



- (51) **International Patent Classification:**
H04W 84/20 (2009.01) *H04W 8/00* (2009.01)
- (21) **International Application Number:**
PCT/IB2012/053822
- (22) **International Filing Date:**
26 July 2012 (26.07.2012)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
1113008.5 28 July 2011 (28.07.2011) GB
13/193,055 28 July 2011 (28.07.2011) US
- (71) **Applicant (for all designated States except US):** RENE-SAS MOBILE CORPORATION [JP/JP]; 6-2, Otemachi 2-Chome, Chiyoda-Ku, Tokyo (JP).
- (72) **Inventors; and**
- (75) **Inventors/Applicants (for US only):** KOSKELA, Timo [FI/FI]; Rautatiekatu 50 as 5, FI-90120 Oulu (FI). HAKOLA, Sami-Jukka [FI/FI]; Peikontie 7, FI-90450 Kempele (FI). TURTINEN, Samuli [FI/FI]; Poolatie 3a, FI-91100 Ii (FI). OJALA, Jussi K [FI/FI]; Torkkelinkatu 21B 32, FI-00530 Helsinki (FI).
- (74) **Agent:** FLINT, Adam; EIP, Fairfax House, 15 Fulwood Place, London, Greater London WC1V 6HU (GB).

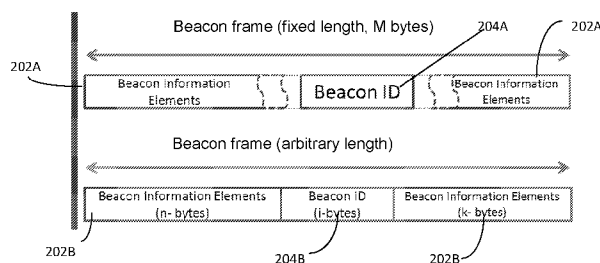
(81) **Designated States** (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, 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, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, 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, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(54) **Title:** METHODS, APPARATUS AND COMPUTER PROGRAMS FOR COMPILING A BEACON AND FILTERING RECEIVED BEACONS

**Figure 2A****Figure 2B**

(57) **Abstract:** There is stored in a memory an association between each n th one of N content types with a respective n th group of N groups of identifiers (N is an integer greater than one, n indexes from 1 to N , and at least one of the groups has more than one identifier). A beacon sender selects one of the content types for a beacon to be transmitted and selects a beacon identifier (204A, 204B) from the group associated with the selected content type. The beacon to be transmitted is compiled to include content of the selected content type and the selected beacon identifier (204A, 204B). The beacon receiver selects at least one of the content types; and, for a plurality of beacons received, filters out from further processing each beacon having a beacon identifier (204A, 204B) that is not within the group of identifiers associated with any of the at least one selected content types. The network creates the association and broadcasts it in a network cell.

METHODS, APPARATUS AND COMPUTER PROGRAMS FOR
COMPILING A BEACON AND FILTERING RECEIVED BEACONS

Cross Reference to Related Application

5 This application claims benefit under 35 U.S.C. § 119(a) and 37 CFR 1.55 to UK patent application no. 1113008.5, filed on July 28, 2011, the entire content of which is hereby incorporated by reference.

10 This application also claims the benefit of US patent application no. 13/193,055, filed on July 28, 2011, the entire content of which is hereby incorporated by reference.

Technical Field

15 The present invention relates to methods, apparatus and computer programs for compiling a beacon and methods, apparatus and computer programs for filtering received beacons.

20 The exemplary and non-limiting embodiments of this invention relate generally to wireless communication systems, methods, devices and computer programs and, in specific embodiments, relate to network-directed filtering of user communications such as for example machine-to-machine or device-to-device communications directly between mobile nodes.

Background

25 The following abbreviations which may be found in the specification and/or the drawing figures are defined as follows:

3GPP	Third Generation Partnership Project
AP	access point
BSS	basic service set
30 D2D	device to device
eNB	evolved NodeB

	IBSS	independent basic service set
	ID	identification, identifier
	IEEE	Institute of Electrical and Electronics Engineers
	ISM	industrial, scientific, medical
5	LTE	Long Term Evolution (evolved UTRAN)
	M2M	machine to machine
	MAC	medium access control
	OFDM	orthogonal frequency-division multiplexing
	RAT	radio access technology
10	RNTI	radio network temporary identifier
	SFN	system frame number
	STA	station
	UE	user equipment
	UTRAN	universal terrestrial radio access network
15	WLAN	wireless local area network

In the wireless communication arts, there has been increasing research into D2D communications in which portable radio devices (two or more) form their own ad hoc network to communicate directly with one another without having to send their data through a conventional (cellular) network. M2M is a subset of D2D in that the M2M communications are typically between un-manned user devices, such as remotely mounted sensors and data collection/aggregation nodes which collect and analyse data from several such sensors for event-based reporting of abnormal conditions. Typically M2M devices will have lesser processing power than their user-operated D2D companions but sometimes need not rely on a temporary power source (unlike a UE radio which relies on a battery for portable power). The following discussion of D2D includes the M2M subset unless specifically noted otherwise.

In some implementations, the radio spectrum these D2D devices use for their D2D communications lies in the unlicensed frequency bands, such as the ISM band in which WLAN communications occur or what is known as television whitespaces. In

others it lies in a cellular band, either from opportunistic use of spectrum “holes” the mobile devices find and exploit while avoiding interference to the primary (conventional cellular) users on that licensed band, or by being allocated certain radio resources by the cellular network itself for their D2D communications. In any of these, the cellular network might exercise some varying level of control over the D2D communications in order to ensure a more efficient use of the limited radio spectrum.

Figure 1 illustrates an exemplary wireless environment in which embodiments of these teachings may be practised to advantage. Cell A is a cellular region in which UEs operating on the licensed band are controlled by an eNB 22, and is adjacent to cell B which is controlled by eNB 23. Near the border there is a cluster of UEs (UE1, UE2, UE3, UE4) which seek to engage in D2D communications.

In conventional infrastructure mode WLAN, each UE not operating as the AP for the group would be associated to a given AP by responding to the AP’s beacon requesting to associate to the AP’s group, termed a BSS. The AP coordinates communications, some of which may be D2D, and also provides the UEs (termed non-AP STAs in WLAN) with connectivity to a broader network, such as the Internet. In conventional ad hoc mode WLAN, there is no AP and so no AP’s beacon to which the STAs can associate. In this case, one of the STAs takes on some limited functions of the AP by transmitting its own beacon using an IBSS ID it selects; the other STAs join that IBSS and the joined devices can then engage in D2D communications. Unlike the infrastructure mode, the D2D devices in the ad hoc mode must discover one another without the aid of a centralised AP to which all interested devices in the area are associated.

D2D is not nearly as ubiquitous as other communication techniques, but it is anticipated that some proximity-based or location-based applications might be added to broaden its usability. See for example document Tdoc RP-110706 entitled “On the need for a 3GPP study on LTE device-to-device discovery and communication”, Tdoc RP-110707 entitled “Study on LTE Device to Device Discovery and

Communication – Radio Aspects”, and Tdoc-RP-110708 entitled “Study on LTE Device to Device Discovery and Communication – Service and System Aspects”, each from 3GPP TSG-RAN #52; Bratislava, Slovakia; 31 May to 3 June 2011 and by Qualcomm Inc.

5

In the inventors’ view, D2D in its current state is not seen to be well adapted for very wide adoption; the current protocols for device discovery in the radio/physical layer may tend to flood the higher layers (MAC and L1 layers) if the lower radio/physical layers have to pass all the D2D discovery signalling they detect to the upper layers for processing and decision making. If D2D were more common, the devices seeking to join an ad hoc IBSS would be scanning and reading many beacons which they then disregard after decoding and deciding that they choose not to join. The IEEE 802.11mb specifications which give the beacon frame format note that the beacon frame is a subtype of a management frame, and that the beacon frame origins are separated by the BSS/IBSS ID field and the sender’s MAC address field, both in the header. Additionally, the current D2D protocols do not seem to support proximity-based or location-based applications as the above 3GPP documents seek.

Summary

According to a first aspect of the present invention, there is provided a method of compiling a beacon to be transmitted, the method comprising: storing in a computer-readable memory an association between each n th one of N content types with a respective n th group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N , and at least one of the groups has more than one identifier; selecting one of the content types for a beacon to be transmitted and selecting a beacon identifier from the group associated with the selected content type; and compiling the beacon to be transmitted to include content of the selected content type and the selected beacon identifier.

According to a second aspect of the present invention, there is provided apparatus for compiling a beacon to be transmitted, the apparatus comprising: a

processing system arranged to at least: store in a memory an association between each nth one of N content types with a respective nth group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N, and at least one of the groups has more than one identifier; select one of the content types for a beacon to be transmitted and select a beacon identifier from the group associated with the selected content type; and compile the beacon to be transmitted to include content of the selected content type and the selected beacon identifier.

According to a third aspect of the present invention, there is provided a computer program for compiling a beacon to be transmitted, the computer program comprising: code for storing in a computer-readable memory an association between each nth one of N content types with a respective nth group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N, and at least one of the groups has more than one identifier; code for selecting one of the content types for a beacon to be transmitted and selecting a beacon identifier from the group associated with the selected content type; and code for compiling the beacon to be transmitted to include content of the selected content type and the selected beacon identifier.

The beacon to be transmitted may be arranged to be transmitted at a transmit power within a transmit power range associated with the selected content type

According to a fourth aspect of the present invention, there is provided a method of filtering received beacons, the method comprising: storing in a computer-readable memory an association between each nth one of N content types with a respective nth group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N, and at least one of the groups has more than one identifier; selecting at least one of the content types; and for a plurality of beacons received, filtering out from further processing each beacon having a beacon identifier that is not within the group of identifiers associated with any of the at least one selected content types.

According to a fifth aspect of the present invention, there is provided apparatus for filtering received beacons, the apparatus comprising: a processing system arranged to at least: store in a memory an association between each nth one of N content types with a respective nth group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N, and at least one of the groups has more than one identifier; select at least one of the content types; and for a plurality of beacons received, filter out from further processing each beacon having a beacon identifier that is not within the group of identifiers associated with any of the at least one selected content types.

According to a sixth aspect of the present invention, there is provided a computer program for filtering received beacons, the computer program comprising: code for storing in a memory an association between each nth one of N content types with a respective nth group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N, and at least one of the groups has more than one identifier; code for selecting at least one of the content types; and for a plurality of beacons received, code for filtering out from further processing each beacon having a beacon identifier that is not within the group of identifiers associated with any of the at least one selected content types.

According to a seventh aspect of the present invention, there is provided a method of broadcasting an association between content types and identifiers, the method comprising: creating and storing in a computer-readable memory an association between each nth one of N content types and a respective nth group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N, and at least one of the groups has more than one identifier; and broadcasting the association in a network cell.

According to an eighth aspect of the present invention, there is provided apparatus for broadcasting an association between content types and identifiers, the apparatus comprising: a processing system arranged to at least: create, and store in a

memory, an association between each nth one of N content types and a respective nth group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N, and at least one of the groups has more than one identifier; and broadcast the association in a network cell.

5

According to a ninth aspect of the present invention, there is provided a computer program for broadcasting an association between content types and identifiers, the computer program comprising: code for creating, and for storing in a memory, an association between each nth one of N content types and a respective nth group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N, and at least one of the groups has more than one identifier; and code for broadcasting the association in a network cell.

10

Any of the computer programs may be stored in tangible form in a memory and be executable by at least one processor.

15

Any of the processing systems may comprise a memory storing a computer program and at least one processor.

20

Further features and advantages of the invention will become apparent from the following description of preferred embodiments of the invention, given by way of example only, which is made with reference to the accompanying drawings.

Brief Description of the Drawings

25

Figure 1 is a schematic diagram showing a radio environment with a group of four UEs under one cell A and adjacent to another cell B, in which exemplary embodiments detailed herein may be practised to advantage;

Figure 2A and 2B show schematic diagrams showing two different exemplary structures for a beacon frame adapted according to the teachings set forth herein;

30

Figures 3A and 3B show schematic diagrams showing two different exemplary implementations of the beacon ID field of the beacon frames shown at Figures 2A and 2B according to the teachings set forth herein;

5 Figures 4 and 6 show logic flow diagrams illustrating the operation of a method, and a result of execution of computer program instructions embodied on a computer-readable memory, for practising exemplary embodiments of these teachings from the perspective of various devices shown at Figures 1 and 7; and

10 Figure 7 shows a simplified block diagram of some of the devices shown at Figure 1 which are exemplary electronic devices suitable for use in practising the exemplary embodiments of this invention.

Detailed Description

15 In the environment of Figure 1 consider that the D2D communications are under some management control by the eNB 22. In order to first establish D2D communications with the other UEs, UE1 will send a beacon broadcasting its IBSS to which the others can join. According to exemplary embodiments of these teachings, the UE1 will select a beacon ID to be disposed within the beacon it transmits which
20 indicates the type of contents of that beacon frame. The network (eNB 22) manages how this occurs by designating certain beacon IDs for the different types of information. The network may choose to group the beacon IDs in any number of ways: leading integer or triplet of digital values, trailing integer/triplet, a simple mathematical operation on the beacon ID, and the like. For simplicity of explaining
25 the concept, the examples below group sequential beacon ID values to the same type of beacon content.

For example, if K is an arbitrary constant integer, the network may designate beacon IDs as follows:

- 30
 - D2D control information has ID range from K to K+10;
 - D2D device discovery information has the ID range from K+11 to K+20;

- D2D unicast/multicast information has the ID range from K+21 to K+30;
- D2D commercial advertising has the ID range K+31 to K+40;
- M2M data has the ID range of K+41 to K+50;
- etc.

5

The eNB 22 distributes this information in the cell A, such as for example including it in the eNB's broadcast system information which the D2D devices UE1 to UE4 can listen to even while in a cellular inactive mode in the cell A (such as the idle mode or registration area/location area tracking mode). Therefore, if UE1 seeks to check whether there are other devices in the area with which it would like to engage in D2D communications, it can select one of the beacon IDs between K+11 to K+20 and insert the selected value within a new beacon frame UE1 broadcast. UE1 will be sending this beacon for device discovery purposes and so it has relevant broadcast information which enables other devices UE2, UE3, UE4 to pair with UE1. Other types of beacon frames might have control information such as channel allocations or transmit durations, unicast or multicast data, or even commercial advertisements from vendors/shop owners in the local area of the D2D devices to inform those devices of the vendor's presence or some special offer. The beacon-sending UE1 can select any beacon ID within the network-defined range of IDs which is not already in use in the local area; UE1 can check beacon ID availability by monitoring the airwaves to see if any other beacon IDs within the network-defined range are currently being used.

Any of the other UEs which are also seeking to pair with a D2D device may then fully process (decode and read) only the beacons they see whose beacon ID is within the range K+11 through K+20, and disregard all others which have beacon IDs corresponding to any other content type. It may be that UE4 does not recognise UE1 as a trusted D2D partner and so will not pair with it, but regardless, the association of specific beacon IDs with only one category of beacon contents enables UE4 to ignore all other beacons whose beacon ID is not associated with the device discovery type of content. This saves UE4 battery power and processing capacity in that it does not

have to decode and read all of the other beacons in the area, and only need process the beacon ID fields first to see if the whole beacon might be relevant. Since the location of the beacon ID field within the beacon and the ID ranges of the specific categories/content types are known in advance to the UEs, the D2D UE can filter the beacon messages it hears based on the ID range.

In the embodiment above, it is the eNB 22 which selects the specific beacon ID values which are associated with the different categories. In another embodiment of these teachings, the beacon ID values are fixedly associated with a beacon content type and all network cells will use the same IDs associated to the same beacon content type. This may be implemented by stipulating in a published D2D wireless standard the specific beacon ID values that are associated to the various content types. Regardless, the ID values are associated to the content types by the network, and so it may be considered that the network configures filtering by the UEs which receive the beacon since they will filter by content type. This is particularly valuable for M2M devices which normally have lesser processing capacity. In one embodiment, there is a range of beacon IDs specifically associated with M2M data to facilitate power savings at any M2M devices that may be operating in the area, the power savings over and above those achieved by enabling these M2M devices to ignore unrelated beacons after reading only the beacon ID field.

From the above description, it is clear that the network is configuring the filtering parameters for the beacon-receiving D2D devices, since the network sets the beacon IDs per category and the receiving devices filter the beacons they receive according to the beacon IDs. But in an embodiment, the network also configures filtering parameters for the beacon-transmitting D2D devices.

For example, if we assume that the eNBs 22, 23 in Figure 1 are home eNBs (HeNBs) which cover a much smaller area within a LTE macro cell, then the network (macro cell or above) may associate one range of beacon IDs K+11 to K+15 with the device discovery content type for HeNB 22 and a different range K+16 to K+20 of

beacon IDs with the device discovery type for HeNB 23. HeNB 22 would inform the UEs in its area via its broadcast system information that beacon IDs K+11 to K+15 are for device discovery content while simultaneously HeNB 23 would do similarly for beacon IDs K+16 to K+20. UE4 lies near the border of HeNB22 and HeNB 23 and can read both their system information broadcasts. In the above example, UE4 can know, from hearing some beacon with beacon ID selected from the set {K+11 to K+15}, that the beacon sending UE1 is nearer to HeNB 22 than to HeNB 23. In this manner, the beacon ID can be used to intrinsically give location or proximity information of the sending device.

The above is but one simple example. Other ways of making location information inherent in the beacon ID groups is to make the beacon ID groups related to the network cell ID by a simple mathematical formula. In another embodiment, the beacon ID groups are related to the uplink or downlink pathloss that the beacon sending device sees with respect to the network cell. An example of this is that the UE is expected to choose a progressively lower value within the designated beacon ID range when it sees progressively higher pathloss (lowest beacon ID in the range for near maximum pathloss. The receiving device interprets the beacon ID value that it reads as the sending device being further from that network cell than if the beacon ID were higher within the range). These are but a few examples of how location or proximity information can be intrinsic with the beacon ID value, and any given implementation may use one of the above examples or a combination of them.

Another way for the network to impose filtering on the beacon-sending side is to reserve certain beacon IDs for emergency or other high priority service, and then allow only certain devices to use those beacon IDs while restricting all others. So for example, if beacon IDs K+51 to K+53 were reserved for emergency weather alerts and/or abducted children alerts (known as Amber alerts in the US), the network might restrict only fixed devices with certain cell IDs to use them in beacons which those devices transmit. As this is relatively rare, other beacon receiving devices would

sacrifice little in the way of battery and processing power if they also filtered in beacons bearing those restricted beacon IDs rather than filtering them out.

Any of the above implementations may be supplemented with transmit power limits for the different beacon ID ranges. In the above emergency beacon example, beacons bearing an ID selected from the smaller ID range K+51 to K+53 would be transmitted at a higher power, while beacons carrying commercial advertising and having an ID selected from K+31 to K+40 would be transmitted with a low power (for example, with a range on the order of tens of meters). More routine but important D2D beacons, such as for device discovery (K+11 to K+20) and control information for initial pairing of already-discovered D2D devices (K to K+10) would be sent with a medium power between the above two. In these implementations, there is a transmit power range associated with a group of beacon IDs which are in turn associated with content of the underlying beacon frame.

15

In the above description, the network configures the filtering of beacons based on the type of content of the beacon. In an exemplary embodiment, the network can configure further filters for the D2D devices by setting filtering triggers which are based on the beacon ID. So for example if the beacon ID is value Y then the beacon-sending and/or the beacon-receiving UE applies an additional beacon filter for beacons with IDs between H and J.

20

The following examples show the network signalling the parameters for such further filters for the beacon-sending device. If for example there is a multicell configuration such as is shown at Figure 1 with cells A and B, it may be useful to synchronise the beacon-sending device's (UE1) transmit power for a beacon bearing a given beacon ID and the resource allocations (assuming the case in which the D2D communications use radio resources allocated by the network/eNB 22). In this case, the certain beacon IDs are mapped to certain radio resources and so the specific beacon ID in the transmitted beacon maps to a specific radio resource, similar to an allocated uplink or downlink resource mapping to another resource on which the

25

30

acknowledgement or negative acknowledgement is sent. The network/eNB 22 can then signal parameters to the beacon-sending device UE1 which the beacon sending device UE1 can use to derive the transmit power for any beacon which has a beacon ID in the ID range that is reserved for the content type. In this manner, if there were
5 other UEs in cell B of Figure 1 which might choose the same beacon ID for their beacon as does UE1 in cell A, then the devices in the different cells will transmit their respective beacons which bear the same beacon ID with different transmit powers. The network is then able to control transmit powers of various beacons; for example enforcing a low transmit power for commercial advertisements sent by devices near
10 the eNB.

As a specific example, for time interval T1, UE1 would transmit its beacon with high transmit power and the UE in cell B would transmit its beacon with low power and, for a next succeeding time interval T2, the UE1 in cell A would transmit
15 its beacon with low power while the UE in cell B would transmit its beacon with high power. So even if these two UEs, which are not coordinating which beacon ID they choose, happen to choose the same beacon ID and also happen to transmit a same-content-type beacon at the same time, they are differentiated by the transmit power distinction. As an alternative, the UE that sees it will transmit with low power will
20 delay its transmission until the time interval in which it can transmit at high power. In one example, this time-varying transmit power computation may be implemented by applying a function to the system frame number which is common across the different cells A and B. One such function is a modulo operation, for example $\text{SFN mod } X$ in which X is an integer value specific to the different cells A and B. In this manner, the
25 beacons with a certain beacon ID or beacon ID range can be transmitted only in certain sub-frames, so for example if a given beacon ID or ID range is tied to $X = 10$, the beacon can be transmitted only in every 10th sub-frame. The values of X and the range of beacon IDs associated with a given X value can be fixed (for example, set forth in a published wireless protocol) or it can be configurable by the network/eNB
30 22.

In an exemplary embodiment, the beacon also informs the beacon-receiving UE (UE2, UE3, UE4) of what the transmit power was. In one embodiment, the transmit power is indicated explicitly in the beacon itself. An alternative embodiment saves signalling bits; the transmit power information is comparative only (low, medium or high for example without specific quantisation) and the transmit power indication is implicit within the beacon message, or more specifically within the beacon ID of the beacon. Recall that it was detailed above that different content-types may have different transmit powers associated with them. In this embodiment of implicitly indicating the transmit power in the beacon, there are different powers associated with different beacon IDs within the ID range of one beacon content-type. As a specific example, if the beacon is to have device discovery type contents for which the reserved beacon ID range is K+11 to K+20, the beacon-sending UE1 will select from among K+11 to K+13 if it is to send the beacon with low power, and from among K+18 to K+20 if it is to send the beacon with high power, and from among K+14 to K+17 if it is to send the beacon with medium power. This implicit indication ties the beacon ID for a particular content type to the transmit power. Indicating the transmit power in the beacon itself, either explicitly or implicitly, enables the beacon-receiving UEs (UE2, UE3, UE4) to estimate their distance from the beacon-sending device UE1.

20

Figures 2A and 2B illustrate two exemplary embodiments of a beacon frame adapted according to these teachings to include a beacon ID field, and Figures 3A and 3B illustrate two exemplary embodiments of the beacon ID field itself. Continuing with the LTE example as the governing RAT, a radio frame consists of 10 sub-frames each 1ms in duration. One sub-frame consists of 2 slots which in turn have 7 OFDM symbols each. A beacon frame may be transmitted in one or multiple such sub-frames or slots.

The example at Figure 2A illustrates a fixed length beacon frame. In this case, each field 202A, 204A has a specific length which is known to the receiving devices without explicit information carried in the frame. The new beacon ID field is shown

30

as 204A. The example at Figure 2B illustrates an arbitrary length beacon frame. The length is indicated in the beacon information elements 202B and the frame size can be dynamic. In this case, the beacon ID field 204B can be fixed length, or as illustrated it may be an arbitrary length. The various beacon information elements 202A, 202B
5 can include information such as the sender address, the receiver address, frame length fields, etc. In conventional practice, the sender and receiver addresses are MAC addresses. The beacon ID field 204A, 204B is disposed at a predetermined location within the frame, or is indicated by one or more of the various information elements 202A, 202B.

10

Now consider the exemplary but non-limiting structures for the beacon ID field shown at Figures 3A and 3B. Beacon messages are categorised based on the utilised service (device discovery, unicast/multicast, control signalling, etc.) and according to these teachings there are assigned specific ID groups for different
15 services. In an exemplary embodiment, such services can be further distinguished according to subtype by using different portions of the beacon ID field 204A, 204B. Separation of portions of the beacon ID field may be indicated by a single bit as in the examples below, or by multiple bits, or the separation may be known to both receiver and transmitter prior to the frame being sent (e.g. at bit position x if the beacon ID
20 204A is fixed length, or known to occur at x bits from one end of the beacon ID field 204B if it is an i-byte variable length field).

20

In these embodiments, the type portion 310C, 310D of the beacon ID field indicates the content type as is detailed above by example (device discovery, unicast/multicast, etc.), and the network may define how many bits are used for that
25 portion. In both Figures 3A and 3B, there are 16 available bit positions in the beacon ID field. In Figure 3A, the network has defined eight bits for the type portion 310C and in Figure 3B, the network has defined six bits for the type portion 310D. Assuming a single bit A 312C, 312D as indicating separation of the type portion from the subtype portion, then that leaves seven bits for the sub-type portion 314C in
30 Figure 3A and nine bits for the sub-type portion 314D in Figure 3B. The network

30

may define the length of this sub-type portion 314C, 314D also, in either the fixed length beacon ID field 204A or the variable length beacon ID field 204B. As indicated above, the sub-type portions 314C, 314D may be used to signal transmit power, either relative (high, low) or quantitatively if there are sufficient bits available in the sub-type portion 314C, 314D. Sub-type bits not used for such transmit power purposes may be used in relation to the content type bits, so for example if the beacon content type is a commercial advertisement the sub-type bits might distinguish whether it is for a restaurant, for men's or women's fashion, for consumer electronics, etc.

The D2D beacon message IDs can be implemented in the MAC layer. Upon receiving the beacon with a certain beacon ID such as RNTI, the MAC layer entity at the receiving device UE2, UE3, UE4 can decide whether to further process the message. For example, a receiving D2D device may read the RNTI of a received message, decide it is not a trusted D2D device, and refrain from further processing it. Where the beacon ID serves to filter out such a message from further processing at the receiving UE, the end result is to prevent the forwarding of unwanted packets to the higher layer of that receiving UE which would otherwise further consume processing power. In one embodiment, the beacon ID has the length of an RNTI (or if a RAT other than UTRAN/LTE, the length of the network assigned temporary identifier). This is not a limiting factor though; the beacon ID may be implemented with a different length than the RNTI.

One technical effect of these teachings is that when implemented for D2D device discovery at least, these teachings enable a fast discovery which occurs at lower processing layers of the communication protocol stack and thereby saving processing power at the receiving device by filtering out unwanted beacons from further processing in higher layers. Such filtering of the discovery messages additionally improves the battery life of beacon-receiving UE.

Figures 4 to 6 are logic flow diagrams which may be considered to illustrate the operation of a method, and a result of execution of a computer program stored in a computer-readable memory, and a specific manner in which components of an electronic device are configured to cause that electronic device to operate. The various blocks shown in Figure 4 may also be considered as a plurality of coupled logic circuit elements constructed to carry out the associated function(s), or specific result of strings of computer program code stored in a memory.

Such blocks and the functions they represent are non-limiting examples, and may be practised in various components such as integrated circuit chips and modules, and the exemplary embodiments of this invention may be realised in an apparatus that is embodied as an integrated circuit. The integrated circuit, or circuits, may comprise circuitry (as well as possibly firmware) for embodying at least one or more of a data processor or data processors, a digital signal processor or processors, baseband circuitry and radio frequency circuitry that are configurable so as to operate in accordance with the exemplary embodiments of this invention.

Figure 4 shows particular exemplary embodiments of the invention from the perspective of the beacon-sending device UE1 (or one or more components thereof, more generally termed an apparatus which may or may not be the entire UE1). At block 402 of Figure 4, the apparatus stores in its computer-readable memory an association between each n^{th} one of N content types with a respective n^{th} group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N , and at least one of the groups has more than one identifier. Then at block 404, it selects one of the content types for a beacon to be transmitted and selects a beacon identifier from the group associated with the selected content type. Finally at block 406, it compiles the beacon to be transmitted to include content of the selected content type and the selected beacon identifier. Compiling here simply means filling in the various fields of the beacon frame with the relevant information as detailed above for Figures 2A and 2B.

Further portions of Figure 4 are optional and may or may not be combined with one another in various embodiments. As noted above, the association may be fixed as in a published wireless protocol, or it may be provided to the UE1 by the network/eNB 22 (more generally an access node), such as by being broadcast in system information. Block 408 shows that compiling the beacon may further comprise indicating location information in the beacon. In one embodiment above, this location information was an indication of pathloss or transmit power. While that indication might in some embodiments be explicit, in other embodiments it might be implicit by the beacon identifier that is selected from the group associated with the selected content type.

Block 410 shows the further embodiment in which the stored association additionally comprises an n^{th} transmit power associated with each of the N groups. Not all transmit powers per group must differ, but the respective transmit powers associated with at least two of the N groups are different from one another in this embodiment. In another embodiment, each group has a different transmit power associated with it.

Block 412 shows the embodiment from above in which the UE1 maps the selected beacon identifier to a radio resource, and determines a transmit power for the compiled beacon from signalling received (from the network) on the mapped radio resource.

Block 414 shows the embodiment in which the UE1 determines the transmit power for the compiled beacon by applying a function to a value specific to a network access node or a radio system frame number (for example, SFN modulo X, where X is cell-specific).

Figure 5 shows particular exemplary embodiments of the invention from the perspective of the beacon-receiving device UE2, UE3 or UE4 (or one or more components thereof, more generally termed an apparatus which may or may not be an

entire UE). At block 502, the apparatus stores in its computer-readable memory an association between each n^{th} one of N content types with a respective n^{th} group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N , and at least one of the groups has more than one identifier. At block 504, the UE
5 selects at least one of the content types (for example, whichever content type it is interested in receiving) and, at block 506, for a plurality of beacons received, the UE filters out from further processing each beacon having a beacon identifier that is not within the group of identifiers associated with any of the at least one selected content types. If the UE is interested in receiving only one content type, then there is only one
10 group of beacon IDs to filter in and all others are filtered out.

Further portions of Figure 5 are optional and may or may not be combined with one another in various embodiments. At block 508, for at least one of the beacons which is not filtered out, the UE determines location information from at
15 least one of pathloss and transmit power indicated in the beacon. As above, this pathloss or transmit power may be indicated implicitly in the beacon by the beacon identifier itself, or explicitly.

For the embodiment in which the stored association further comprises an n^{th}
20 transmit power associated with each n^{th} one of the N groups, block 510 shows the embodiment in which the UE obtains location information by accessing the stored association with the beacon identifier and estimating transmit power of the beacon from the transmit power associated with the group of which the beacon identifier is a member.

25

Or at block 512 the UE can, for a beacon which is not filtered out, determine a transmit power for the beacon by applying a function to a value specific to a network access node or a radio system frame number (for example, SFN modulo X , where X is cell-specific).

30

Figure 6 shows particular exemplary embodiments of the invention from the perspective of the network access node/eNB 22 (or one or more components thereof, more generally termed an apparatus which may or may not be an entire access node). At block 602, the eNB creates, and stores in its computer-readable memory, an association between each n^{th} one of N content types and a respective n^{th} group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N, and at least one of the groups has more than one identifier. Then in this embodiment, at block 604 the eNB broadcasts the association in a network cell.

As with the UE descriptions above, the association in certain exemplary embodiments may further have an n^{th} transmit power associated with each of the N groups, such that the associated transmit powers for at least two of the N groups are different from one another.

For the embodiment in which the beacon identifier maps to a radio resource, block 606 shows that from the eNB perspective, each of the beacon identifiers maps to a radio resource and the eNB sends signalling on one of the mapped radio resource which indicates transmission power for a beacon which uses the identifier from which the radio resource is mapped.

Reference is now made to Figure 7 for illustrating a simplified block diagram of various electronic devices and apparatus that are suitable for use in practising the exemplary embodiments of this invention. In Figure 7, there is shown a first network access node/eNB 22 coupled via an X1 interface 26 to a second network access node/eNB 23, of which the former is shown as adapted for communication over wireless links 70A, 70B with two apparatus 20, 21, such as mobile terminals or termed more generally as user equipments UEs. The access nodes 22, 23 may be further communicatively coupled to further networks (e.g. a publicly switched telephone network PSTN and/or a data communications network/Internet), possibly via a higher network node, such as a serving gateway in the case of the LTE system.

The first UE 20 includes processing means such as at least one data processor (DP) 20A, storing means such as at least one computer-readable memory (MEM) 20B storing at least one computer program (PROG) 20C, and communicating means such as a transmitter TX 20D and a receiver RX 20E for bidirectional wireless communications with the access node 22 via one or more antennas 20F. Within the memory 20B of the first UE 20 is also the association 20G of content type with specific beacon ID groups as was discussed above which the UE 20 uses to filter those beacons it transmits and those it receives. The second UE 21 is similarly functional with blocks 21A, 21B, 21C, 21D, 21F and 21G.

The first access node 22 also includes processing means such as at least one data processor (DP) 22A, storing means such as at least one computer-readable memory (MEM) 22B storing at least one computer program (PROG) 22C, and communicating means such as a transmitter TX 22D and a receiver RX 22E for bidirectional wireless communications with its associated user devices 20, 21 via one or more antennas 22F and a modem 22H. The first access node 22 also has stored in its memory the association 22G of content type with specific beacon ID groups as was discussed above, which the access node 22 uses to enforce beacon filtering by the UEs 20, 21. In one embodiment, this association 22G is created by the access node 22.

The second access node 23 is similarly functional with blocks 23A, 23B, 23C, 23D, 23F and 23H. The second access node 23 may have its own association of content type to beacon IDs but is not shown since it may or may not be identical to that of the first access node in all embodiments of these teachings.

While not particularly illustrated for the UEs 20, 21, those devices are also assumed to include as part of their wireless communicating means a modem which may in one exemplary but non-limiting embodiment be inbuilt on an RF front end chip so as to carry the respective TX 20D/21D and RX 20E/21E.

At least one of the PROGs 20C, 21C, 22C in the UEs 20, 21 and in the first access node 22 is assumed to include program instructions that, when executed by the associated DP 20A, 21A, 22A, enable the device to operate in accordance with the exemplary embodiments of this invention as discussed more fully above. In this regard, the exemplary embodiments of this invention may be implemented at least in part by computer software stored on the MEM 20B, 21B, 22B which is executable by the DP 20A, 21A, 22A of the respective devices 20, 21, 22; or by hardware; or by a combination of tangibly stored software and hardware (and tangibly stored firmware). Electronic devices implementing these aspects of the invention need not be the entire UE 20, 21 or access node 22, but exemplary embodiments may be implemented by one or more components of same such as the above described tangibly stored software, hardware, firmware and DP, or a system on a chip SOC or an application specific integrated circuit ASIC or a digital signal processor DSP or a modem or a subscriber identity module commonly referred to as a SIM card.

15

Various embodiments of the UE 20, 21 can include, but are not limited to: cellular telephones; data cards, USB dongles, personal portable digital devices having wireless communication capabilities including but not limited to laptop/palmtop/tablet computers, digital cameras and music devices, and Internet appliances. Other embodiments of the described UE 20, 21 may be implemented as a M2M device which may not have a user interface directly but instead be remotely disposed for user-free operation.

20

Various embodiments of the computer-readable MEM 20B, 21B, 22B include any data storage technology type which is suitable to the local technical environment, including but not limited to semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory, removable memory, disc memory, flash memory, DRAM, SRAM, EEPROM and the like. Various embodiments of the DP 20A, 21A, 22A include but are not limited to general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and multi-core processors.

25

30

Various modifications and adaptations to the foregoing exemplary embodiments of this invention may become apparent to those skilled in the relevant arts in view of the foregoing description. While the exemplary embodiments have been described above in the context of the WLAN and LTE systems, it should be appreciated that the exemplary embodiments of this invention are not limited for use with only this one particular type of wireless communication system, and that they may be used to advantage in other wireless communication systems, such as for example UTRAN, WCDMA and others.

10

Some of the various features of the above non-limiting embodiments may be used to advantage without the corresponding use of other described features. The foregoing description should therefore be considered as merely illustrative of the principles, teachings and exemplary embodiments of this invention, and not in limitation thereof.

15

The above embodiments are to be understood as illustrative examples of the invention. Further embodiments of the invention are envisaged. It is to be understood that any feature described in relation to any one embodiment may be used alone, or in combination with other features described, and may also be used in combination with one or more features of any other of the embodiments, or any combination of any other of the embodiments. Furthermore, equivalents and modifications not described above may also be employed without departing from the scope of the invention, which is defined in the accompanying claims.

20

CLAIMS

1. A method of compiling a beacon to be transmitted, the method comprising:
storing in a computer-readable memory an association between each n^{th} one of
5 N content types with a respective n^{th} group of N groups of identifiers, in which N is an
integer greater than one, n indexes from 1 to N, and at least one of the groups has
more than one identifier;
selecting one of the content types for a beacon to be transmitted and selecting
a beacon identifier from the group associated with the selected content type; and
10 compiling the beacon to be transmitted to include content of the selected
content type and the selected beacon identifier.
2. A method according to claim 1, in which the association between each n^{th} one
of N content types with the respective n^{th} group of N groups of identifiers is received
15 from a network access node and stored in the memory thereafter.
3. A method according to claim 1 or claim 2, in which the content types
comprise: control information; device discovery; and unicast/multicast.
- 20 4. A method according to any of claims 1 to 3, in which compiling the beacon
comprises indicating location information in the beacon.
5. A method according to claim 4, in which the location information is indicated
by one of pathloss and transmit power for the beacon.
25
6. A method according to claim 5, in which the said one of pathloss and transmit
power for the beacon is indicated implicitly by the beacon identifier that is selected
from the group associated with the selected content type.
- 30 7. A method according to any of claims 1 to 6, in which the stored association
comprises an n^{th} transmit power associated with each of the N groups, such that the

associated transmit powers for at least two of the N groups are different from one another.

8. A method according to any of claims 1 to 6, comprising:
5 mapping the selected beacon identifier to a radio resource; and
determining a transmit power for the compiled beacon from signalling received on the mapped radio resource.
9. A method according to any of claims 1 to 6, comprising:
10 determining a transmit power for the compiled beacon by applying a function to a value specific to a network access node or a radio system frame number.
10. A method according to any of claims 1 to 9, in which the transmit power for the beacon is derived based on parameters received from a cellular network access
15 node.
11. A method according to any of claims 1 to 10, in which compiling the beacon to be transmitted comprises:
inserting the selected beacon identifier in a type portion of a beacon field; and
20 inserting a further identifier of a beacon sub-type in a sub-type portion of the beacon field.
12. A method according to any of claims 1 to 11, in which the method is executed by a user equipment and the beacon is for device-to-device communications.
25
13. Apparatus for compiling a beacon to be transmitted, the apparatus comprising:
a processing system arranged to at least:
store in a memory an association between each n^{th} one of N content types with
a respective n^{th} group of N groups of identifiers, in which N is an integer greater than
30 one, n indexes from 1 to N, and at least one of the groups has more than one identifier;

select one of the content types for a beacon to be transmitted and select a beacon identifier from the group associated with the selected content type; and

compile the beacon to be transmitted to include content of the selected content type and the selected beacon identifier.

5

14. Apparatus according to claim 13, in which the association between each n^{th} one of N content types with the respective n^{th} group of N groups of identifiers is received from a network access node and stored in the memory thereafter.

10 15. Apparatus according to claim 13 or claim 14, in which compiling the beacon comprises indicating in the beacon location information.

16. Apparatus according to claim 15, in which the location information is indicated by one of pathloss and transmit power for the beacon, and is indicated
15 implicitly by the beacon identifier that is selected from the group associated with the selected content type.

17. Apparatus according to any of claims 13 to 16, in which the stored association comprises an n^{th} transmit power associated with each of the N groups, such that the
20 associated transmit powers for at least two of the N groups are different from one another.

18. Apparatus according to any of claims 13 to 16, in which the processing system is arranged to:
25 map the selected beacon identifier to a radio resource; and
determine a transmit power for the compiled beacon from signalling received on the mapped radio resource.

19. Apparatus according to any of claims 13 to 16, in which the processing system
30 is arranged to:

determine a transmit power for the compiled beacon by applying a function to a value specific to a network access node or a radio system frame number.

20. Apparatus according to any of claims 13 to 16, in which the processing system
5 is arranged such that the transmit power for the beacon is derived based on parameters received from a cellular network access node.

21. A computer program for compiling a beacon to be transmitted, the computer
program comprising:
10 code for storing in a computer-readable memory an association between each n^{th} one of N content types with a respective n^{th} group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N , and at least one of the groups has more than one identifier;
code for selecting one of the content types for a beacon to be transmitted and
15 selecting a beacon identifier from the group associated with the selected content type;
and
code for compiling the beacon to be transmitted to include content of the selected content type and the selected beacon identifier.

20 22. A computer program according to claim 21, in which compiling the beacon comprises indicating in the beacon location information.

23. A method of filtering received beacons, the method comprising:
storing in a computer-readable memory an association between each n^{th} one of
25 N content types with a respective n^{th} group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N , and at least one of the groups has more than one identifier;
selecting at least one of the content types; and
for a plurality of beacons received, filtering out from further processing each
30 beacon having a beacon identifier that is not within the group of identifiers associated with any of the at least one selected content types.

24. A method according to claim 23, in which the content types comprise: control information; device discovery; and unicast/multicast.
- 5 25. A method according to claim 23 or claim 24, comprising for at least one of the beacons that is not filtered out:
determining location information from at least one of pathloss and transmit power indicated in the beacon.
- 10 26. A method according to claim 25, in which the said one of pathloss and transmit power is indicated implicitly in the beacon by the beacon identifier.
27. A method according to any of claims 23 to 26, in which the stored association comprises an n^{th} transmit power associated with each n^{th} one of the N groups, such
15 that the associated transmit powers for at least two of the N groups are different from one another; the method comprising for at least one of the beacons which is not filtered out:
obtaining location information by accessing the stored association with the beacon identifier and estimating transmit power of the beacon from the transmit
20 power associated with the group of which the beacon identifier is a member.
28. A method according to any of claims 23 to 26, comprising for at least one of the beacons which is not filtered out:
determining a transmit power for the beacon by applying a function to a value
25 specific to a network access node or a radio system frame number.
29. A method according to any of claims 23 to 28, in which the method is executed by a user equipment and the beacon is for device-to-device communications.
- 30 30. Apparatus for filtering received beacons, the apparatus comprising:
a processing system arranged to at least:

store in a memory an association between each n^{th} one of N content types with a respective n^{th} group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N , and at least one of the groups has more than one identifier;

5 select at least one of the content types; and

for a plurality of beacons received, filter out from further processing each beacon having a beacon identifier that is not within the group of identifiers associated with any of the at least one selected content types.

10 31. Apparatus according to claim 30, in which the processing system is arranged, for at least one of the beacons which is not filtered out, to determine location information from at least one of pathloss and transmit power indicated in the beacon.

15 32. A computer program for filtering received beacons, the computer program comprising:

code for storing in a memory an association between each n^{th} one of N content types with a respective n^{th} group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N , and at least one of the groups has more than one identifier;

20 code for selecting at least one of the content types; and

for a plurality of beacons received, code for filtering out from further processing each beacon having a beacon identifier that is not within the group of identifiers associated with any of the at least one selected content types.

25 33. A computer program according to claim 32, comprising code for determining, for at least one of the beacons that is not filtered out, location information from at least one of pathloss and transmit power indicated in the beacon.

30 34. A method of broadcasting an association between content types and identifiers, the method comprising:

creating and storing in a computer-readable memory an association between each n^{th} one of N content types and a respective n^{th} group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N , and at least one of the groups has more than one identifier; and

5 broadcasting the association in a network cell.

35. A method according to claim 34, in which the content types comprise: control information; device discovery; and unicast/multicast.

10 36. A method according to any claim 34 or claim 35, in which the association comprises an n^{th} transmit power associated with each of the N groups, such that the associated transmit powers for at least two of the N groups are different from one another.

15 37. A method according to claim 34 or claim 35, in which each of the beacon identifiers maps to a radio resource, the method comprising:

 sending signalling on one of the mapped radio resources which indicates transmission power for a beacon that uses the identifier from which the radio resource is mapped.

20

38. A method according to any of claims 34 to 37, in which the method is executed by a network access node, the association is broadcast in system information, and the association is for beacons used in device-to-device communications within the cell.

25

39. Apparatus for broadcasting an association between content types and identifiers, the apparatus comprising:

 a processing system arranged to at least:

 create, and store in a memory, an association between each n^{th} one of N content types and a respective n^{th} group of N groups of identifiers, in which N is an

30

integer greater than one, n indexes from 1 to N , and at least one of the groups has more than one identifier; and

broadcast the association in a network cell.

- 5 40. Apparatus according to claim 39, in which the association comprises an n th transmit power associated with each of the N groups, such that the associated transmit powers for at least two of the N groups are different from one another.

- 10 41. A computer program for broadcasting an association between content types and identifiers, the computer program comprising:

code for creating, and for storing in a memory, an association between each n th one of N content types and a respective n th group of N groups of identifiers, in which N is an integer greater than one, n indexes from 1 to N , and at least one of the groups has more than one identifier; and

- 15 code for broadcasting the association in a network cell.

- 20 42. A computer program according to claim 41, in which the association comprises an n th transmit power associated with each of the N groups, such that the associated transmit powers for at least two of the N groups are different from one another.

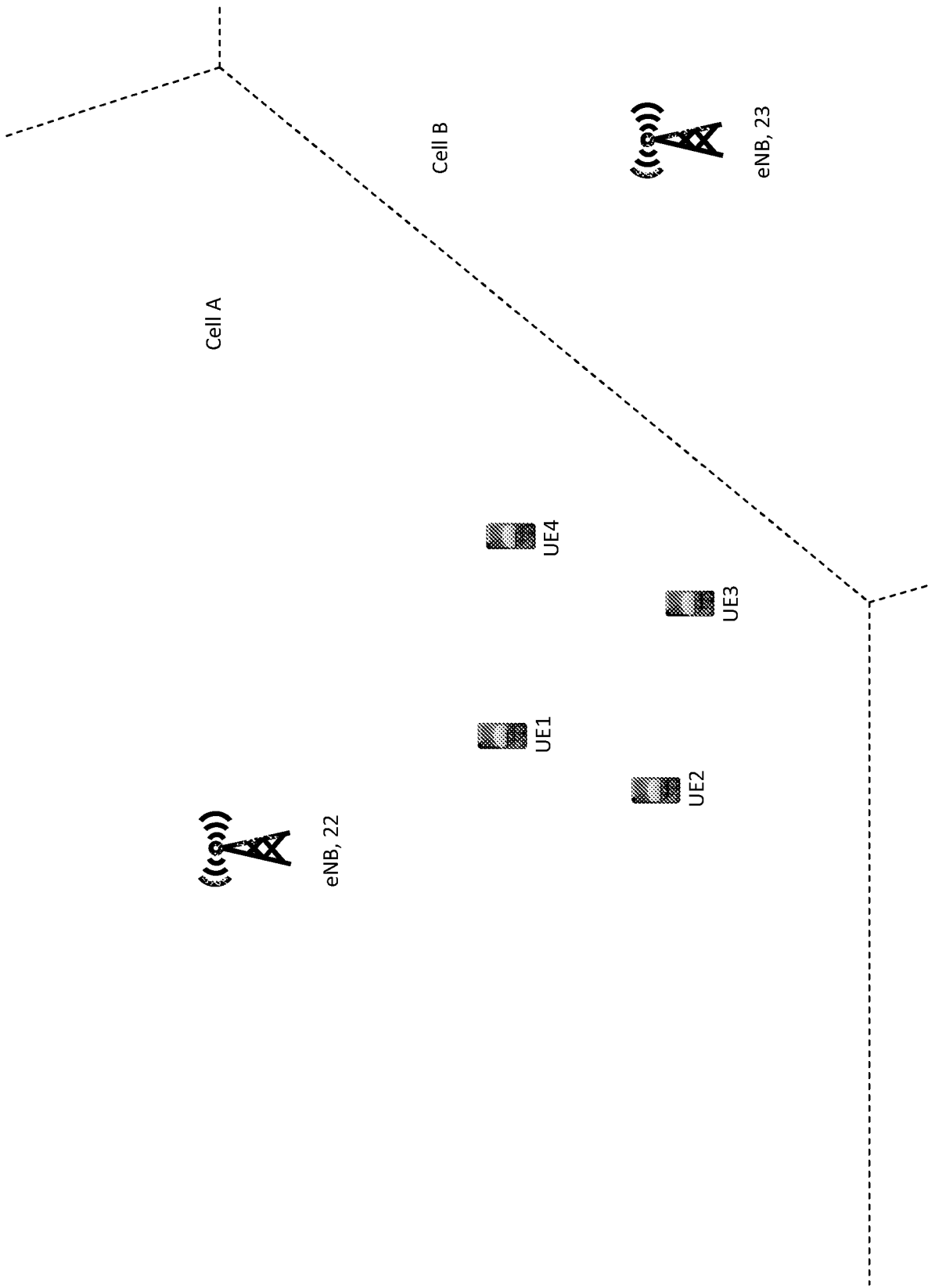


Figure 1

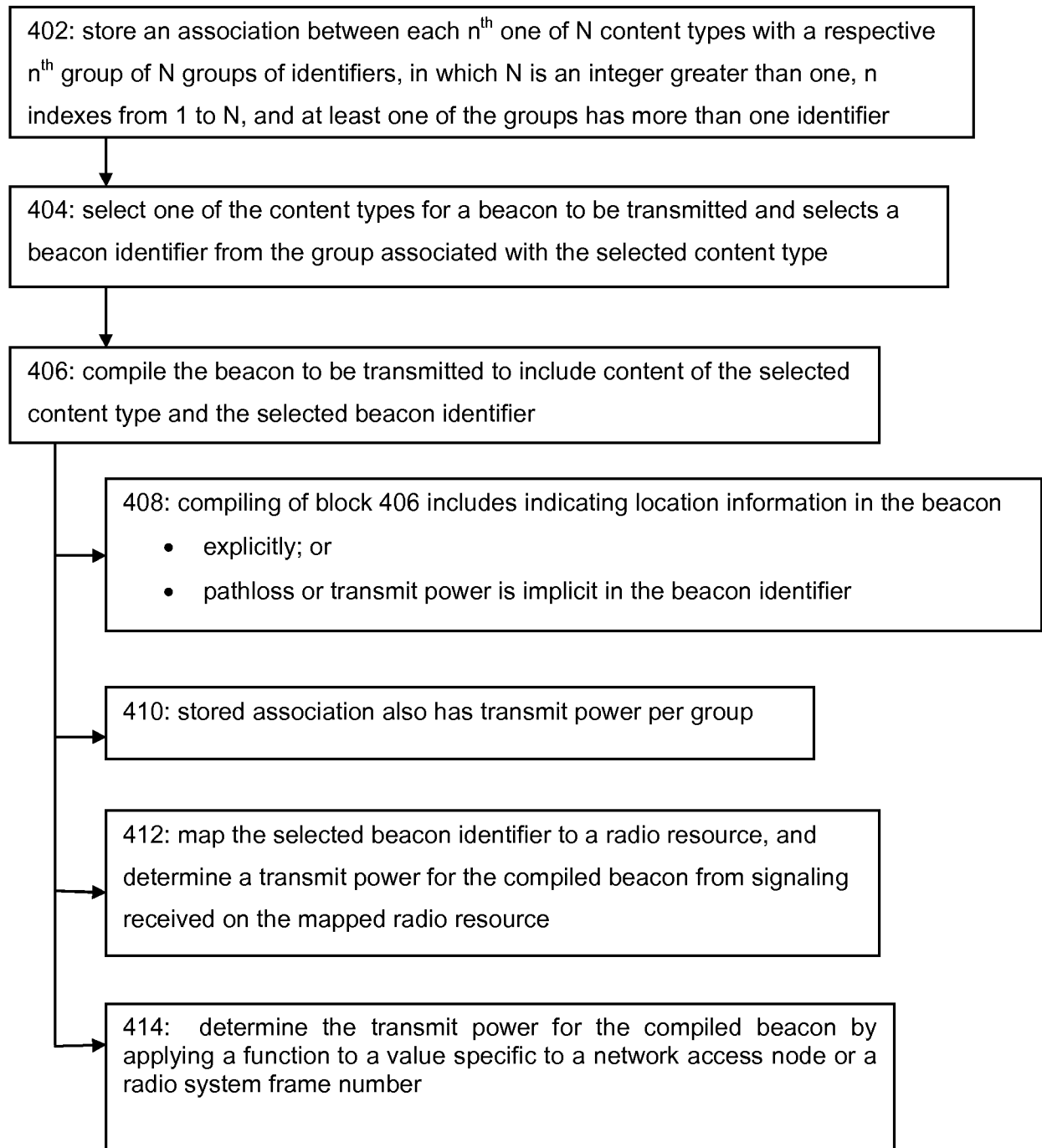


Figure 4

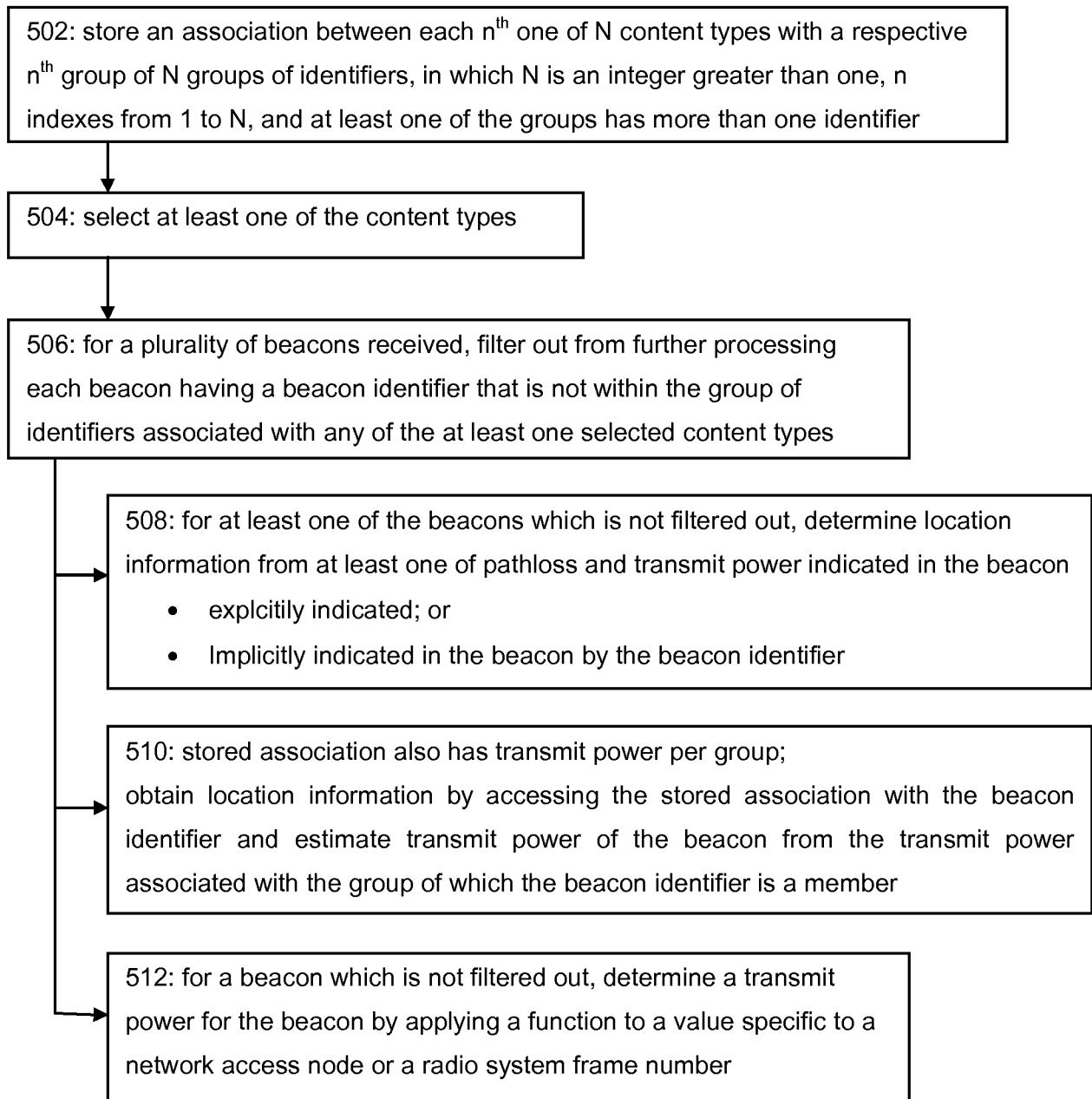
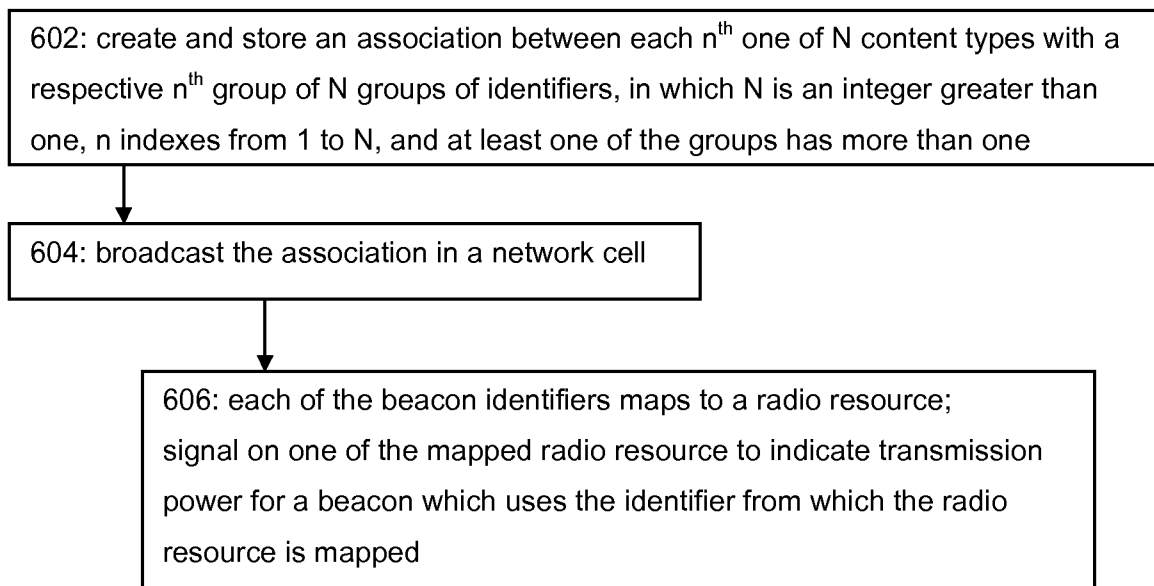


Figure 5

**Figure 6**

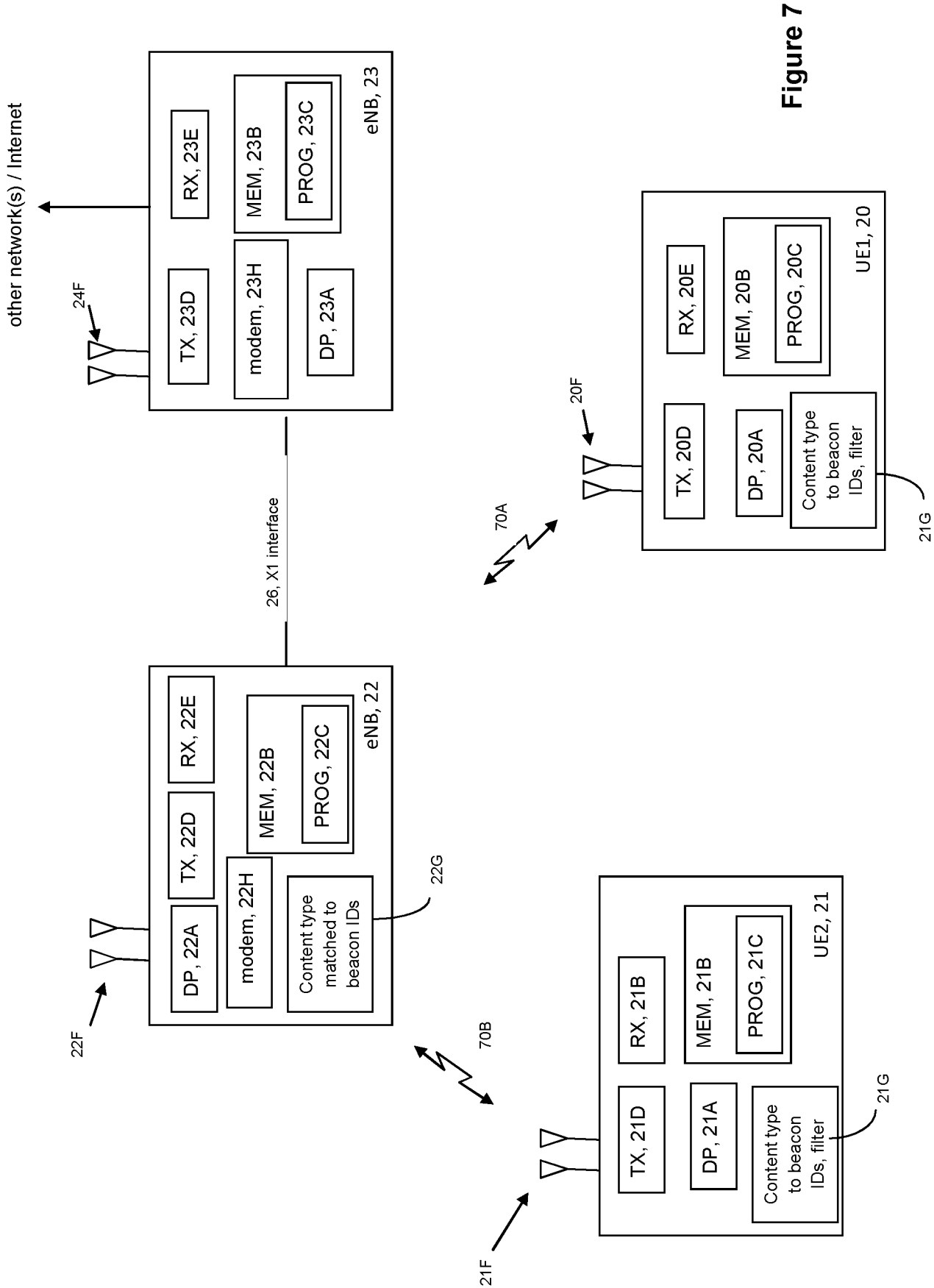


Figure 7

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2012/053822

A. CLASSIFICATION OF SUBJECT MATTER
 INV. H04W84/20 H04W8/00
 ADD.

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

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011/028843 A2 (ICONTROL INC [US]; TUBB EARL FRED [US]; INOKUCHI TOM [US]) 10 March 2011 (2011-03-10)	1-3,5,9, 13,14, 19,21, 23-25, 27,28, 30-35, 39,41
Y	paragraph [0040] paragraph [0047] paragraph [0054] paragraph [0099] figure 3b ----- -/-	4,6-8, 10-12, 15-18, 20,22, 26,29, 36-38, 40,42



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

21 November 2012

Date of mailing of the international search report

29/11/2012

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040,
 Fax: (+31-70) 340-3016

Authorized officer

Kahl, Marcus

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2012/053822

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2002/002034 A1 (DAVIES ROBERT J [GB] ET AL) 3 January 2002 (2002-01-03) paragraph [0008] paragraph [0018] paragraph [0030] paragraph [0031] claim 1 claim 6 claim 10	4,6-8, 10-12, 15-18, 20,22, 26,29, 36-38, 40,42
A	----- US 2011/130149 A1 (YAO ZONGMING [CN] ET AL) 2 June 2011 (2011-06-02) paragraph [0010]; figure 5 paragraph [0047] paragraph [0056] paragraph [0060] paragraph [0062] -----	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2012/053822

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2011028843 A2	10-03-2011	CN 102577313 A EP 2474144 A2 SG 178883 A1 WO 2011028843 A2	11-07-2012 11-07-2012 27-04-2012 10-03-2011
US 2002002034 A1	03-01-2002	AT 356497 T CN 1389052 A DE 60127094 T2 EP 1249104 A2 US 2002002034 A1 WO 0201813 A2	15-03-2007 01-01-2003 22-11-2007 16-10-2002 03-01-2002 03-01-2002
US 2011130149 A1	02-06-2011	NONE	