

Description

Title

REPEATED TRANSMISSION OF SCHEDULING ASSIGNMENT FOR RANDOM ACCESS RESPONSE

One technique proposed for enhancing the coverage of a radio communication device involves repeating the transmission of scheduling assignments for random access response messages, and allowing the use of the same set of radio resources for more than one scheduling assignment.

The inventors for the present application have identified the challenge of developing new techniques to avoid or alleviate problems that can arise from repeating the transmission of scheduling assignments for random access response messages.

According to a first aspect, there is hereby provided a method, comprising: detecting a preamble signal transmitted by a communication device; and transmitting a scheduling assignment for a random access response message over a wireless interface; wherein the scheduling assignment is identified by an identifier having a value dependent at least partly on one or more of: (i) a feature of said communication device relating to the transmission of said scheduling assignment and/or identifiable from the preamble signal ; and (ii) the index of the system frame in which the preamble signal was detected.

In one embodiment, the preamble signal is transmitted in more than one system frame, and said identifier has a value dependent at least partly on the index of the system frame in which the preamble signal was first detected.

- 5 In one embodiment, the method comprises repeatedly transmitting the scheduling assignment over a number of subframes dependent on said feature of said communication device.

10 In one embodiment, said feature of said communication device is a coverage enhancement level assigned to the communication device; and said identifier has a value derived from a formula including the assigned coverage enhancement level as one variable.

15 In one embodiment, respective sets of possible values for said identifier are reserved for respective coverage enhancement levels; and the method further comprises selecting a value for said identifier for said scheduling assignment from the set of possible values reserved for the coverage enhancement level assigned to said communication device.

20 In one embodiment, said identifier is random access radio network temporary identifier.

According to a second aspect, there is also provided a method, comprising: transmitting a preamble signal from a communication device; and searching for a random access response scheduling assignment identified by an identifier having a value dependent at least partly on one or

more of: (i) a feature of said communication device related to transmission of said scheduling assignment and/or identifiable from said preamble signal; and (ii) the index of the system frame in which the preamble signal was transmitted.

- 5 In one embodiment, the method comprises transmitting the preamble signal in more than one system frame, and wherein said identifier has a value dependent at least partly on the index of the system frame in which the preamble signal was first transmitted.

In an example, there is also provided a method, comprising: detecting a preamble
10 signal transmitted by a communication device; generating a random access response scheduling assignment in response to the preamble signal; and starting transmission of the scheduling assignment over a wireless interface at some time in a response window; wherein the size and/or location of the response window is dependent at least partly on one or more of: a feature of said communication device relating to transmission
15 of said scheduling assignment; and the index of the system frame at which the random access preamble signal was detected.

In one embodiment, the preamble signal is transmitted in more than one system frame, and the size and/or location of the response window has a value dependent at least partly on the index of the system frame in which the preamble signal was first detected.

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In one embodiment, the method comprises comprising repeatedly transmitting the scheduling assignment in a number of contiguous subframes dependent on said feature of said communication device.

In one embodiment, the size of the response window is dependent on whether or not said communication device is required to transmit the preamble signal in an even system frame number.

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In one embodiment, said feature of said communication device is a coverage enhancement level assigned to the communication device; respective different parts of the response window are assigned to respective coverage enhancement levels; and the method comprises starting transmission of the scheduling assignment in the part of the
10 response window assigned to the coverage enhancement level assigned to said communication device.

In an example, there is also provided a method, comprising: transmitting a preamble signal; and restricting a search for a random access response scheduling assignment from a radio access network to a search space whose size and/or location
15 is dependent at least partly on one or more of: a feature of said communication device related to transmission of said scheduling assignment and/or identifiable from said preamble signal; and/or the index of the system frame in which said communication device transmits the random access preamble signal.

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In one embodiment, the method comprises comprising transmitting the preamble signal in more than one system frame, and said identifier has a value dependent at least partly on the index of the system frame in which the preamble signal was first transmitted.

In one embodiment, the method comprises the preamble signal is a physical random access channel signal and the scheduling assignment is a physical downlink control channel signal.

- 5 According to a third aspect, there is also provided 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: detect a preamble signal transmitted by a communication device; and transmit a scheduling assignment for a random access response message over a wireless interface; wherein the scheduling assignment is identified by an identifier having a value dependent at least partly
- 10 on one or more of: (i) a feature of said communication device relating to the transmission of said scheduling assignment and/or identifiable from the preamble signal ; and (ii) the index of the system frame in which the preamble signal was detected.
- 15 In one embodiment, the preamble signal is transmitted in more than one system frame, and said identifier has a value dependent at least partly on the index of the system frame in which the preamble signal was first detected.

- In one embodiment, the memory and computer program code are further configured to,
- 20 with the processor, cause the apparatus to: repeatedly transmit the scheduling assignment over a number of subframes dependent on said feature of said communication device.

In one embodiment, said feature of said communication device is a coverage enhancement level assigned to the communication device; and said identifier has a value derived from a formula including the assigned coverage enhancement level as one variable.

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In one embodiment, respective sets of possible values for said identifier are reserved for respective coverage enhancement levels; and wherein the memory and computer program code are further configured to, with the processor, cause the apparatus to: select a value for said identifier for said scheduling assignment from the set of possible values
10 reserved for the coverage enhancement level assigned to said communication device.

In one embodiment, said identifier is random access radio network temporary identifier.

According to a fourth aspect, there is also provided an apparatus comprising: a
15 processor and memory including computer program code, wherein the memory and computer program code are configured to, with the processor, cause the apparatus to: transmit a preamble signal from a communication device; and search for a random access response scheduling assignment identified by an identifier having a value dependent at least partly on one or more of: (i) a feature of said communication
20 device related to transmission of said scheduling assignment and/or identifiable from said preamble signal; and (ii) the index of the system frame in which the preamble signal was transmitted.

In one embodiment, the memory and computer program code are further configured to, with the processor, cause the apparatus to: transmit the preamble signal in more than one

system frame, and wherein said identifier has a value dependent at least partly on the index of the system frame in which the preamble signal was first transmitted.

According to a fifth aspect, there is also provided an apparatus comprising: a
5 processor and memory including computer program code, wherein the memory and computer program code are configured to, with the processor, cause the apparatus to: detect a preamble signal transmitted by a communication device; generate a random access response scheduling assignment in response to the preamble signal; and start transmission of the scheduling assignment over a wireless interface at some time in a response window; wherein the size and/or location of the response window is
10 dependent at least partly on one or more of: a feature of said communication device relating to transmission of said scheduling assignment; and the index of the system frame at which the random access preamble signal was detected.

In one embodiment, the preamble signal is transmitted in more than one system frame,
15 and the size and/or location of the response window has a value dependent at least partly on the index of the system frame in which the preamble signal was first detected.

In one embodiment, the memory and computer program code are further configured to, with the processor, cause the apparatus to: repeatedly transmit the scheduling
20 assignment in a number of contiguous subframes dependent on said feature of said communication device.

In one embodiment, the size of the response window is dependent on whether or not said communication device is required to transmit the preamble signal in an even system frame number.

5 In one embodiment, said feature of said communication device is a coverage enhancement level assigned to the communication device; respective different parts of the response window are assigned to respective coverage enhancement levels; and wherein the memory and computer program code are further configured to, with the processor, cause the apparatus to: start transmission of the scheduling assignment in the part of the
10 response window assigned to the coverage enhancement level assigned to said communication device.

According to a sixth aspect, there is also provided 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
15 to: transmit a preamble signal; and restrict a search for a random access response scheduling assignment from a radio access network to a search space whose size and/or location is dependent at least partly on one or more of: a feature of said communication device related to transmission of said scheduling assignment and/or identifiable from said preamble signal; and/or the index of the system frame in which said communication
20 device transmits the random access preamble signal.

In one embodiment, the memory and computer program code are further configured to, with the processor, cause the apparatus to: transmit the preamble signal in more than one system frame, and said identifier has a value dependent at least partly on the index of the
25 system frame in which the preamble signal was first transmitted.

In one embodiment, the preamble signal is a physical random access channel signal and the scheduling assignment is a physical downlink control channel signal.

- 5 In an example, there is also provided an apparatus configured to perform any of the above methods.

In an example, there is also provided a computer program product comprising program code means which when loaded into a computer controls the computer to: detect a preamble signal transmitted by a communication device; and transmit a scheduling assignment for a random access response message over a wireless

- 10 interface; wherein the scheduling assignment is identified by an identifier having a value dependent at least partly on one or more of: (i) a feature of said communication device relating to the transmission of said scheduling assignment and/or identifiable from the preamble signal ; and (ii) the index of the system frame in which the preamble signal was detected.

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According to a seventh aspect, there is also provided a computer program product comprising program code means which when loaded into a computer controls the computer to: transmit a preamble signal from a communication device; and search for a random access response scheduling assignment identified by an identifier having a value dependent at least partly on one or more of: (i) a feature of said

20 communication device related to transmission of said scheduling assignment and/or identifiable from said preamble signal; and (ii) the index of the system frame in which the preamble signal was transmitted.

In an example, there is also provided a computer program product comprising program code means which when loaded into a computer controls the computer to: detect a preamble signal transmitted by a communication device; generate a random access response scheduling assignment in response to the preamble signal; and start transmission of the scheduling assignment over a wireless interface at some time

5 in a response window; wherein the size and/or location of the response window is dependent at least partly on one or more of: a feature of said communication device relating to transmission of said scheduling assignment; and the index of the system frame at which the random access preamble signal was detected.

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In an example, there is also provided a computer program product comprising program code means which when loaded into a computer controls the computer to: transmit a preamble signal; and restrict a search for a random access response scheduling assignment from a radio access network to a search space whose size and/or location is dependent at least partly on one or more of: a feature of said communication

15 device related to transmission of said scheduling assignment and/or identifiable from said preamble signal; and/or the index of the system frame in which said communication device transmits the random access preamble signal.

20 Hereunder is provided, by way of example only, a detailed description of techniques related to the repeated transmission of scheduling assignments for random access response message, with reference to the accompanying drawings, in which:

Figure 1 illustrates an example of communication devices in communication with an access node of a radio access network;

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5. A method according to claim 1, wherein respective sets of possible values for said identifier are reserved for respective coverage enhancement levels; and wherein the method further comprises selecting a value for said identifier for said scheduling assignment
10 from the set of possible values reserved for the coverage enhancement level assigned to said communication device.

6. A method according to any of claims 1 to 5, wherein said identifier is random access radio network temporary identifier.

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7. A method, comprising:
transmitting a preamble signal from a communication device; and
searching for a random access response scheduling assignment
identified by an identifier having a value dependent at least partly on
20 one or more of: (i) a feature of said communication device related to transmission of said scheduling assignment and/or identifiable from said preamble signal; and (ii) the index of the system frame in which the preamble signal was transmitted.

25 8. A method according to claim 7, comprising transmitting the preamble signal in more than one system frame, and wherein said identifier has a value dependent at least partly on the index of the system frame in which the preamble signal was first transmitted.

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5 9. 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:
detect a preamble signal transmitted by a communication device; and
transmit a scheduling assignment for a random access response
10 message over a wireless interface; wherein the scheduling assignment
is identified by an identifier having a value dependent at least partly
on one or more of: (i) a feature of said communication device relating
to the transmission of said scheduling

5 assignment and/or identifiable from the preamble signal ; and (ii) the index of the system frame in which the preamble signal was detected.

10 10. An apparatus according to claim 9, wherein the preamble signal is transmitted in more than one system frame, and said identifier has a value dependent at least partly on the index of the system frame in which the preamble signal was first detected.

15 11. An apparatus according to claim 9 or claim 10, wherein the memory and computer program code are further configured to, with the processor, cause the apparatus to: repeatedly transmit the scheduling assignment over a number of subframes dependent on said feature of said communication device.

20 12. An apparatus according to any of claims 9 to 11, wherein said feature of said communication device is a coverage enhancement level assigned to the communication device; and said identifier has a value derived from a formula including the assigned coverage enhancement level as one variable.

25 13. An apparatus according to claim 9, wherein respective sets of possible values for said identifier are reserved for respective coverage enhancement levels; and wherein the memory and computer program code are further configured to, with the processor, cause the apparatus to: select a value for said identifier for said scheduling assignment
30 from the set of possible values reserved for the coverage enhancement level assigned to said communication device.

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14. An apparatus according to any of claims 9 to 13, wherein said identifier is random access radio network temporary identifier.

15. An apparatus comprising:

10 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: transmit a preamble signal from a communication device; and search for a random access response scheduling assignment identified by an identifier having a value
15 dependent at least partly on one or more of: (i) a feature of said communication device related to transmission of said scheduling assignment and/or identifiable from said preamble signal; and (ii) the index of the system frame in which the preamble signal was transmitted.

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16. An apparatus according to claim 15, wherein the memory and computer program code are further configured to, with the processor, cause the apparatus to: transmit the preamble signal in more than one system frame, and wherein said identifier has a value dependent at
25 least partly on the index of the system frame in which the preamble signal was first transmitted.

17. An apparatus comprising: a processor and memory including computer program code, wherein the memory and computer program
30 code are configured to, with the processor, cause the apparatus to: detect a preamble signal transmitted by a communication device; generate a random access response scheduling assignment in response to the preamble signal; and start transmission of the scheduling assignment

5 over a wireless interface at some time in a response window; wherein
the size and/or location of the response window is dependent at least
partly on one or more of: a feature of said communication device
relating to transmission of said scheduling assignment; and the index
of the system frame at which the random access preamble signal was
10 detected.

18. An apparatus according to claim 17, wherein the preamble signal
is transmitted in more than one system frame, and the size and/or
location of the response window has a value dependent at least partly
15 on the index of the system frame in which the preamble signal was
first detected.

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19. 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: transmit a preamble signal; and restrict a search for a random access
10 response scheduling assignment from a radio access network to a search space whose size and/or location is dependent at least partly on one or more of: a feature of said communication device related to transmission of said scheduling assignment and/or identifiable from said preamble signal; and/or the index of the system frame in which
15 said communication device transmits the random access preamble signal.

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20. A computer program product comprising program code means which when loaded into a computer controls the computer to: transmit a preamble signal from a communication device; and search for a random access response scheduling assignment identified by an identifier having a value dependent at least partly on one or more of:
10 (i) a feature of said communication device related to transmission of said scheduling assignment and/or identifiable from said preamble signal; and (ii) the index of the system frame in which the preamble signal was transmitted.

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