted indication of the result of a selection for said first communication device of a combination of search spaces for transmissions by said plurality of transmission techniques of downlink control information; or (b) in the absence of a transmitted indication of the result of a selection for said first communication device of a combination of search spaces for transmissions by said plurality of transmission techniques of downlink control information, on the basis of a default combination of search spaces for transmissions by said plurality of transmission techniques of downlink control information for said first communication device.

According to a third aspect, there is a method comprising searching at a first communication device for transmissions of downlink control information for said communication device

by a plurality of transmission techniques, wherein the communication device applies blind decoding in finding the downlink control information for the communication device; wherein said searching is performed on the basis of a transmitted indication of the result of a selection of a combination of search spaces for transmissions of downlink control information for said first communication device by said plurality of transmission techniques.

According to a fourth aspect, there is an apparatus comprising a processor and memory including computer program code, wherein the memory and computer program code are configured to, with the processor, cause the apparatus to: in a system in which a communication device searches for transmissions of downlink control information for said communication device, wherein the communication device applies blind decoding in finding the downlink control information for the communication device: select a combination of search spaces for transmissions of downlink control information for a communication device by a plurality of transmission techniques: and transmitting an indication of the result of the selected combination to said communication device.

According to a fifth aspect, there is an apparatus comprising: a processor and memory including computer program code, wherein the memory and computer program code are configured to, with the processor, cause the apparatus to: in a system in which a radio access network transmits indications of the results of selections of combinations of search spaces for transmissions by a plurality of transmission techniques of downlink control information for one or more communication devices: search at a first communication device for trans-

missions of downlink control information for said communication device, wherein the communication device applies blind decoding in finding the downlink control information for the communication device; wherein said searching is performed either: (a) on the basis of a transmitted indication of the result of a selection for said first communication device of a combination of search spaces for transmissions by said plurality of transmission techniques of down link control information; or (b) in the absence of a transmitted indication of the result of a selection for said first communication device of a combination of search spaces for transmissions by said plurality of transmission techniques of downlink control information, on the basis of a default combination of search spaces for transmissions by said plurality of transmission techniques of downlink control information for said first communication device.

According to a sixth aspect, there is an apparatus comprising: a processor and memory including computer program code, wherein the memory and computer program code are configured to, with the processor, cause the apparatus to: search at a first communication device for transmissions of downlink control information for said communication device by a plurality of transmission techniques; wherein the communication device applies blind decoding in finding the downlink control information for the communication device; wherein said searching is performed on the basis of a transmitted indication of the result of a selection of a combination of search spaces for transmissions of downlink control information for said first communication device by said plurality of transmission techniques.

According to a seventh aspect, there is a computer program product comprising program code means which when loaded into a computer controls the computer to: in a system in which a communication device searches for transmissions of downlink control information for said communication device, wherein the communication device applies blind decoding in finding the downlink control information for the communication device: select a combination of search spaces for transmissions of downlink control information for a communication device by a plurality of transmission techniques: and transmitting an indication of the result of the selected combination to said communication device.

According to a eighth aspect, there is a computer program product comprising program code means which when loaded into a computer controls the computer to: in a system in which a radio access network transmits indications of the results of selections of combinations of search spaces for transmissions by a plurality of transmission techniques of downlink control information for one or more communication devices, wherein the communication device applies blind decoding in finding the downlink control information for the communication device: search at a first communication device for transmissions of downlink control information for said communication device; wherein said searching is performed either: (a) on the basis of a transmitted indication of the result of a selection for said first communication device of a combination of search spaces for transmissions by said plurality of transmission techniques of downlink control information; or (b) in the absence of a transmitted indication of the result of a selection for said first communication device of a combination of search spaces for transmissions by said plurality

of transmission techniques of downlink control information, on the basis of a default combination of search spaces for transmissions by said plurality of transmission techniques of downlink control information for said first communication device.

According to a nineth aspect, there is a computer program product comprising program code means which when loaded into a computer controls the computer to: search at a first communication device for trans transmissions of downlink control information for said communication device by a plurality of transmission techniques, wherein the communication device applies blind decoding in finding the downlink control information for the communication device; wherein said searching is performed on the basis of a transmitted indication of the result of a selection of a combination of search spaces for transmissions of downlink control information for said first communication device by said plurality of transmission techniques.

According to one embodiment, the method further comprises deciding how much search space to assign to unscheduled transmissions of downlink control information for said communication device by one or more of said plurality of transmission techniques relative to unscheduled transmissions of downlink control information for said communication device by one or more others of said plurality of transmission techniques.

According to one embodiment, said selecting comprises selecting a predefined combination from a plurality of predefined combinations.

According to one embodiment, said plurality of predefined combinations includes a predefined combination according to which no search space is assigned to unscheduled transmissions of downlink control information by one of said plurality of transmission techniques.

According to one embodiment, a plurality of aggregation levels are used for the transmission of downlink control information, and a respective search space is predefined for each aggregation level for each transmission technique; and the method further comprises: selecting a respective set of one or more aggregation levels for each of said plurality of transmission techniques; and transmitting an indication of

CLAIMS

1. A method, comprising: in a system in which a communication device searches for transmissions of downlink control information for said communication device: selecting a combination of search spaces for the transmissions of downlink control information for the communication device by a plurality of transmission techniques, wherein the communication device applies blind decoding in finding the downlink control information for the communication device: and

transmitting an indication of the result of the selected combination to said communication device.

2. A method according to claim 1, comprising deciding how much search space to assign to transmissions of downlink control information for said communication device by one or more of said plurality of transmission techniques relative to transmissions of downlink control information for said communication device by one or more others of said plurality of transmission techniques.

3. A method according to any preceding claim, wherein said selecting comprises selecting a predefined combination from a plurality of predefined combinations.

4. A method according to claim 3, wherein said plurality of predefined combinations includes a predefined combination according to which no search space is assigned to transmissions of downlink control information by one of said plurality of transmission techniques.

10. A method, comprising: in a system in which a radio access network transmits indications of the results of selections of combinations of search spaces for transmissions by a plurality of transmission techniques of downlink control information for one or more communication devices, wherein the communication device applies blind decoding in finding the downlink control information for the one or more communication devices:

searching at a first communication device for transmissions of downlink control information for said communication device; wherein said searching is performed either: (a) on the basis of a transmitted indication of the result of a selection for said first communication device of a combination of search spaces for transmissions by said plurality of transmission techniques of downlink control information; or (b) in the absence of a transmitted indication of the result of a selection for said first communication device of a combination of search spaces for transmissions by said plurality of transmission techniques of downlink control information, on the basis of a default combination of search spaces for transmissions by

said plurality of transmission techniques of downlink control information for said first communication device.

11. A method, comprising: searching at a first communication device for transmissions of downlink control information for said communication device by a plurality of transmission techniques, wherein the communication device applies blind decoding in finding the downlink control information for the communication device; wherein said searching is performed on the basis of a transmitted indication of the result of a selection of a combination of search spaces for transmissions of downlink control information for said first communication device by said plurality of transmission techniques.

12. A method according to claim 10 or claim 11, wherein said transmitted indication indicates how much search space has been assigned to transmissions of downlink control information for said first communication device by one or more of said plurality of transmission techniques relative to transmissions of downlink control information for said first communication device by one or more others of said plurality of transmission techniques.

13. A method according to any of claims 10 to 12, wherein said transmitted indication identifies one of a plurality of predefined combinations.

14. A method according to claim 13, wherein said plurality of predefined combinations includes a predefined combination according to which no search space is assigned to

20. An apparatus comprising: a processor and memory including computer program code, wherein the memory and computer program code are configured to, with the processor, cause the apparatus to: in a system in which a communication device searches for transmissions of downlink control information for said communication device, wherein the communication device applies blind decoding in finding the downlink control information for the communication device: select a combination of search spaces for transmissions of downlink control information for a communication device by a plurality of transmission techniques: and transmitting an indication of the result of the selected combination to said communication device.

29. An apparatus comprising: a processor and memory including computer program code, wherein the memory and computer program code are configured to, with the processor, cause the apparatus to: in a system in which a radio access network transmits indications of the results of selections of combinations of search spaces for transmissions by a plurality of transmission techniques of downlink control information for one or more communication devices: search at a first communication device for transmissions of downlink control information for said communication device, wherein the communication device applies blind decoding in finding the downlink control information for the communication device; wherein said searching is performed either: (a) on the basis of a transmitted indication of the result of a selection for said first communication device of a combination of search spaces for transmissions by said plurality of transmission techniques of downlink control information; or (b) in the absence of a transmitted indication of the result

of a selection for said first communication device of a combination of search spaces for transmissions by said plurality of transmission techniques of downlink control information, on the basis of a default combination of search spaces for transmissions by said plurality of transmission techniques of downlink control information for said first communication device.

30. An apparatus comprising: a processor and memory including computer program code, wherein the memory and computer program code are configured to, with the processor, cause the apparatus to: search at a first communication device for transmissions of downlink control information for said communication device by a plurality of transmission techniques; wherein the communication device applies blind decoding in finding the downlink control information for the communication device; wherein said searching is performed on the basis of a transmitted indication of the result of a selection of a combination of search spaces for transmissions of downlink control information for said first communication device by said plurality of transmission techniques.

31. An apparatus according to claim 29 or claim 30, wherein said transmitted indication indicates how much search space has been assigned to transmissions of downlink control information for said first communication device by one or more of said plurality of transmission techniques relative to transmissions of downlink control information for said first communication device by one or more others of said plurality of transmission techniques.

39. A computer program product comprising program code means which when loaded into a computer controls the computer to: in a system in which a communication device searches for transmissions of downlink control information for said communication device, wherein the communication device applies blind decoding in finding the downlink control information for the communication device: select a combination of search spaces for transmissions of downlink control information for a communication device by a plurality of transmission techniques: and transmitting an indication of the result of the selected combination to said communication device.

40. A computer program product comprising program code means which when loaded into a computer controls the computer to: in a system in which a radio access network transmits indications of the results of selections of combinations of search spaces for transmissions by a plurality of transmission techniques of downlink control information for one or more communication devices, wherein the communication device applies blind decoding in finding the downlink control information for the communication device: search at a first communication device for transmissions of downlink

control information for said communication device; wherein said searching is performed either: (a) on the basis of a transmitted indication of the result of a selection for said first communication device of a combination of search spaces for transmissions by said plurality of transmission techniques of downlink control information; or (b) in the absence of a transmitted indication of the result of a selection for said first communication device of a combination of search spaces for transmissions by said plurality of transmission techniques of downlink control information, on the basis of a default combination of search spaces for transmissions by said plurality of transmission techniques of downlink control information for said first communication device.

41. A computer program product comprising program code means which when loaded into a computer controls the computer to: search at a first communication device for transmissions of downlink control information for said communication device by a plurality of transmission techniques, wherein the communication device applies blind decoding in finding the downlink control information for the communication device; wherein said searching is performed on the basis of a transmitted indication of the result of a selection of a combination of search spaces for transmissions of downlink control information for said first communication device by said plurality of transmission techniques.