(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
09 August 2018 (09.08.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/141384 A1

(51) International Patent Classification:
H04W 52/02 (2009.01) *H04W 76/04* (2009.01)
H04W 88/06 (2009.01) *H04W 28/02* (2009.01)

(21) International Application Number:
PCT/EP2017/052197

(22) International Filing Date:
02 February 2017 (02.02.2017)

(25) Filing Language: English

(26) Publication Language: English

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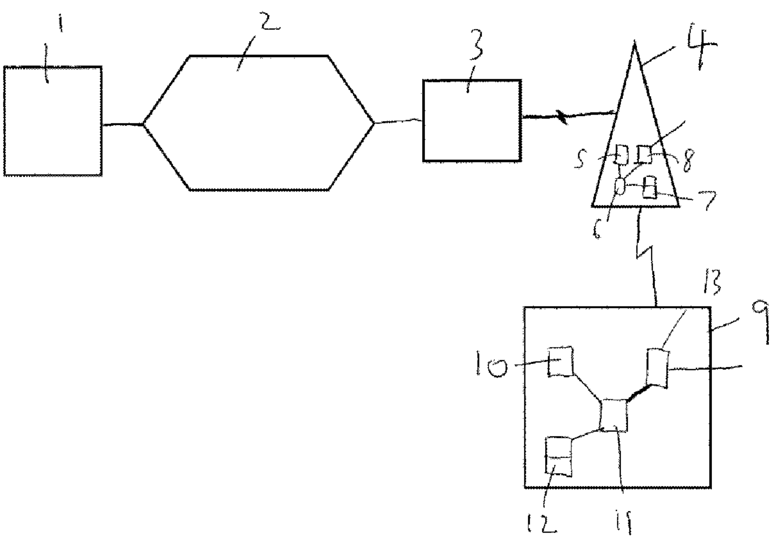
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,

(54) Title: POWER-COGNISANT ADAPTIVE PROTOCOLS

Figure 1



(57) Abstract: A telecommunications system comprising a network entity and a power-limited transceiver entity, the network entity being capable of communicating with the transceiver entity according to a first protocol mode and a second protocol mode, the second protocol mode being such as to require a lower surge energy for reception and/or transmission by the transceiver entity than does the first protocol mode; the network entity being configured to: estimate the power availability of the transceiver; and select one of the first and second modes for communication with the transceiver in dependence on the estimated power availability of the transceiver.

WO 2018/141384 A1

[Continued on next page]

TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

POWER-COGNISANT ADAPTIVE PROTOCOLS

BACKGROUND

User equipment (UE) devices for use in a low-power wide-area network may have a range of battery sizes and capacities depending on their purpose. Devices may also have different coverage classes, due to different link budgets. Some devices may communicate using a fast modulation and coding scheme (MCS), whereas some may use a slow MCS. Additionally, the protocols and latencies used for these different user devices may vary.

Device battery chemistry can be restrictive and devices with a small battery capacity may have limitations on the maximum current that may be drawn. Some user equipment devices might need to be equipped with a small factor battery which is not able to provide sufficient current to enable the devices to transmit or receive signal continuously. Some devices may use secondary charge storage devices such as capacitors, which are charged by the battery and can then discharge at a greater current than the battery supplies to allow bursts of higher power. However, peak power measured over a period of time is capped, as a capacitor stores a finite amount of energy, and there may still be a trade off against the battery life.

Therefore, for example, when sending out a large payload, the UE device may not have enough power to send the message. The UE’s battery may not be able to supply sufficient current to drive the transmitter, and the UE’s secondary charge storage device may not be able to supply sufficient power to drive the transmitter for the full duration of the message sending.

It is desirable for a communications network to recognise devices which are power-constrained, such that communications are adapted accordingly to limit peak power consumption.

SUMMARY OF THE INVENTION

According to one aspect of the invention there is provided a telecommunications system comprising a network entity and a power-limited transceiver entity, the network entity being capable of communicating with the transceiver entity according to a first protocol mode and a second protocol mode, the second protocol mode being such as to require a lower surge energy for reception and/or transmission by the transceiver entity than does the first protocol mode; the network entity being configured to: estimate the power availability of the transceiver;

and select one of the first and second modes for communication with the transceiver in dependence on the estimated power availability of the transceiver.

According to a second aspect of the invention there is provided a method for selecting a communication mode in a telecommunications system comprising a network entity and a power-limited transceiver entity, the network entity being capable of communicating with the transceiver entity according to a first protocol mode and a second protocol mode, the second protocol mode being such as to require a lower surge energy for reception and/or transmission by the transceiver entity than does the first protocol mode; the method comprising: the network entity estimating the power availability of the transceiver; and the network entity selecting one of the first and second modes for communication with the transceiver in dependence on the estimated power availability of the transceiver.

The second protocol mode may be such as to require a lower surge energy for reception and/or transmission by the transceiver entity than does the first protocol mode for the same traffic data.

The second protocol mode may be such as to require a lower total energy consumption over a predetermined time for reception and/or transmission by the transceiver entity than does the first protocol mode for the same traffic data.

The transceiver entity may have a radio frequency receiver and the said total energy consumption may be the total energy consumption of the radio frequency receiver when receiving over the predetermined time.

The predetermined time may be greater than 50 % of the maximum duration of a message in the second protocol mode.

The power-limited transceiver entity may be powered by a battery.

The battery might power at least part of the power-limited transceiver entity through a charge storage device configured for delivering a greater peak power than the battery is capable of delivering.

The power-limited transceiver entity may be arranged to charge the charge storage device from the battery.

The charge storage device may be a capacitor.

The network entity might estimate the power availability of the transceiver in dependence on a signal received from the transceiver, the signal comprising a field whose content indicates the power availability of the transceiver.

The network entity may store data indicating the service age of the transceiver and may estimate the power availability of the transceiver in dependence on the stored data.

Each message may comprise a payload and the first and second protocol modes may be capable of supporting messages up to a certain uplink payload size, the uplink payload size of the second protocol mode being smaller than the uplink payload size of the first protocol mode.

Each message may comprise a payload and the first and second protocol modes may be capable of supporting messages up to a certain downlink payload size, the downlink payload size of the second protocol mode being smaller than the downlink payload size of the first protocol mode.

The first and second protocol modes might each define a respective messaging duty-cycle, the duty-cycle of the second protocol mode being lower than the duty-cycle of the first protocol mode. The duty-cycle may be the ratio of (i) the duration for which the protocol permits transmit and/or receive activity between a pair of participants during a predetermined time period to (ii) the duration of that predetermined time period. The predetermined time period may be greater than 100ms, greater than 500ms or greater than 1s.

BRIEF DESCRIPTION OF THE FIGURES

The present invention will now be described by way of example with reference to the accompanying drawings.

In the drawings:

Figure 1 shows a communication network for sending messages from a server to a user equipment device.

Figure 2 illustrates the UE notifying the network of its power capability and the subsequent utilisation of an appropriate protocol.

DETAILED DESCRIPTION OF THE INVENTION

The system to be described below may be used in a communications network, as illustrated in Figure 1.

A server 1 is connected, via a network 2 such as the internet, to a core network 3. The core network is connected to a base station 4, which comprises a wireless transceiver 5, a processor 6 and a memory 7, with two parts for storing code and messages respectively. A wireless transceiver 8 in the base station communicates with a user equipment device 9 via wireless transceiver 10. The user equipment device also comprises a processor 11, a memory 12 with two parts for storing code and messages respectively, and a user interface 13 for presenting information or for sensing environmental data. The user interface 13 may comprise a mechanism for communicating or interacting with the device's environment or user, for example a display, touch screen, or one or more transducers.

The server 1 can send a message to the core network 3 via the network 2. The message includes a destination address. Based on that destination address, which is the address of the UE to which the message is intended to be delivered, the core network routes the message to a suitable base station 4. At the base station, the message is sent on to the user equipment device 9. The message is sent over a wireless link from wireless transceiver 8 in the base station to a wireless transceiver 10 in the device.

The network 2 may be a wide or narrow band network. It may be an internet of things network.

The UE may have a primary power source such as a battery, fuel cell or solar cell which is capable of delivering a limited amount of power over a prolonged period. In addition, the UE may have a secondary power storage device which is capable of storing a limited amount of energy from the primary power source and delivering that energy at a greater rate (i.e. delivering a greater power than the maximum power that can be delivered by the primary power source) over a period of time until the secondary power storage device is depleted. The secondary power storage device will typically be capable of delivering its maximum power for a relatively short period of time: for example, a period less then 50ms, less than 20ms, less than 10ms or less then 5ms. The power storage device may, for example, be one or more capacitors.

The UE's receiver or transmitter may be such that when the UE is operating to receive or transmit a data message, it needs to draw more power than the primary power source can deliver. In that situation the UE's receiver can be powered from the secondary power storage device, provided that the length of the message is sufficiently short that the secondary power source will not be fully depleted before the message has been fully received. When the UE is operating for other purposes, for example to digitally process the received message or when sleeping, it may require a power that is within the power level that can be delivered by the primary power source. The surge energy that the UE requires for a particular function is dependent on the time over which the energy is used and the power consumed during that time. Over a relatively short period of time the surge energy available to the device may be limited by the power output of the secondary storage device. Over a longer period of time the surge energy may be limited by the capacity of the secondary storage device since a UE of this type can only maintain its maximum operational power until the secondary storage device has been depleted. Ultimately, the energy available to the UE may be limited by the charge stored in the primary storage device.

As illustrated in Figure 2, the UE device 9 attaches to the base station 4 (which is attached to core network 3, shown at 14) at 15. At this point, the base station communicates with the device according to a first protocol mode. The UE can indicate its power capability to the base station by sending a signal, as shown at 16. The base station can also communicate this capability to the core network 3, as shown at 17.

In response to receiving the indication of the UE device's power capability, the core network may notify the base station of an appropriate protocol mode to be used when subsequently sending or receiving communications to or from the device, as shown at 18. The network and/or the base station subsequently utilise the appropriate protocol when communicating with the UE device, shown at 19.

The network (e.g. an element in a core network or the base station to which the UE is attached) selects, in response to the power capability of the UE as indicated in a message from the UE, a suitable protocol for use in communicating with the UE. The selection may be made in dependence on a pre-stored set of selection criteria available to the element performing the selection. The selection is made so that the selected protocol is expected to be usable by the UE: i.e. that the protocol will not require the UE to operate with a surge energy greater than the UE is capable of. In this way, the UE can be expected to operate to transmit and/or receive signals according to the selected protocol without exceeding its power capability as signalled to the network.

Some examples of ways in which the wireless protocol may be adapted to suit a UE with a limited power capability are that, in comparison to how the system might operate with another UE:

- There could be a reduction in the maximum uplink payload size that can be transmitted according to the selected protocol, such that the time spent transmitting is within the capability of the UE's power supply.
- There could be a reduction in the maximum downlink payload size that can be transmitted according to the selected protocol. This is useful when the receive time is limited.
- The duty-cycle of the selected protocol could be lower. There could be duty-cycle restrictions for both uplink and downlink communications.
- The protocol could provide for an increased delay in uplink opportunities after a previous transmit or receive event to/from the UE. This could permit the UE to recharge its secondary power supply before being required to make a further transmission.
- The protocol could provide for an increased delay in the signalling of responses to the UE device, with a pause before acknowledgement.
- There could be a larger gap between transmissions of Mobile-Terminated data.

The protocol selected for use with a UE having relatively low power availability may be such that the delays between successive transmit/receive events to/from the UE are defined to be such that the UE may pre-emptively charge its secondary charge storage device such that the time spent charged (and leaking) is limited (presuming that the capacitor leakage power is greater than the battery leakage power).

The UE may transmit to the network an explicit indication of its power availability: for example one or more of (i) an indication of a maximum power draw of which it is capable, (ii) an indication of the time over which that power can be drawn and (iii) an indication of the time required between events in which the maximum power is drawn for the maximum time (e.g. the time required to recharge the secondary power source from the primary power source). Alternatively, the network may have pre-stored information indicating the power availabilities of different classes of devices and the UE may simply transmit an indication of which of those classes it belongs to. In order to select a suitable protocol the network may assume a predetermined level of power consumption by the UE for transmit and/or receive. Alternatively, the UE may transmit to the network an indication of its power consumption for transmit and/or receive, or the network may store power consumption information for a set of classes of device and the UE may transmit an indication of which of that set it belongs to.

Instead of receiving a signal notifying it of the UE device’s power capability and using this to select an appropriate protocol, the network may store data indicating the service age of the UE device and may estimate the power capability of the UE device in dependence on the stored data.

The protocol selection might be influenced by battery level metrics received from the UE device. The protocols may be adapted according to a model for the UE device’s power supply over time. For example, freshly-deployed UE devices could use different protocols to ones which have batteries that are almost depleted.

Alternatively, or additionally, the eDRX (extended discontinuous reception) parameters for the UE device could be changed based on the battery capacity of the device.

Instead of being powered by a battery, the device could be powered by another source such as a fuel cell, solar panel or other means.

The invention is described above in the case of a wireless link between the base station and the UE device. This technique could also be implemented for a non-wireless network.

The applicant hereby discloses in isolation each individual feature described herein and any combination of two or more such features, to the extent that such features or combinations are capable of being carried out based on the present specification as a whole in the light of the common general knowledge of a person skilled in the art, irrespective of whether such features or combinations of features solve any problems disclosed herein, and without limitation to the scope of the claims. The applicant indicates that aspects of the present invention may consist of any such individual feature or combination of features. In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention.

CLAIMS

1. A telecommunications system comprising a network entity and a power-limited transceiver entity, the network entity being capable of communicating with the transceiver entity according to a first protocol mode and a second protocol mode, the second protocol mode being such as to require a lower surge energy for reception and/or transmission by the transceiver entity than does the first protocol mode; the network entity being configured to:

estimate the power availability of the transceiver; and

select one of the first and second modes for communication with the transceiver in dependence on the estimated power availability of the transceiver.

2. The telecommunications system of claim 1, wherein the second protocol mode is such as to require a lower surge energy for reception and/or transmission by the transceiver entity than does the first protocol mode for the same traffic data.

3. The telecommunications system of claim 1 or claim 2, wherein the second protocol mode is such as to require a lower total energy consumption over a predetermined time for reception and/or transmission by the transceiver entity than does the first protocol mode for the same traffic data.

4. The telecommunications system of claim 3, wherein the transceiver entity has a radio frequency receiver and the said total energy consumption is the total energy consumption of the radio frequency receiver when receiving over the predetermined time.

5. The telecommunications system of claim 3 or claim 4, wherein the predetermined time is greater than 50 % of the maximum duration of a message in the second protocol mode.

6. The telecommunications system of any preceding claim, wherein the power-limited transceiver entity is powered by a battery.

7. The telecommunications system of claim 6, wherein the battery powers at least part of the power-limited transceiver entity through a charge storage device configured for delivering a greater peak power than the battery is capable of delivering.

8. The telecommunications system of claim 7, wherein the power-limited transceiver entity is arranged to charge the charge storage device from the battery.

9. The telecommunications system of any preceding claim, wherein the network entity estimates the power availability of the transceiver in dependence on a signal received from the transceiver, the signal comprising a field whose content indicates the power availability of the of the transceiver.

10. The telecommunications system of any preceding claim, wherein the network entity stores data indicating the service age of the transceiver and estimates the power availability of the transceiver in dependence on the stored data.

11. The telecommunications system of any preceding claim, wherein each message comprises a payload and the first and second protocol modes are capable of supporting messages up to a certain uplink payload size, the uplink payload size of the second protocol mode being smaller than the uplink payload size of the first protocol mode.

12. The telecommunications system of any preceding claim, wherein each message comprises a payload and the first and second protocol modes are capable of supporting messages up to a certain downlink payload size, the downlink payload size of the second protocol mode being smaller than the downlink payload size of the first protocol mode.

13. The telecommunications system of any preceding claim, wherein the first and second protocol modes each define a respective messaging duty-cycle, the duty-cycle of the second protocol mode being lower than the duty-cycle of the first protocol mode.

14. A method for selecting a communication mode in a telecommunications system comprising a network entity and a power-limited transceiver entity, the network entity being capable of communicating with the transceiver entity according to a first protocol mode and a second protocol mode, the second protocol mode being such as to require a lower surge energy for reception and/or transmission by the transceiver entity than does the first protocol mode; the method comprising:

the network entity estimating the power availability of the transceiver; and

the network entity selecting one of the first and second modes for communication with the transceiver in dependence on the estimated power availability of the transceiver.

15. The method of claim 14, wherein the second protocol mode is such as to require a lower surge energy for reception and/or transmission by the transceiver entity than does the first protocol mode for the same traffic data.

16. The method of claim 14 or claim 15, wherein the second protocol mode is such as to require a lower total energy consumption over a predetermined time for reception and/or transmission by the transceiver entity than does the first protocol mode for the same traffic data.

17. The method of claim 16, wherein the transceiver entity has a radio frequency receiver and the said total energy consumption is the total energy consumption of the radio frequency receiver over the predetermined time.

18. The method of claim 16 or claim 17, wherein the predetermined time is greater than 50 % of the maximum duration of a message in the second protocol mode.

19. The method of any of claims 14 to 18, wherein the power-limited transceiver entity is powered by a battery.

20. The method of claim 19, wherein the battery powers at least part of the power-limited transceiver entity through a charge storage device configured for delivering a greater peak power than the battery is capable of delivering.

21. The method of claim 20, wherein the power-limited transceiver entity is arranged to charge the charge storage device from the battery.

22. The method of any of claims 14 to 21, wherein the network entity estimates the power availability of the transceiver in dependence on a signal received from the transceiver, the signal comprising a field whose content indicates the power availability of the of the transceiver.

23. The method of any of claims 14 to 22, wherein the network entity stores data indicating the service age of the transceiver and estimates the power availability of the transceiver in dependence on the stored data.

24. The method of any of claims 14 to 23, wherein each message comprises a payload and the first and second protocol modes are capable of supporting messages up to a certain uplink payload size, the uplink payload size of the second protocol mode being smaller than the uplink payload size of the first protocol mode.

25. The method of any of claims 14 to 24, wherein each message comprises a payload and the first and second protocol modes are capable of supporting messages up to a certain downlink payload size, the downlink payload size of the second protocol mode being smaller than the downlink payload size of the first protocol mode.

26. The method of any of claims 14 to 25, wherein the first and second protocol modes each define a respective messaging duty-cycle, the duty-cycle of the second protocol mode being lower than the duty-cycle of the first protocol mode.

Figure 1

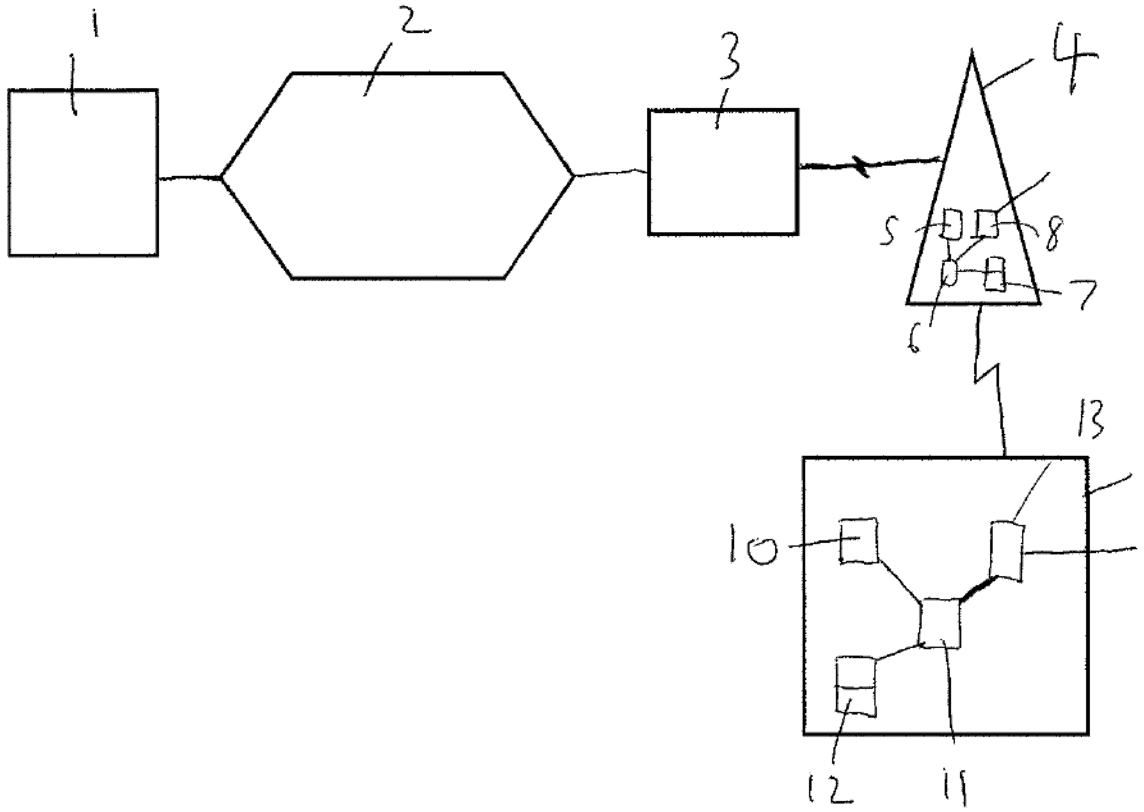
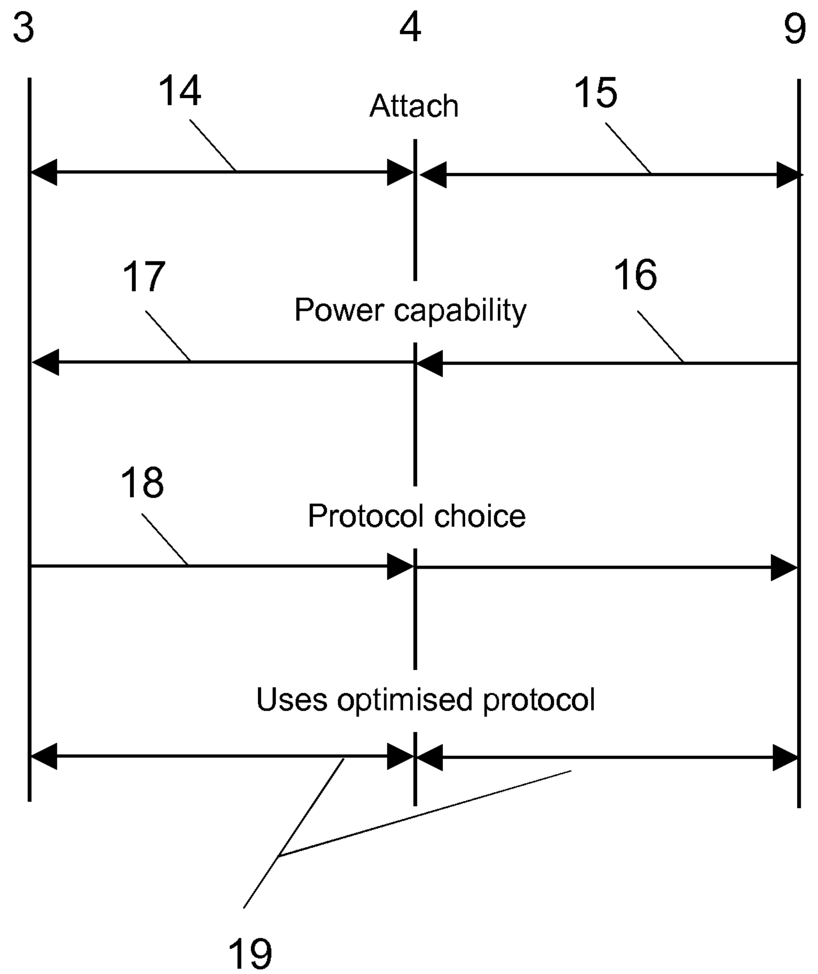


Figure 2


3
4
9
14
Attach
15
17
Power capability
16
18
Protocol choice
Uses optimised protocol
19

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/052197

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W52/02
ADD. H04W88/06 H04W76/04 H04W28/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X Y	US 2011/143699 A1 (NOH SEUNG PYO [KR] ET AL) 16 June 2011 (2011-06-16) figures 1, 10-12, 18, 19 paragraph [0015] paragraph [0075] - paragraph [0076] paragraph [0080] paragraph [0099] - paragraph [0111] paragraph [0145] - paragraph [0146] paragraph [0192] -----	1-10, 14-23 11-13, 24-26
Y A	US 2008/088417 A1 (SMITH PATRICK [US] ET AL) 17 April 2008 (2008-04-17) paragraph [0067] - paragraph [0068] ----- -/--	13,26 1-12, 14-25

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
13 September 2017	20/09/2017

Name and mailing address of the ISA/	Authorized officer
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2

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/052197

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	"3 Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures (Release 14)", 3GPP STANDARD; 3GPP TS 36.213, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. V14.0.0, 29 September 2016 (2016-09-29), pages 46-263, XP051172656, [retrieved on 2016-09-29]	11,12, 24,25
A	tables 7.2.2-3	1-10, 13-23,26

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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