Title: DOWNLINK MESSAGE TRANSMISSION IN CONNECTION WITH MULTIPLE ASSOCIATIONS

Abstract: Methods, apparatuses, and computer programs for use in communication between a terminal device and an access node or a network apparatus are provided. The terminal device may be configured to operate multiple associations in parallel and have an address for each association. One of the addresses may be configured as a maintenance address for use in contacting the terminal device when an association is inactive.
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Downlink Message Transmission in Connection with Multiple Associations

Field

The invention relates to the field of wireless networks and, particularly, to downlink message transmission when a terminal device has multiple parallel associations to different access nodes.

Background

A terminal device may employ multiple associations to different access nodes. The terminal device may have a first association to a first access node and have a first address for use in the first association. The terminal device may further have a second association to a second access node and have a second address for use in the second association.

Brief description

The invention is defined by the independent claims.

Embodiments of the invention are defined in the dependent claims.

List of drawings

Embodiments of the present invention are described below, by way of example only, with reference to the accompanying drawings, in which

Figure 1 illustrates a wireless communication environment to which some embodiments of the invention may be applied;

Figures 2A and 2B illustrate flow diagrams of processes for utilizing multiple addresses to communicate between a terminal device and an access node according to some embodiments of the invention;

Figure 3 illustrates a signalling diagram for establishing and using a maintenance address of the terminal device according to an embodiment of the invention;

Figures 4 to 6 illustrate some embodiments of contents of notification messages used in contacting the terminal device via its maintenance address according to some embodiments of the invention;

Figure 7 illustrates a flow diagram of a process for controlling the transmission of messages to the maintenance address in an access node according to an embodiment of the invention;
Figure 8 illustrates a signalling diagram of a procedure for using multiple addresses in a data source according to an embodiment of the invention; and

Figures 9 and 10 illustrate block diagrams of apparatuses according to some embodiments of the invention.

Description of embodiments

The following embodiments are exemplary. Although the specification may refer to "an", "one", or "some" embodiment(s) in several locations, this does not necessarily mean that each such reference is to the same embodiment(s), or that the feature only applies to a single embodiment. Single features of different embodiments may also be combined to provide other embodiments. Furthermore, words "comprising" and "including" should be understood as not limiting the described embodiments to consist of only those features that have been mentioned and such embodiments may contain also features/structures that have not been specifically mentioned.

A general wireless communication scenario to which embodiments of the invention may be applied is illustrated in Figure 1. Figure 1 illustrates wireless communication devices comprising access points (AP) 100 and a plurality of terminal devices (STA) 104, 106. The APs 100, 102 may be stationary access points. A general term used in this specification and encompassing both the APs and STAs is a wireless apparatus. The access point may refer to an access point specified in IEEE 802.11 specifications or to a base station of another wireless access network. At least one of the terminal devices 106 may have a functionality of an AP as well. Therefore, a common term encompassing both the stationary APs 100, 102 and mobile APs 106 is an access node. An access node 100, 102, 106 may provide or be comprised in a basic service set (BSS) which is a basic building block of an IEEE 802.11 wireless local area network (WLAN). Each access node 100, 102, 106 may represent a different BSS. The most common BSS type is an infrastructure BSS that includes a single access node together with all STAs associated with the AP. The access node may provide access to other networks, e.g. the Internet 110. In another embodiment, the BSSs may be connected with each other by a distribution system (DS) to form an extended service set (ESS). An independent BSS (IBSS) is formed by an ad hoc network of terminal devices without a stationary controlling access point. While embodiments of the invention are described in the context of the above-described topologies of IEEE 802.11, it should be appreciated that these or other embodiments of the
invention may be applicable to networks based on other specifications, e.g. WiMAX (Worldwide Interoperability for Microwave Access), UMTS LTE (Long-term Evolution for Universal Mobile Telecommunication System), mobile ad hoc networks (MANET), mesh networks, and other networks having cognitive radio features, e.g. transmission medium sensing features and adaptive capability to coexist with radio access networks based on different specifications and/or standards. Some embodiments may be applicable to networks having features under development by other IEEE task groups, e.g. 802.19 task group 1 (TG1).

The different access nodes 100, 102, 106 may operate at least partly on different channels, e.g. on different frequency channels. IEEE 802.11 specification specifies a data transmission mode that includes 20 megahertz (MHz) wide primary and secondary channels. The primary channel is used in all data transmissions with clients supporting only the 20 MHz mode and with clients supporting higher bandwidths. A further definition in 802.11 specification is that the primary and secondary channels are adjacent. The 802.11 specification also defines a mode in which a STA may, in addition to the primary channel, occupy one secondary channel which results in a maximum bandwidth of 40 MHz. IEEE 802.11ac task group extends such an operation model to provide for wider bandwidths by increasing the number of secondary channels from 1 up to 7, thus resulting in bandwidths of 20 MHz, 40 MHz, 80 MHz, and 160 MHz. A 40 MHz transmission band may be formed by two contiguous 20 MHz bands, and an 80 MHz transmission band may be formed by two contiguous 40 MHz bands. However, a 160 MHz band may be formed by two contiguous or non-contiguous 80 MHz bands. Different BSSs may employ different primary channels.

As mentioned above, the transmission band of a BSS contains the primary channel and zero or more secondary channels. The secondary channels may be used to increase data transfer capacity of a transmission opportunity (TXOP). The secondary channels may be called a secondary channel, a tertiary channel, a quaternary channel, etc. However, let us for the sake of simplicity use the secondary channel as the common term to refer also to the tertiary or quaternary channel, etc. The primary channel may be used for channel contention, and a TXOP may be gained after successful channel contention on the primary channel. Some IEEE 802.11 networks are based on carrier sense multiple access with collision avoidance (CSMA/CA) for channel access. Some networks may employ enhanced distributed channel access (EDCA) which provides quality-of-service (QoS) enhancements to medium access control (MAC) layer. The QoS enhancements may be realized by providing a plurality of access categories (AC)
for prioritizing frame transmissions. The access categories may comprise the following priority levels in the order of increasing priority: background (AC_BK), best effort (AC_BE), video streaming (AC_VI), and voice (AC_VO). A higher priority frame transmission may use a shorter contention window and a shorter arbitration inter-frame spacing (AIFS) that result in higher probability of gaining the TXOP.

As described above, the BSS may be represented by the access node and one or more terminal devices connected to the access node. A terminal device 102 may establish a connection with any one of the access nodes 100, 102, 106 it has detected to provide a wireless connection within the neighbourhood of the terminal device. The connection establishment may include authentication in which an identity of the terminal device is established in the access node. The authentication may comprise exchanging an encryption key used in the BSS. After the authentication, the access node and the terminal device may carry out association in which the terminal device is fully registered in the BSS, e.g. by providing the terminal device with an association identifier (AID). It should be noted that in other systems terms authentication and association are not necessarily used and, therefore, the association of the terminal device to an access node should be understood broadly as establishing a connection between the terminal device and the access node such that the terminal device is in a connected state with respect to the access node and scanning for downlink frame transmissions from the access node and its own buffers for uplink frame transmissions.

Embodiments described herein are applicable to a multipath scenario in which a terminal device 104 operates a plurality of parallel associations to different access nodes 100, 102, 106. The terminal device 104 may utilize the multipath scenario to provide a multipath connection to a network server or, in general, a network device via multiple different access nodes. The multipath connection may be a transport or network level connection between the terminal device 104 and the network device, and it may comprise at least two parallel radio links through different access nodes 100, 102, 106. The use of the parallel radio links may be used in order to improve data throughput. The increase in throughput may be realized with the additional capacity in the radio interface and in the backbone link between each access node and the network device to which the multipath connection is established. As a consequence, different data may be routed through different radio links and backbones between the terminal device and the network device. Such a multipath connection is supported on higher protocol
layers, e.g. by a multipath real time protocol (RTP), multipath transport control protocol (TCP) and multipath universal datagram protocol (UDP) defined within Internet Engineering Task Force (IETF). IEEE 802.11 (WLAN/Wi-Fi) radio is one of the main candidate radios to be used with the multipath protocols. The multipath connection may be employed for an application executed in the terminal device, and the application itself may be unaware of whether or not the connection is the multipath connection. Similarly, if the application transmits and receives data from multiple sources through separate TCP sessions, the terminal may allocate different TCP sessions to different links and hide the complexity by using a protocol similar to the multipath TCP. The parallel associations may, however, be used for other purposes as well.

The multipath scenario may be enabled to associate / establish links with many access nodes. Use of multiple links is advantageous, if the associated access nodes are capable of transmitting traffic efficiently over the air interface but backbone links of the access nodes used to connect the access nodes to the Internet have a low throughput, e.g. an ADSL (asynchronous digital subscriber line) modem. In these cases, operating with multiple APs may increase the total throughput experienced by the terminal device.

Embodiments of the invention relate to a situation where the terminal device has at least two associations to different access nodes, and one of the associations is in an active state while at least one other association is in an inactive state. Let us now consider operation of the terminal device and an access node with reference to Figures 2A and 2B, respectively. Referring to Figure 2A, the terminal device provides or establishes a first association to the first access node and acquires a first address associated with the first association in block 202. In block 204, the terminal device provides or establishes a second association to a second access node and acquires a second address associated with the second association. In block 206, the terminal device causes transmission of the second address to the first access node and configures the first access node to employ the second address in sending notifications of downlink messages related to the first association. In block 208, the terminal device acquires messages from the first access node directly when the first association is in an active state and indirectly through the second access node when the first association is in an inactive state. Reception of messages directly may be defined as receiving messages from the first access node as addressed to the first address, and reception of messages indirectly from the first access node may be defined as receiving messages as addressed to the second address.
Referring to Figure 2B, the first access node of a wireless network establishes a first association to the terminal device and acquiring a first address of the terminal device for use in the first association (block 212). In block 214, the first access node acquires a second address of the terminal device, wherein the second address is associated with a second association between the terminal device and a second access node. The first access node and the second access node may be different access nodes. In block 216, the first access node causes transmission of downlink messages from the first access node to the terminal device as addressed to the first address when the first association is in an active state and to the second address when the first association is in an inactive state.

Advantages provided by this embodiment comprise reduction of a delay associated with the detection of the message arrived at the access node of an association that is inactive. The access node may indicate the presence of downlink traffic via the active association and, thus, the terminal device detects the presence of the downlink message in the inactive association via the active association. Additionally, the terminal device does not need to maintain multiple associations in an active state and, accordingly, power consumption may be reduced.

The terminal device may maintain the second association active more frequently than the first association. The second association may be a default association which is maintained active until the terminal device detect the presence of downlink traffic in at least one other association. Then, the terminal device may activate the association having the downlink traffic and, after the transfer of the downlink traffic, the terminal device may revert to the default association until it detects further downlink traffic in the inactive association(s).

In an embodiment, an association is inactive when the terminal device uses a power-save mode with respect to the association. When the association is inactive, the terminal device is not capable of either transmitting or receiving messages over the association. As a consequence, the access node is temporarily unable to communicate with the terminal device over the inactive association. When the association is active, the terminal device is able to transmit and/or receive frames of the association.

In an embodiment, the first address and the second address are both internet protocol addresses. In another embodiment, at least the second address is a combination of a medium access control (MAC) address of the terminal device and a BSS identifier employed by a corresponding access node. In the latter embodiment, the first access node and the terminal device may belong to the
same network with respect to the second address, or they may be connected to each other via a distribution system providing Layer 2 logic that enables the first access node to address the terminal device with the second address comprising the Layer 2 MAC address.

In an embodiment, both the first access node and the second access node operate according to the same specifications with respect to the radio protocol, e.g. both access nodes are 802.11 access nodes. In another embodiment, the first access node and the second access node operate according to different specifications with respect to the radio protocol, e.g. one of the access nodes is an 802.11 access node while the other access node is an LTE base station. The connection between the access nodes may be routed through one or more computer networks, and the one or more computer networks may comprise the Internet, for example. In another embodiment where the access nodes operate according to the same specifications, the connection between the access nodes may be routed through an internal network infrastructure comprising at least one of the following: a radio access network, a core network, and an 802.11 distribution system.

Let us now consider using the second address to contact the terminal device indirectly according to an embodiment with reference to a signalling diagram of Figure 3. Figure 3 illustrates communication between the first access node, the second access node, and the terminal device in the above-described scenario. Referring to Figure 3, the terminal device carries out link establishment with the first access node in step 300. Step 300 may comprise authentication, association, and assignment of the first address to the terminal device. As a result, the first association between the first access node and the terminal device is realized. The first address is used in communication over the first association, e.g. when the first access node transmits messages to the terminal device over the first association, the first access node may insert the first address into a destination address field of the messages. When the terminal device transmits messages to the first access node over the first association, the terminal device may insert the first address into a source address and/or a transmitter address field of the messages.

In step 302, the terminal device carries out link establishment with the second access node. Step 302 may comprise authentication, association, and assignment of the second address to the terminal device. Operations carried out in steps 300 and 302 may be substantially similar or they may comprise different
functions, depending on whether or not the access nodes operate according to the same specifications.

The intention of using parallel associations may be to improve the total throughput of the terminal device. The terminal device may intend to use the associations in parallel continuously which distinguishes the scenario from handoff situations, for example.

The terminal device may determine to prioritize the associations in the sense that it chooses an association that is used more frequently than the other(s). The more active association may be selected on the basis of capacity, throughput, or other characteristics of the associations. In this example, the terminal device chooses the second association as the more active association. As a consequence, the terminal device may configure the first access node to employ the second address to reach the terminal device according to an embodiment of the invention (see Figure 2B). The terminal device may configure the first access node to employ the second address by configuring the second address as a maintenance address for use by the first access node to reach the terminal device when the first association is inactive. The configuration may be carried out by the terminal device transmitting a maintenance address setup request to the first access node (step 304). The maintenance address setup request may comprise at least some of the contents described below in connection with Table 1.

<table>
<thead>
<tr>
<th>Order</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inactivity Delay</td>
</tr>
<tr>
<td>2</td>
<td>Maximum Number of Forwarded Messages</td>
</tr>
<tr>
<td>3</td>
<td>TCLAS of Maintenance Address</td>
</tr>
<tr>
<td>4</td>
<td>TCLAS Processing of Arrivals</td>
</tr>
<tr>
<td>5 to N</td>
<td>TCLAS of Arrivals</td>
</tr>
</tbody>
</table>

Table 1

Element Maintenance Address may comprise the second address of the terminal device, e.g. an IP address assigned to the terminal device for use in the second association.

Element Inactivity Delay may be an unsigned integer and indicate duration in defined time units, e.g. 50 milliseconds (ms). If the first association has not been in the active state for the duration specified by this element, the access node may start contacting the terminal device from the maintenance address.

Element Maximum Number of Forwarded Messages may indicate the maximum number of packets that may be transmitted to the maintenance address before the next active state of the first association. The use of this parameter by
the first access node is described in greater detail below with reference to Figure 7.

Element TCLAS (Traffic Classification) of Maintenance Address may indicate the maintenance address (the second address) of the terminal device.

Element TCLAS Processing of Arrivals may provide instructions of the order of the processing TCLAS elements. As used in 802.11 networks, a TCLAS element may contain an Ethernet or Layer 3 IP address which defines the address of the messages that are mapped to a given traffic stream. If the address information is specified by multiple TCLAS elements, the TCLAS Processing of Arrivals defines rules for ordering of the TCLAS elements in order to acquire the address.

Element TCLAS of Arrivals may provide the addresses that indicate the packets that the first access node should notify to the maintenance address. This element may comprise at least the first address but it may comprise other addresses of the terminal device as well.

Upon receiving the maintenance address setup request from the terminal device in step 304, the first access node may process the request, determine whether or not it is capable of using the addressing to the maintenance address with the parameters specified in the request, and transmit a maintenance address setup response to the terminal device (step 306). The maintenance address setup response may comprise at least some of the elements of Table 2.

<table>
<thead>
<tr>
<th>Order</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Success</td>
</tr>
<tr>
<td>2</td>
<td>Unavailability duration</td>
</tr>
<tr>
<td>3</td>
<td>Inactivity Delay</td>
</tr>
<tr>
<td>4</td>
<td>Maximum Number of Forwarded Messages</td>
</tr>
<tr>
<td>5</td>
<td>TCLAS of Maintenance Address</td>
</tr>
<tr>
<td>6</td>
<td>TCLAS Processing of Arrivals</td>
</tr>
<tr>
<td>7 to N</td>
<td>TCLAS of Arrivals</td>
</tr>
</tbody>
</table>

Table 2

Element Success may indicate whether or not the configuration of the maintenance address has been completed successfully. The element may indicate that the setup was successful, that setup will be accepted if the parameters are changed as provided by the other elements of the maintenance address setup response frame, or that setup failed.

Element Unavailability Duration may be present, if the value of the Success indicates failure. The Unavailability Duration may specify a time interval
after which the terminal device may request for a new setup of the maintenance address.

The other elements 3 - N may have similar functions as described in connection with Table 1 and they may be, if the access node accepts the maintenance address setup request conditionally. The fields may indicate new parameter values that are acceptable to the access node.

If the access node proposes changed parameters values for the maintenance address setup, the terminal device may send a further message in which it either accepts or rejects the proposal of the access node.

After the configuration of the use of the maintenance address, the terminal device may switch the functionality on or off with a one-bit indicator comprised in a message transmitted by the terminal device to the first access node. The one-bit indicator may be comprised in a MAC header of the message. When the terminal device has switched the functionality off, the first access node does not send any messages to the maintenance address.

When the maintenance address has been configured, the first access node may transmit messages to the terminal device directly when the first association is active and indirectly when the first association is inactive. Referring to Figure 3, the message transmissions may be carried out in a state-of-the-art manner when the first association is active (duration 320). Upon acquiring downlink data or management information to be transmitted to the terminal device (step 308), the first access node prepares a message and transmits the message as addressed to the first address of the terminal device (step 310). The terminal device then receives the message and associated data or information over the first association. On the other hand, when the access node acquires the data or the management information when the first association is inactive (duration 322) in step 311, it prepares a message and transmits the message as addressed to the second address of the terminal device (step 312). Depending on the embodiment, the first access node may then transmit the message over a radio interface or through the internet, depending on how the access node is configured to communicate with other access nodes. In an embodiment, the first access node transmits messages addressed to the first address to a radio interface with parameters of the first association and messages addressed to the second address to a wired connection that connects the first access node to the second access node. As the second address is linked to the second association, the message is routed to the second access node, and the second access node receives the message in step 312. Upon extracting the destination address from
the received message and determining that the destination address is the second address of the terminal device, the second access node may transmit the message to the terminal device over the active second association (step 313).

Upon receiving the message in step 313, the terminal device may determine from the contents of the received message that the first access node has downlink messages buffered for the terminal device (block 314). As a response, the terminal device may activate the first association in order to receive the downlink messages from the first access node. In the context of 802.11 networks, the terminal device may start to scan the channel(s) of the first association in order to receive a traffic indication map (TIM) that indicates that the first access node has buffered downlink traffic for the terminal device. Upon receiving the TIM and detecting the presence of downlink traffic, the terminal device may transmit a trigger frame to the first access node in step 315, wherein the trigger frame initiates a service period in the first association. Upon activating the first association, the first access node may start transmitting buffered downlink messages to the terminal device (step 316). These messages may be addressed to the first address of the terminal device. The messages may be transmitted in this manner for the duration of the service period indicated by number 324. In the context where the first access node is a base station of a cellular communication system, the terminal device may activate the first association by accessing the first access node on a random access channel (RACH), for example.

As indicated above, the message transmitted by the first access node to the maintenance address of the terminal device may be an indication that the access node has data and/or management information buffered for transmission to the terminal device. The access node may thus send a notification of the buffered data to the maintenance address and then wait for the terminal device to activate the first association for the transmission of the buffered data. In another embodiment, the first access node may transmit at least some of the buffered data to the maintenance address. Figures 4 to 6 illustrate some embodiments of the messages transmitted by the first access node to the maintenance address of the terminal device.

Referring to Figure 4, the first access node may receive a downlink message 400 addressed to the terminal device, e.g., addressed to the first address of the terminal device. The message 400 may comprise a header 402 and a payload 404. The header 402 may comprise any protocol information necessary to deliver the payload to the terminal device, e.g., the first address of the terminal device, and the payload 404 may comprise application data, for example. In the
embodiment of Figure 4, the first access node forms a message 410 comprising the header 402 and the payload 404 of the received message 400 in a payload portion 408, and adds a new header 406 that comprises the maintenance address of the terminal device. Additionally, the new header 406 may comprise any parameters necessary to deliver the message to the terminal device through the second association and the second access node. The first access node may then transmit the message towards the second access node, e.g. through the Internet.

With respect to the embodiment of Figure 4, as the first access node may transmit the payload portion 404 in the message 410, the terminal device may acquire the payload portion 404 from the message when it receives it from the second access node. In an embodiment, the first access node discards the received downlink message 400 after the transmission of the message 410. In another embodiment, the first access node maintains a copy of the downlink message 400 in its buffer and transmits the downlink message 400 to the terminal device when the terminal device activates the first association.

In an embodiment, the message 410 comprises a more data indicator that indicates whether or not the first access node has further downlink data buffered for the terminal device. The more data indicator may be a one-bit indicator. The first access node may set the more data indicator to indicate that no further data is buffered for the terminal device, when the received downlink message 400 is the first downlink message addressed to the terminal device and received after an activity period of the first association or after the first access node has cleared its buffers from downlink data addressed to the terminal device. The first access node may set the more data indicator to indicate the presence of more data in its buffers for later messages addressed to the maintenance address. According to another aspect, the first access node may have received more than one downlink message 400, and it indicates of the presence of multiple downlink messages with a single notification message 410. Then, the more data indicator may be set to indicate the presence of further buffered data even if the message 410 is the first message transmitted after the activity period or after the buffers have been cleared of messages addressed to the terminal device.

In the embodiment of Figure 4, the notification message 410 may be considered as a forwarded message, as it comprises the received downlink message 400.

Referring to Figure 5, the first access node includes the header 402 of the received downlink message 400 in the message 500 to be transmitted to the maintenance address but not the payload portion 404. In this embodiment, the
header 402 is inserted into the payload portion 504, and the new header comprising the maintenance address is added to the message 500. The message may then be transmitted towards the second access node. An advantage of this embodiment is that protocol information, e.g. a source address for the payload portion 404, comprised in the header 402 may be delivered to the terminal device. Accordingly, the terminal device may acquire the protocol information without significant increase in data traffic, because the payload portion 404 is not delivered.

In the embodiments of Figures 4 and 5, the messages 410, 500 transmitted by the first access node to the maintenance address may comprise both the first address and the second address of the terminal device. The first address may be comprised in the payload portion 408, 504 of the message, and the second address may be added to the header 406, 502 as it is the maintenance address.

Referring to Figure 6, the message transmitted by the first access node to the maintenance address may be a notification message 600 comprising a new header 602 created by the first access node and a notification 604 that the first access node has buffered data to be transmitted to the terminal device over the first association. The header 602 may comprise the maintenance address. The notification 604 may be an arbitrary indicator that enables the terminal device to identify the message as the notification message. The first access node may insert its own address as a source address or a transmitter address of the notification message 600, which enables the terminal device to identify the first access node as the transmitter of the notification message and to activate the correct association for the reception of the buffered data.

In an embodiment applicable to any one of the embodiments of Figures 4 to 6, the message transmitted by the first access node to the maintenance address may comprise the elements of Table 3.

<table>
<thead>
<tr>
<th>Order</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reception Timing</td>
</tr>
<tr>
<td>2</td>
<td>Forwarded Header/Payload/Notification</td>
</tr>
</tbody>
</table>

Table 3

Element Reception Timing may be added by the first access node and it may indicate a reception timing of the downlink message received and notified by the first access node. In the context of 802.11 networks, the reception timing may be indicated by a value of a timing synchronization function of the 802.11 network. The terminal device may use the reception timing to eliminate unnecessary
notifications, for example. The terminal device may compare the reception timing with a timing of the latest activity period of the first association. If the reception timing is earlier or falls into the timing of the latest activity period, the terminal device may determine that it has already received the downlink message associated with the notification and discard the notification without initiating another service period. The message may further comprise the header, payload, and/or the notification, as described above.

The description above may be used when the downlink messages received or created by the first access node are unicast messages. However, the principles of the above-described embodiments may be applied with respect to multicast or broadcast messages as well. In the case of multicast and/or broadcast messages, the first access node may keep track of the multicast groups subscribed by the terminal device so that it knows which multicast messages should be delivered to the terminal device. The broadcast messages are inherently delivered to the terminal device. The first access node may use the maintenance address to notify the terminal device about the multicast/broadcast messages that are to be delivered to the terminal device. Let us consider some embodiments for realizing the notification and the delivery of the multicast/broadcast messages when the first association is inactive.

In an embodiment, the first access node changes the multicast or broadcast messages into unicast messages and delivers them to the terminal device in the above-described manner, e.g. by sending the notification to the maintenance address when the first association is inactive. The terminal device may then activate the first association and collect the unicast copies of the multicast/broadcast messages. An advantage of changing the multicast/broadcast messages into unicast messages is that the unicast messages may have more relaxed rules with respect to the delivery. As a consequence, the reception of the multicast/broadcast messages in the terminal device is ensured even though the first association is temporarily inactive.

In another embodiment, the first access node maintains the multicast/broadcast messages as such and sends the notification of the presence of the multicast/broadcast message to the maintenance address. The notification may comply with any one of the embodiments of Figures 4 to 6, e.g. the notification may comprise the header of the multicast/broadcast message (Figure 5), the header and the payload of the multicast/broadcast message (Figure 4), or a simple notification without the header or the payload (Figure 6).
The terminal device may specify in the maintenance address setup request rules for the notifications with respect to different message. For example, the terminal device may configure the first access node to notify only the presence of the unicast messages to the maintenance address or to notify of the presence of the any messages to the maintenance address. This may be specified with the element TCLAS of Arrivals (see Tables 1 and 2).

In an embodiment, the terminal device is configured to test the use of the maintenance address. Let us assume the above-described situation where the terminal device has configured the first access node to transmit the notifications of the acquired downlink traffic to the maintenance address of the terminal device. The terminal device may test the operation by transmitting an artificial data packet to the first address of the terminal device and by checking whether or not it receives a notification of the artificial data as addressed to the second address (the maintenance address). The terminal device should receive the notification through the second access node, if the maintenance address is used correctly. The terminal device may further measure a delay of delivering the notification to the maintenance address. If the terminal device does not receive the notification, the terminal device may investigate a path between the addresses and attempt to detect a problem in network address translators (NAT).

As described above, the first access node may forward or transmit only a limited number of notifications to the second address of the terminal device between activity periods of the first association. Figure 7 illustrates a flow diagram of the operation of the first access node in this respect. The start of the procedure may be triggered by an end of an active period in the first association or when the terminal moves from active mode to power save mode. The first access node may have acquired the parameter Maximum Number of Forwarded Messages during the setup of the maintenance address, as described above. The parameter may define the maximum number of messages the first access node may transmit to the second address between consecutive active periods of the first association. In more detail, the parameter may define the maximum number of messages the first access node may transmit to the second address between an end of an active period and a start of a subsequent active period or when the terminal has transitioned from the power save mode to the active mode. In embodiments where the maintenance address is used to indicate that the first access node has buffered data ready for transmission over the first association, the parameter value may be selected to be substantially low in order not to reduce congestion in the second access node. The example values may depend on application
requirements, a periodicity of the operations carried out by the terminal device, and/or the number of concurrently operated applications.

If the terminal does not have any specific application actively transferring data, the terminal device may specify that one or two messages are notified to the maintenance address. Target of the operation may be to detect if any traffic has arrived to the access node.

If the terminal has an application actively receiving data or in a stand-by state where data packets or bursts of packets are generated/received periodically, the terminal device may set the maximum number of messages notified to maintenance address to a value that ensures that the terminal device is able to receive the data packets according to quality-of-service (QoS) requirements of the application. The maximum number of messages transmitted may then be equal to or larger than the number of packets that the application generates during a periodicity used by the terminal device to scan a channel of the maintenance address. For instance, if an application generates/receives a packet every 10 ms and the terminal checks the maintenance address every 40 ms, the first access node may be configured to transmit four or more packets to the maintenance address between consecutive active periods. Accordingly, the maximum number of forwarded messages may be four or higher.

If the terminal device operates multiple applications at the same time, the terminal device may consider the QoS requirements of all applications as a combination when setting the number of forwarded packets. The maximum number of forwarded messages may thus be set to a higher value than a value set when considering only a single application.

When terminal operates applications having delay constrains (defined by QoS requirements) and applications having no delay constraints simultaneously, the terminal device may configure the first access node to send notifications of only the messages associated with the delay-constrained applications to the maintenance address.

Referring to Figure 7, the first access node starts a counter that counts the number of messages the first access node transmits to the second address after the end of the activity period, and the counter is incremented upon transmitting a message to the second address (block 702). In block 704, a current value of the counter is compared with the value of the maximum number of forwarded messages. If the counter value is below the maximum number of forwarded messages, the process returns to block 702. On the other hand, if the counter value equals to the maximum number of forwarded messages, or is higher
than that, the process proceeds to block 706 in which the first access node prevents further transmission of messages to the second address. In block 708, the next activity period of the first association is triggered. As a consequence, the first access node resets the counter value (block 710), and the process returns to the start to wait for the start of the next inactivity period. Note that block 708 may be detected while carrying out block 702. In that case, the counter may also be reset and the process may return to the start.

In an embodiment, the first access node utilizes an association maintenance timer used to monitor the length of the inactivity periods. The timer may be started at the end of an activity period or upon transmitting a first message to the second address after the end of the previous activity period. If the terminal device does not trigger an activity period in the first association before the association maintenance timer expires, the first access node may carry out disassociation of the first association, thus dismantling a connection with the terminal device. The value of the association maintenance timer may be set to define a longer time interval than a default scanning interval of the first or second association.

In an embodiment, the first access node considers the terminal devices that are currently using the maintenance addresses as "secondary users". For example, if the first access node becomes congested or overloaded, it may be configured to first dismantle associations to the terminal devices that have configured the maintenance address. The first access node may assume that such terminal devices are able to maintain connectivity through the second access node with which the maintenance address has been configured.

With respect to the messages acquired by the first access node and notified to the maintenance address of the terminal devices, the messages may comprise downlink data traffic addressed to the first address and/or management messages created by the first access node.

Figure 8 illustrates yet another embodiment where the utilization of the maintenance address to transmit the notifications is provided in a network apparatus that may be a data source, e.g. a network server or another terminal device. The network apparatus may have established an end-to-end connection with the terminal device according to the multipath principles, e.g. the network apparatus may be provided with multiple addresses assigned to the different connections (associations) between the network apparatus and the terminal device. As described above, the network apparatus is provided with the maintenance address of the terminal device and the network apparatus may send
the notifications of downlink data available in the first association to the maintenance address according to any one of the above-described embodiments, e.g. the notification may be formed according to principles of any one of Figures 4 to 6. Referring to Figure 8, the terminal device may send in step 802 the maintenance setup request to enable the notification functionality and provide the network apparatus with the maintenance address of the terminal device. The maintenance address setup may be carried out substantially in the above-described manner. However, it should be appreciated that since the terminal device now communicates with the same network apparatus over the two associations and with the two addresses, the terminal device may send the maintenance address setup messages over any one of the two associations. In step 804, the network apparatus acknowledges the establishment of the notification functionality.

In another embodiment, the network apparatus determines the maintenance address autonomously. The network apparatus may, for example, monitor delay characteristics of the two associations and select an address of an association having the shorter delay characteristics as the maintenance address. The delay characteristics may comprise an average end-to-end delay from the network apparatus to the terminal device. The association having the shorter end-to-end delay may be assumed to be an association the terminal device uses more frequently. In general, the network apparatus may determine the association providing shorter delay characteristics and use the corresponding address as the maintenance address.

In step 806, the network apparatus transmits downlink data to the first address of the terminal device which is not the maintenance address. As the network apparatus is aware that the terminal device operates the association of the maintenance address (the second address) more frequently, it may transmit the notification of the data transmitted in step 806 to the maintenance address in step 808. The notification may be a duplicate of a one or more data packets transmitted to the first address in step 806, e.g. a duplicate of the first data packet, or it may be a separate notification message, as described above. In case of using the duplicates, the terminal device may employ a multipath TCP of multipath RTP protocol to detect the duplicate copies and process them appropriately. In block 810, the terminal device detects from the notification received in step 808 that the network apparatus has sent data to the other association. As a consequence, the terminal device may activate a radio link of the first association and retrieve the buffered data.
Figure 9 illustrates an embodiment of an apparatus comprising means for carrying out the above-mentioned functionalities of the terminal device. The terminal device may comply with specifications of an IEEE 802.11 network and/or another wireless network. The terminal device may also be a cognitive radio apparatus capable of adapting its operation to a changing radio environment, e.g. to changes in parameters of another system on the same frequency band. The terminal device may be or may be comprised in a computer (PC), a laptop, a tablet computer, a cellular phone, a palm computer, or any other wireless apparatus provided with radio communication capability. In another embodiment, the apparatus carrying out the above-described functionalities of the terminal device is comprised in such a wireless apparatus, e.g. the apparatus may comprise a circuitry, e.g. a chip, a processor, a micro controller, or a combination of such circuitries in the wireless apparatus.

Referring to Figure 9, the apparatus may comprise a communication controller circuitry 10 configured to control wireless communications in the terminal device. The communication controller circuitry 10 may configure the establishment, operation, and termination of connections or associations in the apparatus, as described above. The communication controller circuitry 10 may comprise a control part 12 handling control signalling communication with respect to transmission, reception, and extraction of control or management frames including the maintenance address setup messages, notification messages addressed to the maintenance address, etc. The control part 12 may additionally carry out channel sensing procedures in order to scan the channel(s) of the established associations for messages addressed to the terminal device. The communication controller circuitry 10 may further comprise a data part 16 that handles transmission and reception of payload data when the terminal device is associated to one or more access nodes or to one or more wireless devices.

The communication control circuitry 10 may further comprise a multipath connection controller circuitry 15. The multipath connection controller circuitry 15 may be configured to control the multipath connections in the apparatus. Upon receiving an instruction from an application executed in the apparatus to establish a connection with a network device, e.g. a server, the multipath connection controller circuitry 15 may determine whether or not to establish the connection with the network device as the multipath connection. Upon determining to establish the multipath connection, the multipath connection controller circuitry 15 may instruct the control part 12 to create an association to at least two different access nodes in parallel. The multipath connection controller
circuitry 15 may have knowledge of the presence of wireless networks, and it may
select the access nodes to which to associate according to a determined logic. For
example, the multipath connection controller circuitry 15 may prefer to use
wireless networks of different operators or internet service providers for a
multipath connection. The reasoning may be that they typically have different
backbone links and, thus, the probability of the throughput increase as a result of
the multipath may be increased. Other types of selection logic may naturally be
used. The multipath connection controller circuitry 15 may also control the
association to new access nodes and disassociation from currently serving access
nodes during the operation of the multipath connection. The set of associated
access nodes may need to be changed as a result of mobility of the terminal
device, changing radio environment, changing congestion in the serving access
nodes, etc. The use of the multipath connection may be invisible to the application
using the multipath connection, e.g. in the multipath TCP or multipath real-time
protocol.

The communication control circuitry 10 may further comprise a
maintenance address controller 18 configured to select an address assigned to the
terminal device with respect to one of the associations as the above-described
maintenance address. The maintenance address controller 18 may further control
the above-described configuration of the access nodes of the other associations to
transmit notification messages to the maintenance address whenever their
respective associations are in an inactive state. The control part 12 may be further
configured to operate the association having the maintenance address more
frequently than the other association(s). Upon operating the association having the
maintenance address and detecting a message from an access node of an access
node of another association and addressed to the maintenance address, the
control part 12 may be configured to cause activation of said other association in
order to retrieve data through that association.

The circuitries 12 to 18 of the communication controller circuitry 10 may
be carried out by the one or more physical circuitries or processors. In practice,
the different circuitries may be realized by different computer program modules.
Depending on the specifications and the design of the apparatus, the apparatus
may comprise some of the circuitries 12 to 18 or all of them.

The apparatus may further comprise the memory 20 that stores
computer programs (software) 24 configuring the apparatus to perform the above-
described functionalities of the terminal device. The memory 20 may also store
communication parameters and other information needed for the wireless
communications, e.g. addresses and other parameters assigned to the terminal device with respect to different associations. The apparatus may further comprise radio interface components 22 providing the apparatus with radio communication capabilities within one or more wireless networks. The radio interface components 22 may comprise standard well-known components such as an amplifier, filter, frequency-converter, (de)modulator, and encoder/decoder circuitries and one or more antennas. The apparatus may further comprise a user interface enabling interaction with the user of the communication device. The user interface may comprise a display, a keypad or a keyboard, a loudspeaker, etc.

In an embodiment, the apparatus carrying out the embodiments of the invention in the terminal device comprises at least one processor and at least one memory including a computer program code, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to carry out the functionalities of the terminal device according to any one of the embodiments of Figures 2A, 3 to 6, and 8. Accordingly, the at least one processor, the memory, and the computer program code form processing means for carrying out embodiments of the present invention in the terminal device.

Figure 10 illustrates an embodiment of an apparatus comprising means for carrying out the above-mentioned functionalities of the access node. The access node may be a wireless apparatus which complies with specifications of an IEEE 802.11 network or another wireless network. The wireless apparatus may also be a cognitive radio apparatus capable of adapting its operation to a changing radio environment, e.g. to changes in parameters of another system on the same frequency band. The wireless apparatus may be or may be comprised in a computer (PC), a laptop, a tablet computer, a cellular phone, a palm computer, a base station with routing functionalities, or any other apparatus provided with radio communication capability. In another embodiment, the apparatus carrying out the above-described functionalities of the access node is comprised in such a wireless apparatus, e.g. the apparatus may comprise a circuitry, e.g. a chip, a processor, a micro controller, or a combination of such circuitries in the wireless apparatus.

Referring to Figure 10, the apparatus may comprise a communication controller circuitry 50 configured to control wireless communications in the access node. The communication controller circuitry 50 may comprise a control part 52 handling control signalling communication with respect to transmission, reception, and extraction of control or management frames including the maintenance setup messages and notification messages, as described above. The communication
controller circuitry 50 may further comprise a data part 56 that handles
transmission and reception of payload data with terminal devices associated to the
apparatus or, in some embodiments, with other access nodes.

The communication controller circuitry 50 may further comprise a
message transmission controller 55 configured to determine a route through which
messages should be currently transmitted to a given terminal device. If there
exists an active association with the terminal device, the message transmission
controller 55 may configure the control part 52 and/or the data part 56 to transmit
messages to the terminal device over the active association. On the other hand, if
the association with the terminal device is currently inactive, the message
transmission controller may determine whether or not the terminal device has a
maintenance address through which the terminal device may be reached even
when its association with the access node is currently inactive. If the maintenance
address exists, the message transmission controller 55 may then configure the
control part 52 and/or the data part 56 to transmit messages to the maintenance
address. Depending on the address to which the messages destined to the
terminal device are transmitted, the control part 52 and/or the data part 56 may
transmit the messages to a different transmission medium. For example, if the
association is active, the messages may be transmitted to a wireless medium.
Otherwise, the messages may be transmitted to a wired medium, e.g. towards the
Internet.

The communication controller circuitry 50 may further comprise an
address controller circuitry 58 configured to manage the addresses assigned to
different terminal devices associated to the access node. The address controller
circuitry 58 may be configured to maintain up-to-date knowledge at which address
the terminal device may be currently reached and inform the control part 52 and
data part 56 accordingly. As a result, the control part and the data part may
transmit the messages addressed to the terminal device to an address from which
the terminal device may be currently reached, e.g. either an address of an
association with the access node or the maintenance address.

The circuitries 52 to 58 of the communication controller circuitry 50 may
be carried out by the one or more physical circuitries or processors. In practice,
the different circuitries may be realized by different computer program modules.
Depending on the specifications and the design of the apparatus, the apparatus
may comprise some of the circuitries 52 to 58 or all of them.

The apparatus may further comprise the memory 60 that stores
computer programs (software) 64 configuring the apparatus to perform the above-
described functionalities of the wireless apparatus, e.g. the access node. The
memory 60 may also store communication parameters and other information
needed for the wireless communications within a wireless network of the access
point and with other wireless networks. The memory 60 may store a maintenance
address database 66 comprising maintenance addresses of terminal devices that
have configured to use of the maintenance address to contact them. The
apparatus may further comprise an input/output circuitry 62. The input/output
circuitry 62 may comprise radio interface components providing the apparatus with
radio communication capabilities within its wireless network and/or with other
wireless networks. The radio interface components may comprise standard well-
known components such as an amplifier, filter, frequency-converter,
(de)modulator, and encoder/decoder circuitries and one or more antennas. The
input/output circuitry 62 may further comprise wired interface components
providing the apparatus with a capability of communicating over a wired
connection, e.g. a digital subscriber line (DSL) connection. The apparatus may
further comprise a user interface enabling interaction with the user of the device.
The user interface may comprise a display, a keypad or a keyboard, a
loudspeaker, etc.

In an embodiment, the apparatus carrying out the embodiments of the
invention in the access node comprises at least one processor and at least one
memory including a computer program code, wherein the at least one memory and
the computer program code are configured, with the at least one processor, to
cause the apparatus to carry out the functionalities of the access node according
to any one of the processes described above with respect to Figures 2B and 3 to
7. Accordingly, the at least one processor, the memory, and the computer program
code form processing means for carrying out embodiments of the present
invention in the access node.

As used in this application, the term 'circuitry' refers to all of the
following: (a) hardware-only circuit implementations such as implementations in
only analog and/or digital circuitry; (b) combinations of circuits and software and/or
firmware, such as (as applicable): (i) a combination of processor(s) or processor
cores; or (ii) portions of processor(s)/software including digital signal processor(s),
software, and at least one memory that work together to cause an apparatus to
perform specific functions; and (c) circuits, such as a microprocessor(s) or a
portion of a microprocessor(s), that require software or firmware for operation,
even if the software or firmware is not physically present.
This definition of 'circuitry' applies to all uses of this term in this application. As a further example, as used in this application, the term "circuitry" would also cover an implementation of merely a processor (or multiple processors) or portion of a processor, e.g. one core of a multi-core processor, and its (or their) accompanying software and/or firmware. The term "circuitry" would also cover, for example and if applicable to the particular element, a baseband integrated circuit, an application-specific integrated circuit (ASIC), and/or a field-programmable grid array (FPGA) circuit for the apparatus according to an embodiment of the invention.

The processes or methods described in Figures 2 to 8 may also be carried out in the form of a computer process defined by a computer program. The computer program may be in source code form, object code form, or in some intermediate form, and it may be stored in some sort of carrier, which may be any entity or device capable of carrying the program. Such carriers include transitory and/or non-transitory computer media, e.g. a record medium, computer memory, read-only memory, electrical carrier signal, telecommunications signal, and software distribution package. Depending on the processing power needed, the computer program may be executed in a single electronic digital processing unit or it may be distributed amongst a number of processing units.

The present invention is applicable to wireless systems defined above but also to other suitable systems. The protocols used, the specifications of the wireless systems, their network elements and terminal devices, develop rapidly. Such development may require extra changes to the described embodiments. Therefore, all words and expressions should be interpreted broadly and they are intended to illustrate, not to restrict, the embodiment. It will be obvious to a person skilled in the art that, as technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.
Claims

1. A method comprising:

   providing, in a terminal device, a first association to a first access node and
   acquiring a first address associated with the first association;

   providing, in the terminal device a second association to a second access
   node and acquiring a second address associated with the second association;

   causing, by the terminal device, transmission of the second address to the first
   access node for enabling the first access node to employ the second address
   in contacting the terminal device when the first association is inactive; and

   acquiring, in the terminal device, messages from the first access node directly
   as addressed to the first address when the first association is in an active state
   and indirectly through the second access node as addressed to the second
   address when the first association is in an inactive state.

2. The method of claim 1, further comprising in the terminal device:

   determining from a message received from the first access node through the
   second access node that the first access node has downlink messages
   buffered for the terminal device; and

   as a response to said determining, changing the state of the first association
   from the inactive state to the active state and enabling downlink transmission
   of the downlink messages over the first association.

3. The method of claim 1 or 2, wherein the message acquired indirectly from the
   first access node comprises a notification that the first access node has
   downlink messages buffered for the terminal device.

4. The method of any preceding claim, wherein the message acquired indirectly
   from the first access node comprises a header of a downlink packet buffered
   in the first access node for the terminal device.
5. The method of any preceding claim, wherein the message acquired indirectly from the first access node comprises a header and a payload of a downlink packet for the terminal device.

6. The method of any preceding claim, wherein the message acquired indirectly from the first access node comprises a more data indicator indicating that the first access node has buffered more downlink data for the terminal device.

7. The method of any preceding claim, wherein the message acquired indirectly from the first access node comprises both the first address and the second address of the terminal device.

8. The method of any preceding claim, wherein the message acquired indirectly from the first access node comprises an original header comprised in a downlink message received by the first access node and a header added to the downlink message by the first access node.

9. The method of any preceding claim, further comprising in the terminal device: maintaining the first association and the second association operational in parallel and keeping the second association active when the first association is inactive.

10. The method of any preceding claim, wherein the terminal device is configured to operate the second association more frequently than the first association.

11. The method of any preceding claim, wherein the second address is an internet protocol address or a combination of a medium access control address of the terminal device and a network identifier of a wireless network of the second access node.

12. The method of any preceding claim, further comprising in the terminal device: causing transmission of an uplink message to the first access node, wherein the uplink message comprises an information element that indicates whether or not the indirect transmission of the messages through the second access node is enabled.
13. A method comprising:

providing, in a first access node of a wireless network, a first association to a terminal device and acquiring a first address of the terminal device for use in the first association;

acquiring, in the first access node, a second address of the terminal device, wherein the second address is associated with a second association between the terminal device and a second access node;

after receiving a downlink message addressed to the terminal device, causing, by the first access node, transmission of a first message to the first address when the first association is in an active state and transmission of a second message to the second address when the first association is in an inactive state.

14. The method of claim 13, wherein the second message transmitted to the second address comprises at least one of the following: a notification message indicating that the first access node has buffered the downlink message for the terminal device, a header of the received downlink message, and the header and a payload of the received downlink message.

15. The method of claim 13 or 14, wherein the first message comprises the received downlink message.

16. The method of any preceding claim, further comprising in the first access node:

providing a reference parameter defining a maximum number of messages the first access node is allowed to transmit to the second address between an end of an active state of the first association and a start of a consecutive active state of the first association;

counting a number of messages transmitted to the second address after the end of the active state of the first association;

upon reaching the maximum number of forwarded messages, preventing
transmission of further messages to the second address until the subsequent active state is triggered; and

upon triggering the subsequent active period, resetting a counter counting the number of messages transmitted to the second address.

17. An apparatus comprising:

at least one processor; and

at least one memory including a computer program code, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to:

provide a first association to a first access node and acquire a first address associated with the first association;

provide a second association to a second access node and acquire a second address associated with the second association;

cause transmission of the second address to the first access node for enabling the first access node to employ the second address in contacting the apparatus when the first association is inactive; and

acquire messages from the first access node directly as addressed to the first address when the first association is in an active state and indirectly through the second access node as addressed to the second address when the first association is in an inactive state.

18. The apparatus of claim 17, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to:

determine from a message received from the first access node through the second access node that the first access node has downlink messages buffered for the apparatus; and

as a response to said determining, change the state of the first association from the inactive state to the active state and enable downlink transmission of
the downlink messages over the first association.

19. The apparatus of claim 17 or 18, wherein the message acquired indirectly from the first access node comprises a notification that the first access node has at least one downlink message buffered for the apparatus.

20. The apparatus of any preceding claim 17 to 19, wherein the message acquired indirectly from the first access node comprises a header of a downlink packet for the apparatus.

21. The apparatus of any preceding claim 17 to 20, wherein the message acquired indirectly from the first access node comprises a header and a payload of a downlink packet for the apparatus.

22. The apparatus of any preceding claim 17 to 21, wherein the message acquired indirectly from the first access node comprises a more data indicator indicating that the first access node has buffered more downlink data for the terminal device.

23. The apparatus of any preceding claim 17 to 22, wherein the message acquired indirectly from the first access node comprises both the first address and the second address of the apparatus.

24. The apparatus of any preceding claim 17 to 23, wherein the message acquired indirectly from the first access node comprises an original header comprised in a downlink message received by the first access node and a header added to the downlink message by the first access node.

25. The apparatus of any preceding claim 17 to 24, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to maintain the first association and the second association operational in parallel and keep the second association active when the first association is inactive.

26. The apparatus of any preceding claim 17 to 25, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to operate the second association more
frequently than the first association.

27. The apparatus of any preceding claim 17 to 26, wherein the second address is an internet protocol address or a combination of a medium access control address of the apparatus and a network identifier of a wireless network of the second access node.

28. The apparatus of any preceding claim 17 to 27, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to cause transmission of an uplink message to the first access node, wherein the uplink message comprises an information element that indicates whether or not the indirect transmission of the messages through the second access node is enabled.

29. An apparatus comprising:
   at least one processor; and
   at least one memory including a computer program code, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to:
   provide a first association to a terminal device and acquire a first address of the terminal device for use in the first association;
   acquire a second address of the terminal device, wherein the second address is associated with a second association between the terminal device and a second access node;
   after receiving a downlink message addressed to the terminal device, cause transmission of a first message to the first address when the first association is in an active state and transmission of a second message to the second address when the first association is in an inactive state.

30. The apparatus of claim 29, wherein the second message transmitted to the second address comprises at least one of the following: a notification message indicating that the first access node has buffered the downlink message for the terminal device, a header of the received downlink message, and the header
and a payload of the received downlink message.

31. The apparatus of claim 29 or 30, wherein the first message comprises the received downlink message.

32. The apparatus of any preceding claim 29 to 31, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to:

provide a reference parameter defining a maximum number of messages the apparatus is allowed to transmit to the second address between an end of an active state of the first association and a start of a consecutive active state of the first association;

count a number of messages transmitted to the second address after the end of the active state of the first association;

upon reaching the maximum number of forwarded messages, prevent transmission of further messages to the second address until the subsequent active state is triggered; and

upon triggering the subsequent active period, reset a counter counting the number of messages transmitted to the second address.

33. An apparatus of any preceding claim 17 to 32, further comprising radio interface components providing the apparatus with radio communication capability.

34. An apparatus, comprising means for carrying out all the steps of the method according to any preceding claim 1 to 16.

35. A computer program product embodied on a distribution medium readable by a computer and comprising program instructions which, when loaded into an apparatus, execute the method according to any preceding claim 1 to 16.

36. A method comprising:
providing, in a data source apparatus of a communication network, a first association to a terminal device and acquiring a first address of the terminal device for use in the first association;

providing, in the data source apparatus, a second association to the terminal device and acquiring a second address of the terminal device for use in the second association, wherein the second association has shorter delay characteristics for data delivery from the data source apparatus to the terminal device than corresponding delay characteristics of the first association;

causing, by the data source apparatus, transmission of a downlink message as addressed to the first address and transmission of a notification of the downlink message as addressed to the second address.

37. An apparatus comprising:

at least one processor; and

at least one memory including a computer program code, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to:

provide a first association to a terminal device and acquire a first address of the terminal device for use in the first association;

provide a second association to the terminal device and acquire a second address of the terminal device for use in the second association, wherein the second association has shorter delay characteristics for data delivery from the data source apparatus to the terminal device than corresponding delay characteristics of the first association;

cause transmission of a downlink message as addressed to the first address and transmission of a notification of the downlink message as addressed to the second address.
Fig 1

Fig 2A

START

202: PROVIDE FIRST ASSOCIATION TO FIRST ACCESS NODE AND ACQUIRE FIRST ADDRESS

204: PROVIDE SECOND ASSOCIATION TO SECOND ACCESS NODE AND ACQUIRE SECOND ADDRESS

206: CONFIGURE FIRST ACCESS NODE TO EMPLOY MESSAGE FORWARDING

208: ACQUIRE MESSAGES FROM FIRST ACCESS NODE BOTH DIRECTLY AND INDIRECTLY

END

Fig 2B

START

212: PROVIDE FIRST ASSOCIATION TO FIRST ACCESS NODE AND ACQUIRE FIRST ADDRESS

214: ACQUIRE SECOND ADDRESS OF TERMINAL DEVICE ASSOCIATED TO SECOND ACCESS NODE

216: TRANSMIT MESSAGES TO FIRST ADDRESS WHEN FIRST ASSOCIATION IS ACTIVE AND TO SECOND ADDRESS WHEN FIRST ASSOCIATION IS INACTIVE

END
Fig 3

Access Node 1

300: Associate and negotiate 1st address
304: Maintenance address setup request
306: Maintenance address setup response
320: 1st association active
322: 1st association inactive
324: 1st association active
308: Acquire data
310: Address data to first address
311: Acquire data
312: Transmit message addressed to second address
313: Deliver message to terminal device
314: Determine that access node 1 has buffered data
315: Activate first association
316: Address data to first address

Terminal Device

302: Associate and negotiate 2nd address

Access Node 2

Fig 4

400: Message received by access node 1
401: Message transmitted by access node 1
402: Header
404: Payload
406: Header
408: Payload
402: Header
404: Payload
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W76/02
ADD. H04W92/20 H04W52/02

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

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
</table>

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
  "Z" document member of the same patent family

Date of the actual completion of the international search: 25 February 2014

Date of mailing of the international search report: 06/05/2014

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: Bosch, Michael
## INTERNATIONAL SEARCH REPORT

### DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tr>
<td>A</td>
<td>FORD R0KE MANOR RESEARCH C RAICIU M HANDLEY UNIVERSITY COLLEGE LONDON A: &quot;TCP Extensions for Multipath Operation with Multiple Addresses; draft-ford-mptcp-multipath-03.txt&quot;, TCP EXTENSIONS FOR MULTI PATH OPERATION WITH MULTIPLE ADDRESSES; DRAFT-FORD-MPTCP-MULTIADDRESSED-03.TXT, INTERNET ENGINEERING TASK FORCE, IETF; STANDARD WORKING DRAFT, INTERNET SOCIETY (ISOC) 4, RUE DES FALAISES CH-1205 GENEVA, SWITZERLAND, no. 3, 9 March 2010 (2010-03-09), pages 1-35, XP015068003, paragraphs [01.2] , [01.3] , [04.2] , [04.3] -----</td>
<td>1-35</td>
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INTERNATIONAL SEARCH REPORT

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
   1–35

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/21 0 (continuation of first sheet (2)) (April 2005)
This International Searching Authority found multiple (groups of) inventions in this International application, as follows:

1. Claims: 1-35

The first invention deals with the first problem of enabling a first AP to contact the terminal device when the first association between the first AP and the terminal device is inactive.

According to Claims 1, 17 and 13, 29, this is achieved by:

a) Claim 1 (and Claim 17): the method (in the terminal device) comprising:
   - causing, by the terminal device, transmission of the second address to the first access node for enabling the first access node to employ the second address in contacting the terminal device when the first association is inactive;
   - acquiring, in the terminal device, messages from the first access node indirectly through the second access node as addressed to the second address when the first association is in an inactive state, and

b) Claim 13 (and Claim 29): the method (in a first access node of a wireless network) additionally comprising:
   - providing, in the first access node, a first association to a terminal device and acquiring a first address of the terminal device for use in the first association;
   - acquiring, in the first access node, a second address of the terminal device, wherein the second address is associated with a second association between the terminal device and a second access node;
   - after receiving a downlink message addressed to the terminal device, causing, by the first access node, transmission of a second message to the second address when the first association is in an inactive state.

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2. Claims: 36, 37

The second claimed invention concerns a method (for a data source apparatus) defining a transmission of a notification of the downlink message (transmitted as addressed to a first address, i.e. via a first path having greater delay), as addressed to the second address (i.e. via a second path).

Thus, it is concerned with the second problem of enabling to avoid any measures of the receiving station on (e.g. terminal device, e.g. retransmission requests) in case of great delay experienced by the downlink message transmitted to the first address (i.e. via a first path).
## INTERNATIONAL SEARCH REPORT

**International application No:**

PCT/FI2013/05430

### Information on patent family members

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