

Description

Title

REPEATED TRANSMISSION OF SCHEDULING ASSIGNMENT FOR RANDOM
ACCESS RESPONSE

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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
10 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.

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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
20 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.

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

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 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 reserved for the coverage enhancement level assigned to said communication device.

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

There is also provided an apparatus comprising: a

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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 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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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.

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.

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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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 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.

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 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.

In view of the above, according to a first aspect of the present application, there is 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 the index of system frame in which the preamble signal was detected.

According to a second aspect of the present application, there is 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 the index of system frame in which the preamble signal was transmitted.

According to a third aspect of the present application, there is 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 on the index of system frame in which the preamble signal was detected.

According to a fourth aspect of the present application, there is 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: 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 the index of system frame in which the preamble signal was transmitted.

According to a fifth aspect of the present application, there is 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; 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 dependent at least partly on the index of system frame at which the random access preamble signal was detected.

According to a sixth aspect of the present application, there is 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: 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 the index of system frame in which said communication device transmits the random access preamble signal.

According to a seventh aspect of the present application, there is provided 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 the index of system frame in which the preamble signal was transmitted.

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;

5 CLAIMS

1. 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
10 the scheduling assignment is identified by an identifier having a value dependent at least partly on the index of system frame in which the preamble signal was detected.
2. A method according to claim 1, wherein the preamble signal is
15 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.
3. A method according to claim 1 or 2, wherein the value is further
20 dependent at least partly on a feature of said communication device relating to the transmission of said scheduling assignment and/or identifiable from the preamble signal.
4. A method according to claim 3, comprising repeatedly transmitting
25 scheduling assignment over a number of subframes dependent on said feature of said communication device.
5. A method according to claim 3 or 4, wherein said feature of said communication device is a coverage enhancement level assigned to
30 the communication device; and said identifier has a value derived from a formula including the assigned coverage enhancement level as one variable.

5 6. 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
from the set of possible values reserved for the coverage enhancement
10 level assigned to said communication device.

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

15 8. 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
the index of system frame in which the preamble signal was
20 transmitted.

9. A method according to claim 8, 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
25 system frame in which the preamble signal was first transmitted.

10. A method according to claim 8 or 9, wherein the value is further
dependent at least partly on a feature of said communication device
relating to the transmission of said scheduling assignment and/or
30 identifiable from the preamble signal.

11. An apparatus comprising: a processor and memory including
computer program code, wherein the memory and computer program

5 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 the index of system frame in which the preamble signal was
detected.

12. An apparatus according to claim 11, wherein the preamble signal
is transmitted in more than one system frame, and said identifier has a
15 value dependent at least partly on the index of the system frame in
which the preamble signal was first detected.

13. An apparatus according to claim 11 or 12, wherein the value is
further dependent at least partly on a feature of said communication
20 device relating to the transmission of said scheduling assignment
and/or identifiable from the preamble signal.

14. An apparatus according to claim 13, wherein the memory and
computer program code are further configured to, with the processor,
25 cause the apparatus to: repeatedly transmit the scheduling assignment
over a number of subframes dependent on said feature of said
communication device.

15. An apparatus according to claim 13 or 14, wherein said feature of
30 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.

16. An apparatus according to claim 11, 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 from the set of possible values reserved for the coverage enhancement level assigned to said communication device.

17. An apparatus according to any of claims 11 to 16, wherein said identifier is random access radio network temporary identifier.

18. 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 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 the index of system frame in which the preamble signal was transmitted.

19. An apparatus according to claim 18, 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 least partly on the index of the system frame in which the preamble signal was first transmitted.

20. An apparatus according to claim 18 or 19, wherein the value is further dependent at least partly on a feature of said communication

5 device relating to the transmission of said scheduling assignment and/or identifiable from the preamble signal.

21. An apparatus comprising: a processor and memory including computer program code, wherein the memory and computer program
10 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
15 window; wherein the size and/or location of the response window is dependent at least partly on the index of system frame at which the random access preamble signal was detected.

22. An apparatus according to claim 21, wherein the preamble signal
20 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.

23. An apparatus according to claim 21 or 22, wherein the value is
25 further dependent at least partly on a feature of said communication device relating to the transmission of said scheduling assignment and/or identifiable from the preamble signal.

24. 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: 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
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5 the index of system frame in which said communication device transmits the random access preamble signal.

25. An apparatus according to claim 24, wherein the search space whose size and/or location is further dependent at least partly on a
10 feature of said communication device relating to the transmission of said scheduling assignment and/or identifiable from the preamble signal.

26. A computer program product comprising program code means
15 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 the index of system frame in which the preamble signal was transmitted.

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27. A computer program product according to claim 25, wherein the value is further dependent at least partly on a feature of said communication device relating to the transmission of said scheduling assignment and/or identifiable from the preamble signal.

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