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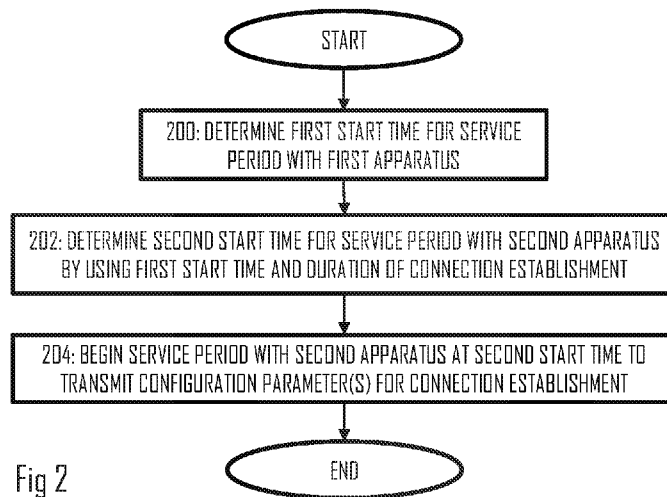


Fig 2

(57) Abstract: This document discloses a solution for facilitating connection establishment to a wireless network. According to an aspect, a method comprises: determining, by a mediator device configured to facilitate connection establishment to an access node, a first start time for transferring at least one configuration parameter, wherein the at least one configuration parameter shall be transferred between the mediator device and a first apparatus on a first frequency channel, and wherein the at least one configuration parameter is for a connection establishment between the first apparatus and the access node on a second frequency channel; determining, by the mediator device, a second start time for transferring at least one configuration parameter for a connection establishment between a second apparatus and the access node on the second frequency channel, wherein the at least one configuration parameter shall be transferred between the mediator device and the second apparatus on the first frequency channel.



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FACILITATING CONNECTION ESTABLISHMENT TO WIRELESS NETWORK

Field

The invention relates to the field of wireless networking and, particularly, to facilitating connection establishment for a wireless device.

5 Background

With the development of Internet-of-Things concept, a number of networking devices is increasing. Some of the devices may have limited capabilities and, therefore, mechanisms for bringing such devices into a wireless network are being developed. Another device may serve as a mediator device facilitating connection establishment with an access node
10 of the wireless network. The mediator device may, for example, provide network discovery and/or authentication features on behalf of the access node.

Brief description

Some aspects of the invention are defined by the independent claims.

Embodiments of the invention are defined in the dependent claims.

15 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 scenario to which embodiments of the invention may be applied;

20 Figure 2 illustrates a process for providing a mediation service facilitating connection establishment according to an embodiment of the invention;

Figure 3 illustrates a process for utilizing the mediation service according to an embodiment of the invention;

Figure 4 illustrates some embodiments related to the mediation service;

25 Figure 5 illustrates a timing diagram of frames transmitted according to some embodiments of the invention; and

Figures 6 and 7 illustrate block diagrams of structures of apparatuses according to some embodiments of the invention.

Description of embodiments

30 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
5 mentioned.

A wireless communication scenario to which embodiments of the invention may be applied is illustrated in Figure 1. Figure 1 illustrates a plurality of wireless devices 100, 110 112, 114. A wireless device 100 may operate as an access node managing a wireless network and providing the other wireless devices 110 to 114 with wireless access, e.g. to other networks 130
10 such as the Internet. Additionally, some of the wireless devices 110 to 114 may form an ad hoc network. The ad hoc network may comply with neighbour awareness networking (NAN) principles described in greater detail below. The wireless devices 100 to 114 may employ a physical layer and a medium access control (MAC) layer that comply with wireless local area network (WLAN) specifications based on IEEE 802.11 but, in other embodiments, the wireless
15 devices may support another wireless communication protocol as an alternative or in addition to the WLAN. For example, the access node 100 may provide a 802.11 network while the ad hoc network may use another physical layer and MAC specification, such as the Bluetooth ® technology. In the WLAN specifications, a wireless network may be called a basic service set (BSS). While embodiments of the invention are described in the context of the IEEE 802.11, it
20 should be appreciated that these or other embodiments of the invention may be applicable to wireless 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
25 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. Therefore, the following description may be generalized to other systems as well.

The different wireless networks may operate at least partly on different channels,
30 e.g. on different frequency channels. For example, the ad hoc network of the wireless devices 110 to 114 may operate on a first frequency channel while the wireless network of the access node operates on a second, different frequency channel. IEEE 802.11n 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
35 20 MHz mode and with clients supporting higher bandwidths. A further definition in 802.11n is that the primary and secondary channels are adjacent. The 802.11n 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 specification 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
5 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.

The access node 100 may be a fixed access point or a mobile access point. The
10 wireless devices 110 to 114 may be terminal devices capable of connecting to the access node 100 in addition to operating in the ad hoc network. The wireless devices 110 to 114 may have different capabilities, as described in greater detail below.

Let us now describe an embodiment of the ad hoc network of the wireless devices
110 to 114 in greater detail. Applications for short-range wireless devices are evolving to include
15 awareness applications providing the device with awareness about a local network environment. A non-limiting example of a neighbor awareness network architecture is Neighbor Awareness Networking (NAN) technology of Wi-Fi Alliance, a network of wireless mobile devices self-organizing to support various applications, ranging from social networking to service discovery. Awareness information may be shared by a short-range wireless device sending an anonymous
20 flooding message that may include a query, over an ad hoc network. A neighboring short-range wireless device may reply to the flooding message over the ad hoc network with a response, such as a pointer to a discovered location-based service.

Awareness information may include any information and/or context about a local
network environment as well as the users and communication devices within the local network
25 environment. Wireless devices may continuously collect and exchange information with other devices in a local network environment. Awareness applications running on short-range wireless devices may create a network for sharing awareness information, locate and organize awareness information, form communities for sharing awareness information, manage power consumption for devices engaged in sharing awareness information, develop applications to take
30 advantage of the awareness information, and maintain the privacy and anonymity of users sharing awareness information.

Awareness applications running on short-range wireless devices may employ a
physical layer and a MAC layer based on the IEEE 802.11 technology. The awareness
application may build upon a scheme in which every device is responsible for participating in
35 beaconing and all the other basic operations that keep the ad hoc network in operation. An ad hoc network may be designed to have one network identifier (NWID) that all of the devices in

the network share. The NWID may be announced in the beacons transmitted by the devices. In the overall design, those devices that operate under same NWID are driven to use a common and shared schedule to allow for awareness information gathering among all the devices within range. The determination of which schedule is used by a device may be made by the network instance timer value, and this timer value is communicated in beacons in the timing synchronization function (TSF) value parameter. The devices may be required to operate by assuming the oldest TSF value (i.e. largest TSF value) contained in the received beacons that represent the network with the NWID in which the devices are operating. Alternatively the devices may be required to select the schedule which to follow based on some other criteria than the TSF value. Beacons may, as an example, contain some other information than the TSF that is used by the devices to determine which schedule to use.

When a physical radio and a MAC entity of a wireless device transmits a beacon, the beacon's MAC-header may contain device's own current TSF value. The device may automatically transmit a reply message when it receives a beacon from another network, the reply message being referred herein as a beacon response message. The beacon response message contains the current TSF value of the replying network. Alternatively the beacon response message may contain other information that is used to determine which schedule to use.

Wireless devices form a network where all devices in proximity may communicate with each other. When two or more groups of devices forming two or more instances of the network come close to each other, the two or more instances may merge to become one network instance. Devices may make a merging or join decision to change the instance autonomously based on the TSF information collected from beacons received during scan periods or based on the TSF information collected from received beacon response messages. A merging decision may be performed when a device receives a beacon or beacon response message with an older (greater) TSF value from another wireless device. Alternatively a merging decision may be done based on some other information available in a beacon or beacon response message from another wireless device. After the merging decision has been performed by a device, the device moves into the new network instance.

The awareness functionality in a short-range wireless device may be divided between four layers of an awareness architecture. An awareness layer and a community layer may provide services for applications, e.g. by providing an awareness application program interface (API). The approximate functional split between the different layers may be as follows.

In accordance with an example embodiment, the present invention may be used in a logical architecture of the Neighbor Awareness Networking (NAN) program being standardized by the Wi-Fi Alliance (WFA). The NAN protocol stack is expected to comprise

of two components: 1) NAN Discovery Engine, 2) MAC with NAN support. MAC with NAN support is a variant of Wi-Fi MAC and provides means for NAN devices to synchronize in time and frequency to provide common availability periods for service discovery frames from/to the NAN Discovery Engine.

5 The NAN Discovery Engine may provide Publish and Subscribe services to the applications for service discovery purposes. Publishing is an ability to make application-selected information about e.g. capabilities and services available for other NAN devices that seek information with Subscribing. The publishing ability may use protocols and mechanisms certified by the Neighbor Awareness Networking program. NAN devices that use Publishing
10 may provide published information in an unsolicited or solicited manner. Subscribing is an ability to discover information that has been made available in other NAN devices with Publishing, using protocols and mechanisms certified by the Neighbor Awareness Networking program. NAN devices that use Subscribing may passively listen for or actively seek published information.

15 Publish and Subscribe services are expected to exploit a discovery protocol that the NAN Discovery Engine implements and which is designed for NAN. The protocol is expected to have two different protocol messages: 1) Discovery query message, and 2) Discovery response message. The Subscribe service is expected to use the Discovery query message to conduct active discovery. The Subscribe service may be configured to operate in the passive
20 mode only. In this mode, no Discovery query messages are transmitted, but one listens for Discovery response messages to find the information sought. The Publishing service is expected to use the Discovery response message to announce availability of application-selected information to discovering devices.

 A device in which the Subscribe service has been activated in active mode,
25 transmits Discovery query messages to trigger Publishing devices to transmit Discovery response messages. In parallel, the Subscribing device monitors received Discovery response messages to determine the availability of services and information being sought. Monitoring is envisioned to be a continuous process that applies to all Discovery response messages received while the Subscribe service is active. With this approach, a Subscribing device may gather
30 valuable information from Discovery response messages that are independent from its own Discovery query message transmissions.

 Upon activating the NAN functions in a device, the device first looks for a NAN network by means of passive discovery. The NAN functions are activated by an application in the device requesting either the Subscribe or the Publish service to be activated, when there is
35 no service active in the NAN Discovery Engine. On default, there is at least one NAN ID that is determined in a NAN specification and the NAN device looks for such a network and its clusters.

With respect to joining a NAN network / NAN cluster, if the device finds at least one NAN cluster that the device may join, the device selects a cluster and joins it. If the device finds no NAN cluster that the device may join, the device establishes a NAN cluster of its own. An application may have also requested the Publish service to be activated in a passive mode. In such case the device doesn't ever establish a NAN cluster, but it only operates in NAN clusters that have been established by others.

Recent developments in 802.11 work groups have involved introduction of a new low-power radio interface called a wake-up radio (WUR). The WUR has been discussed in a WUR study group. A new task group, TGba, has been established and it will continue the work of the study group. One purpose of the new radio interface is to enable further power-savings by allowing a main radio (also known as a primary connectivity radio) interface used for data communication according to 802.11 specifications to doze for longer periods. The low-power radio interface is called in the study group a wake-up radio (WUR) receiver or a low-power WUR (LP-WUR) receiver, and it is considered to be a companion radio to the primary connectivity radio. A wireless device such as the STA may comprise both a WUR interface and the main 802.11 interface. An access node may comprise a WUR interface and the main 802.11 interface. To summarize, a device of the wireless network may include a wake-up radio (WUR) interface and a main radio interface. It has been proposed that the purpose of the wake-up radio interface is only or mainly to wake-up the main radio interface e.g. when the access node has data to transmit to a dozing STA having disabled the main radio interface.

The wake-up radio interface may be designed such that it consumes less power than the main radio interface. The wake-up radio interface may employ a simpler modulation scheme than the main radio interface, e.g. the wake-up radio interface may use only on-off keying (OOK) while the main radio interface uses variable and more complex modulations schemes such as phase-shift keying and (quadrature) amplitude modulation. The wake-up radio interface may operate on a smaller bandwidth than the smallest operational bandwidth of the main radio interface, e.g. 5 Megahertz (MHz) for the wake-up radio and 20 MHz for the smallest bandwidth of the main radio interface.

Since the main purpose of the wake-up radio interface is to wake up the main radio interface, the wake-up radio interface may be powered on when the main radio interface is powered off. A wake-up radio interface of the STA may be configured to receive and extract wake-up radio frames transmitted by a wake-up radio interface of the access node. The wake-up radio interface of the STA may be capable of decoding the wake-up radio frames on its own without any help from the main radio interface. Accordingly, the wake-up radio interface may comprise, in addition to a radio frequency front-end receiver components, digital baseband receiver components and a frame extraction processor capable of decoding contents of a wake-

up radio frame. The wake-up radio frame may comprise a destination address field indicating a STA that should wake up the main radio interface, and the frame extraction processor may perform decoding of the destination address from a received wake-up radio frame and determine whether or not the destination address is an address of the STA of the frame extraction processor.

- 5 If yes, it may output a wake-up signal causing the main radio interface to wake up for radio communication with an access node.

With the development of Internet-of-things (IoT) concept, many devices connecting to a network are “headless” devices. The term “headless” refers to reduced or non-existent user interfacing capabilities. A headless device may, for example, have no display unit and/or no input device. A device provisioning protocol (DPP) is being designed to facilitate networking of such devices, although the DPP may be applicable to other devices as well. A mediator device may employ the DPP to provide a headless device with configuration parameter(s) that facilitate connection establishment between the headless device and an access node of a wireless network. The mediator device may use the DPP, for example, to authenticate the headless device before the headless device begins association to the access node.

In some applications, the number of devices connecting to the access node may be very high. There may exist situations where the high number of devices determine to connect to the access node substantially simultaneously. An example situation could arise when a high number of sensor devices is activated simultaneously and they all start connection establishment. Such a situation may cause collisions and delays in the connection establishment, which degrades the performance of the access node and causes power consumption in the connecting devices because of long delays in the connection establishment.

Figures 2 and 3 illustrate embodiments of processes for controlling connection establishment between wireless devices and the access node. Figure 2 illustrates a process as performed by the mediator device, and Figure 3 illustrates a process as performed by a wireless device connecting to the access node, e.g. a headless device. Referring to Figure 1, the mediator device 110 may facilitate the connection establishment of the wireless devices 112, 114.

Referring to Figure 2, the process comprises: determining (block 200), by the mediator device 110 configured to facilitate connection establishment to an access node, a first start time for transferring at least one configuration parameter, wherein the at least one configuration parameter shall be transferred between the mediator device and a first apparatus 112 on a first frequency channel, and wherein the at least one configuration parameter is for a connection establishment between the first apparatus 112 and the access node 100 on a second frequency channel; determining (block 202), by the mediator device 110, a second start time for transferring at least one configuration parameter for a connection establishment between a second apparatus 114 and the access node 100 on the second frequency channel, wherein the at

least one configuration parameter shall be transferred between the mediator device 110 and the second apparatus 114 on the first frequency channel, and wherein the second start time is determined on the basis of the first start time and an estimated duration of the connection establishment between the first apparatus 112 and the access node; and beginning, by the mediator device 110, a service period with the second apparatus 114 at the second start time and transmitting, by the mediator device 110 during the service period, at least one frame comprising said at least one configuration parameter. The first frequency channel may be a 20MHz frequency channel, or a sub-channel of the 20MHz frequency channel. The second frequency channel may be a 20MHz frequency channel.

Referring to Figure 3, the process comprises: subscribing (block 300), by the first apparatus 112 on a first frequency channel, to a mediation service provided by the mediator device 110 configured to facilitate connection establishment to the access node 100; beginning (block 302), by the first apparatus 112, a service period of the mediation service with the mediator device 110 at a first start time dependent on a second start time of a service period of a second apparatus 114 and further on an estimated duration of a connection establishment between the second apparatus 114 and the access node 100; receiving (block 304), by the first apparatus 112 from the mediator device 110 during the service period, at least one frame comprising at least one configuration parameter facilitating said connection establishment to the access node 100; and upon receiving the at least one configuration parameter, connecting (block 304) by the first apparatus 112 to the access node 100 on a second frequency channel by using the at least one configuration parameter.

The embodiments of Figures 2 and 3 describe a solution where a service period of an apparatus, e.g. the wireless device 112, is started as dependent on a start time of a service period of another apparatus, e.g. the wireless device 114, and further on an estimated duration of connection establishment of the other apparatus. Such a solution enables the mediation device to control the service period in such a manner that collision probability of connection establishments following the service periods can be reduced.

In the embodiments of Figures 2 and 3, the first and second frequency channels are different frequency channels and on non-overlapping frequencies with respect to one another. In some cases the mediation service and the associated connection establishment may, however, be carried out by the first apparatus 112 on the same frequency channel.

The number of apparatuses or wireless devices in the examples of Figures 2 and 3 is two but the number may be significantly higher, e.g. dozens or even hundreds of devices.

In an embodiment of Figure 3, the second start time occurs before the first start time, as illustrated in greater detail below in connection with the embodiment of Figure 4. The start time 1 of Fig. 4 corresponds to the second start time mentioned above, and the start time 2

of Fig.4 corresponds to the first start time. The service periods of the wireless devices 112, 114 may be arranged in a staggered manner.

In an embodiment, the mediator device 110 provides the wireless devices 112, 114 with the same at least one configuration parameter during the respective service periods, e.g. credentials of the access node 100 as described below.

In an embodiment, the mediator device 110 provides the wireless devices 112, 114 with at least partially different configuration parameters. The configuration parameters may be user or device-specific and, therefore, the wireless device 112 is provided with different at least one configuration parameter than the wireless device 114. However, at least one configuration parameter may still be the same for both devices 112, 114.

In an embodiment, the mediator device arranges the start times of the service periods of the wireless devices such that the wireless devices perform the connection establishments in a staggered manner. This may be understood such that connection establishment processes of the wireless devices do not overlap and only one device is performing the connection establishment at a time. However, one wireless device may perform the service period while another wireless device is performing the connection establishment. Since these two operations may be performed on different frequency channels and possibly also with different peer devices such as the mediator device 110 and the access node 100, the operations do not interfere with one another.

Let us assume that the first start time is T_1 and that the estimated duration of the connection establishment is TD . TD may be computed from the end of the service period. The length of the service period TL_{sp} may be fixed. Now, the second start time T_2 for starting a service period of another device may be computed as:

$$T_2 = T_1 + TL_{sp}, \text{ if } TL_{sp} \geq TD$$

$$T_2 = T_1 + TL_{sp} + (TD - TL_{sp}), \text{ if } TL_{sp} < TD$$

If the length of the service period is greater than the duration of the connection establishment with the access node 100, the second start time may indicate a timing directly after the end of the service period. If the length of the service period is lower than the duration of the connection establishment with the access node 100, the second start time may indicate a timing after a certain time interval has expired from the end of the service period. The certain time interval is the difference between the length of the service period and the duration of the connection establishment with the access node 100. This ensures that a wireless device will not start the connection establishment while another wireless device is still performing its connection establishment, provided that the estimate of the duration of the connection establishment is accurate. However, the estimate may be determined such that there is a sufficiently high probability of successfully completing the connection establishment. A basic

assumption may be that a wireless device starts the connection establishment directly after completing the service period and receiving the configuration parameter(s).

Figure 4 illustrates a signalling diagram combining the embodiments of the processes of Figures 2 and 3 and also illustrating further embodiments. Referring to Figure 4, the mediator device 110 may acquire the configuration parameter(s) of the access node 100 in block 400 and store the configuration parameter(s) in a memory of the mediator device 110. The configuration parameter(s) may include at least some of the following: an identifier of a wireless network (e.g. a service set identifier SSID) and/or the access node, credentials of the access node 100 (such as an identifier of the access node or a wireless network of the access node and/or a password of the access node), authentication parameters of the access node such as one or more encryption keys, The password may be a shared, secret, and potentially low-entropy word, phrase, code, or key used as a credential for authentication purposes. As an alternative to the password, another security parameter of the wireless network of the access node 100 may be provided as a configuration parameter.

In block 404, the mediator device 110 may connect to a wireless network. This wireless network is denoted by “#1” in Figure 4. The wireless network may operate according to the NAN protocol described above. In another embodiment, the wireless network operates according to another protocol, e.g. a Bluetooth protocol or a near-field communication (NFC) protocol. In a situation where there is no wireless network to connect to, the mediator device may establish the wireless network in block 404. Block 404 may be carried out before or after block 400.

The wireless devices 112, 114 may be provided with the above-described WUR interface in addition to a main interface. The mediator device 110 may also comprise the WUR interface to enable the mediator device to wake up the wireless devices when necessary. The main interface of the wireless devices 112, 114 may support bidirectional communication in the wireless networks of the mediator device 110 and the access node 100. In an embodiment where the wireless network of the mediator device 110 supports a different communication protocol than the access node, the wireless devices may comprise multiple main radio interfaces so that the wireless devices are capable of communicating in both wireless networks. The wireless devices 112, 114 may operate in block 402 in a power-save mode where the main radio interface(s) is/are disabled and the WUR interface is enabled.

In step 406, the mediator device 110 determines to activate the wireless devices 112, 114 and transmits a wake-up frame by using the WUR interface. The wake-up frame may be addressed to a group address such as a broadcast address or a multicast address. The group-addressed wake-up frame may simultaneously wake up multiple wireless devices 112, 114. In another embodiment, the wake-up frame is a unicast wake-up frame addressed to only one

wireless device. The mediator device may send multiple unicast wake-up frames to wake up multiple wireless devices. An event triggering the transmission of the wake-up frame in the mediator device 110 may be any event. For example, the event may be a user input received through a user interface of the mediator device 110. The event may also be an application event
5 of a computer program application executed in the mediator device 110. For example, the application may require the wireless devices 112, 114 to connect to the access node 100 and to transmit data to a server computer used by the application.

Each wireless device 112, 114 may be configured to monitor for a wake-up frame addressed to a preconfigured groupcast and/or unicast address. Upon receiving the wake-up
10 frame through the WUR interface in step 406 and upon determining that the wake-up frame is addressed to it, each wireless device 112, 114 may switch from the power-save mode to an active mode in block 408 and enable the main radio interface. Accordingly, the WUR interface may be used to wake up the wireless devices 112, 114 for a mediation service provided by the mediator device and described next. The wireless devices 112, 114 may be configured to start scanning
15 for a wireless network of the mediator device 110, e.g. the NAN protocol network.

After transmitting the wake-up frame and after waiting for a while so that the wireless devices 112, 114 power up the main radio interface, the mediator device 110 may transmit a discovery frame advertising the mediation service in step 410. The discovery frame may be a broadcast frame. In an embodiment, the mediator device 110 may transmit one or more
20 beacon messages or other messages that advertise the availability of the wireless network of the mediator device. Such beacon messages or other messages may be transmitted between the wake-up frame and the discovery frame and they may allow the wireless devices 112, 114 just woken up to connect to the wireless network of the mediator device 110. In an embodiment, the discovery frame(s) is/are transmitted within a service discovery window and the wireless devices
25 112, 114 may have to synchronize to the wireless network in order to detect the discovery frame(s) within the service discovery window. After connecting and synchronizing to the wireless network, the wireless devices 112, 114 may be capable of receiving the discovery frame(s).

In an embodiment where the wireless network #1 complies with the NAN protocol
30 and where the mediating service complies with the DPP, the mediator device 110 may broadcast a beacon frame periodically, e.g. a NAN discovery beacon, and the beacon frame may declare a subsequent discovery window that is used for DPP service discovery. The beacon frame may declare also availability of the mediation service with inclusion of a unique service identifier associated with the mediation service. During the discovery window, the mediator device may
35 broadcast the discovery frame advertising the mediation service. The frame may be a NAN Publish DPP Service frame. The discovery frame may comprise a unique service identifier

associated with the mediation service such that a recipient of the discovery frame is capable of detecting the availability of the mediation service. The service identifier may be specified in specifications of the communication protocol of the wireless network #1.

5 Upon detecting the advertising discovery frame in step 410, the wireless devices may subscribe to the mediation service by transmitting a frame comprising an information element indicating the subscription in step 412. In the embodiment complying with the NAN and DPP, the frame may be a NAN Subscribe DPP Service frame. The frame may comprise a public key of the respective wireless device 112, 114 used in the DPP procedure.

10 In the embodiment described above, the discovery frame is an unsolicited discovery frame, and the mediator device 110 may regularly, e.g. periodically, broadcast the discovery frame. In another embodiment, the wireless device 112 or 114 may transmit a request frame requesting for a determined service, e.g. the mediation service. Upon receiving the request, the mediator device 110 may transmit the discovery frame to the requesting wireless device. In this embodiment, the discovery frame may be transmitted in a solicited manner.

15 In another embodiment using the Bluetooth, a similar service discovery may be carried out. The mediator device may advertise the mediation service by transmitting a Bluetooth advertisement frame comprising a unique identifier of the mediation service, and the wireless devices 112, 114 may subscribe to the service by transmitting a frame to the mediator device 110.

20 Upon receiving the frames in step 412, the mediator device 110 may register the wireless devices 112, 114 to the mediation service. The mediator device 110 may wait until a determined number of subscriptions to the mediation service has been received in step 412 or, in another embodiment, initiate the service upon receiving at least one subscription. Upon determining to start the mediation service, the mediator device 110 may allocate the service
25 periods to the wireless devices 112, 114 in block 414. In the embodiment using the NAN protocol, the mediator device 110 may utilize further availability windows (FAW) of the NAN protocol as the service periods.

In block 414, the mediator device 110 determines start times for the service periods of the wireless devices 112, 114. The mediator device 110 may determine the start time T_1 for
30 the wireless device 114 relatively freely when the wireless device is the first one to utilize the mediation service after the advertisement in step 410. The mediator device 110 may then determine the start time T_2 for the wireless device 112 on the basis of the start time T_1 and the estimated duration TD of the connection establishment of the wireless device 114, as described above. Upon determining the start times for the wireless devices 112, 114, and optionally for
35 other wireless devices subscribing to the mediation service, the mediator device 110 may form

one or more frames and insert the start times as information elements into the one or more frames. In step 416, the mediator device transmits the one or more frames to the wireless devices.

In an embodiment, the mediator device uses a single frame to carry the multiple start times. In such a case, the frame may be a groupcast frame addressed to a group address or a broadcast address. In another embodiment, the mediator device 110 uses multiple unicast frames to indicate the start times individually to the respective wireless devices 112, 114.

In an embodiment using the solicited discovery of the mediation service, the mediator device may insert the start time(s) in the discovery frame responding to the request.

In the example of Figure 4, the service period of the wireless device 114 starts first. Upon receiving the one or more frames in step 416 and determining the start time for the service period, the wireless device 114 may begin the service period 430 and exchange the configuration parameter(s) with the mediator device in step 418. In the embodiment using the DPP, a five-step signalling procedure of the DPP may be employed. The five-step procedure may refer to a procedure where the mediator device 110 first authenticates the wireless device 114 and, after successful authentication, transmits the configuration parameter(s) to the wireless device 114. Authentication may require exchange of three frames between the devices 110, 114, and the configuration parameter exchange may require exchange of two frames between the devices 110, 114. As a part of the procedure, the wireless device 114 may provide the mediator device 110 with information on the wireless device 114 and the information may be, as an example, a device name, a device type and/or a secondary device type. The number of frames is an example, and the number of required frames to be exchanged may be different in another embodiment. During the authentication, the mediator device 110 may communicate with an authentication server that authenticates the wireless device 114 and provides encryption key(s) as the configuration parameters after the authentication. After the service period 430 has ended and the configuration parameters have been transferred to the wireless device 114, the wireless device may start connection establishment 434 with the access node 100, e.g. by transmitting an association request to the access node 100 or a wireless network of the access node 100 (denoted by #2 in Figure 4). The wireless network of the access node 100 may be different from the wireless network of the mediator device 110. If the authentication has already been made with the mediator device 110, the connection establishment 434 may be simplified since no further authentication is necessary. In an embodiment, the connection establishment comprises an association procedure according to the 802.11 protocol, and the wireless device 114 may transmit the association request directly after the service period 430 has ended. The connection establishment 434 may involve signalling between the wireless device 114 and the access node in step 422.

As described above and illustrated in Figure 4, the start time of the service period 432 for the wireless device 112 may be arranged such that the service period 430 has ended before the start time of the service period 432. However, the service period 432 may be executed simultaneously with the connection establishment 434. The start time 2 of the service period 432 of the wireless device 112 may be dependent on the start time 1 of the service period 430 of the wireless device 114 and further on the estimated duration of the connection establishment 434 of the wireless device 114. When comparing the embodiment of Figure 3 with the embodiment of Figure 4, Figure 3 may be understood to describe the operation of the wireless device 112. Since the wireless device 112 has to wait for its service period 432, the wireless device 112 may enter the power-save mode in block 428 between step 416 and the start time of the service period 432. Depending on the length of a time interval between step 416 and the start time of the service period 430, the wireless device 114 may also enter the power-save mode during the time interval. The service period 432 of the wireless device 112 may be carried out in a similar manner as described above for the service period 430 and, after the service period 432 has ended and the configuration parameter(s) have been received by the wireless device 112, the wireless device may carry out connection establishment 436 with the access node by exchanging one or more connection establishment frames with the access node 100 in step 424, e.g. the association request. While the connection establishment 436 is being carried out, another wireless device (not shown) may carry out the service period with the mediator device 110.

In the above-described manner, a staggered mediation service and connection establishment may be carried out for virtually any number of wireless devices. When the mediation service is bootstrapped with the connection establishment in the above-described manner, the wireless devices 112, 114 start the connection establishment in a scheduled manner which reduces the probability of collisions. Since the service periods are scheduled, a wireless device may utilize the power-save mode efficiently to reduce the power consumption in the wireless device.

As illustrated in Figure 4, the duration of the connection establishment 434, 436 may be longer than a duration of the service period 430, 432. Therefore, it may be advantageous estimate the duration of the connection establishment 434, 436 and take it/them into account when allocating the start times of the service periods. In this manner, colliding connection establishments by the wireless devices 112, 114 may be reduced or even avoided.

In some embodiments described above, the mediator device 110 is connected to a first network, e.g. one complying with the NAN, and the access node 100 manages another wireless network, e.g. a Wi-Fi infrastructure network. In an embodiment, the mediator device 110 and the access node 100 are different devices physically separate and operationally substantially independent from one another, as illustrated in Figure 1. In another embodiment,

an apparatus operates as the mediator device 110 and the access node 100. The apparatus may be a portable user equipment, for example. The apparatus may comprise in the same housing a circuitry performing the functions of the access node 100 and a circuitry performing the functions of the mediator device 110. The circuitries may be physically separate circuitries but, in some embodiments, the circuitries may share some hardware resources of the apparatus.

Figure 5 illustrates timing of the wake-up frame transmitted in step 406. As described above, the wireless network of the mediator device 110 may be configured to broadcast periodic beacon frames 500 with a determined beacon periodicity 506. The mediator device 110 may determine a transmission timing of the wake-up frame 502 such that the wireless device(s) 112, 114 wake up to receive a subsequent beacon frame. In an embodiment, the mediator device transmits the wake-up frame at a time instant between a first beacon transmission and a second beacon transmission of the wireless network, the second beacon transmission subsequent to the first beacon transmission, such that the time instant is closer to the second beacon transmission than to the first beacon transmission. Accordingly, the wake-up frame may be transmitted during a latter half of a beacon period as determined starting from a transmission of a beacon signal. In another embodiment, the wake-up frame is transmitted during the last quarter of the beacon period. The wake-up frame may be transmitted such that there is at least a wake-up delay 504 between the end of the wake-up frame and the beginning of the subsequent beacon frame 500. This allows the wireless devices to enable the main radio interface upon receiving the wake-up frame 502.

Figure 6 illustrates an embodiment of a structure of the above-mentioned functionalities of an apparatus executing the process of Figure 2 or any one of the embodiments performed by the mediator device 110. The apparatus may be the mediator device 110. The apparatus may comply with specifications of an IEEE 802.11 network and/or another wireless network such as the NAN network. The apparatus may be a station and/or a mobile terminal. The apparatus may be defined as 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 apparatus may be or may be comprised in a computer (PC), a laptop, a tablet computer, a cellular phone, a palm computer, or any other apparatus provided with radio communication capability. In another embodiment, the apparatus carrying out the above-described functionalities is comprised in such a device, e.g. the apparatus may comprise a circuitry, e.g. a chip, a chipset, a processor, a micro controller, or a combination of such circuitries in any one of the above-described devices. The apparatus may be an electronic device comprising electronic circuitries for realizing the embodiments of the present invention.

Referring to Figure 6, the apparatus may comprise the above-described main radio interface 12 configured to provide the apparatus with capability for bidirectional communication

with wireless devices 112, 114 in a wireless network. The main radio interface 12 may operate according to 802.11 technology on a physical layer and a MAC layer, for example. The main radio interface 12 may comprise analogue radio communication components and digital baseband processing components for processing transmission and reception signals. The main
5 radio interface 12 may support multiple modulation formats.

The apparatus may further comprise the above-described wake-up radio interface 16 comprising a transmission circuitry for generating and transmitting the wake-up frames. The wake-up radio interface 16 may be configured for transmission only but, in some embodiments, the wake-up radio interface may enable uplink communications where the wake-up radio
10 interface 16 has reception capability. The wake-up radio interface 16 may comprise analogue radio communication components and digital baseband processing components for processing transmission and reception signals. The wake-up radio interface 16 may support a single modulation scheme only, e.g. the on-off keying.

The main radio interface and the wake-up radio interface may comprise radio
15 interface components providing the apparatus with radio communication capability within one or more 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 apparatus may further comprise a memory 20 storing one or more computer
20 program products 22 configuring the operation of at least one processor of the apparatus, e.g. a transmission controller 14 described below. The memory 20 may further store a configuration database 24 storing operational configurations of the apparatus. The configuration database may, for example, store configuration parameters to be transmitted to wireless devices during the service periods so as to facilitate connection establishment to the access node 100. The
25 configuration database 24 may further store an address of an authentication server employed in authentication of a wireless device during a service period.

The apparatus may further comprise a transmission controller 14 configured to control the operation of the main radio interface 12 and the wake-up radio interface 16. The transmission controller 14 may selectively use the main radio interface 12 and/or the wake-up
30 radio interface 16 to communicate with the wireless devices 112, 114, as described above in connection with Figure 4.

The transmission controller 14 may comprise a mediation controller 18 configured to carry out the mediation service described above. The transmission controller 14 may activate the mediation controller 18 to carry out the mediation service. The mediation controller 18 may
35 then carry out the procedure of Figure 2 or 4 of the mediator device. The mediation controller may first wake up dormant wireless devices 112, 114 by using the WUR interface 16 to transmit

the wake-up frame(s). Thereafter, the mediation controller 18 may employ the main radio interface 12 to advertise the mediation service. Upon receiving subscription(s) to the mediation service from the wireless devices 112, 114, the mediation controller may schedule the service period of the mediation service to the wireless devices in the above-described manner. After the service periods have been completed for all the wireless devices subscribing to the mediation service, the mediation controller may terminate the mediation service.

In an embodiment, the apparatus comprises at least one processor and at least one memory 20 including a computer program code 22, 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 mediator device according to any one of the embodiments of Figures 2, 4, and 5. According to an aspect, when the at least one processor executes the computer program code, the computer program code causes the apparatus to carry out the functionalities according to any one of the embodiments of Figures 2, 4, and 5. According to another embodiment, the apparatus comprises the at least one processor and at least one memory 20 including a computer program code 22, wherein the at least one processor and the computer program code 22 perform the at least some of the functionalities of the mediator device according to any one of the embodiments of Figures 2, 4, and 5. 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 mediator device. According to yet another embodiment, the apparatus carrying out the embodiments of the invention in the mediator device comprises a circuitry including at least one processor and at least one memory 20 including computer program code 22. When activated, the circuitry causes the apparatus to perform the at least some of the functionalities of the mediator device according to any one of the embodiments of Figures 2, 4, and 5.

Figure 7 illustrates an embodiment of a structure of the above-mentioned functionalities of the apparatus executing the process of Figure 3 or any one of the embodiments performed by the wireless device 112 or wireless device 114. The apparatus may be the wireless device 112 or 114. The apparatus may comply with IEEE 802.11 technology and/or another wireless networking technology. The apparatus may be defined as 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 apparatus may be or may be comprised in a computer (PC), a laptop, a tablet computer, a cellular phone, a palm computer, or any other apparatus provided with radio communication capability. In another embodiment, the apparatus carrying out the above-described functionalities is comprised in such a device, e.g. the apparatus may comprise a circuitry, e.g. a chip, a chipset, a processor, a micro controller, or a combination

of such circuitries in any one of the above-described devices. The apparatus may be an electronic device comprising electronic circuitries for realizing the embodiments of the present invention.

Referring to Figure 7, the apparatus may comprise the above-described main radio interface 52 configured to provide the apparatus with capability for bidirectional communication with the access node 100 operating a wireless network and further with the mediator device 110. The main radio interface 52 may operate according to 802.11 specifications, for example. The main radio interface 52 may comprise analogue radio communication components and digital baseband processing components for processing transmission and reception signals. The main radio interface 52 may support multiple modulation formats. In some embodiments where the mediator device 110 and the access node employ different wireless technologies, the apparatus may comprise a main radio interface for each wireless technology, e.g. one radio interface operating according to the 802.11 technology and one radio interface operating according to Bluetooth[®] technology.

The apparatus may further comprise the above-described wake-up radio interface 56 comprising a reception circuitry for receiving the wake-up frames. The wake-up radio interface 56 may be configured for reception only but, in some embodiments, the wake-up radio interface may enable uplink communications where the wake-up radio interface 56 has transmission capability. The wake-up radio interface 56 may comprise analogue radio communication components and digital baseband processing components for processing transmission and reception signals. The wake-up radio interface 16 may support a single modulation scheme only, e.g. the on-off keying.

The main radio interface and the wake-up radio interface may comprise radio interface components providing the apparatus with radio communication capability within one or more 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 apparatus may further comprise a memory 60 storing one or more computer program products 62 configuring the operation of at least one processor of the apparatus. The memory 60 may further store a configuration database 64 storing operational configurations of the apparatus. The configuration database 64 may, for example, store an initial scanning configuration defining a wireless network the apparatus starts to scan for upon activated by a received wake-up frame. The configuration database 64 may further store one or more encryption keys to be used in the mediation service. The configuration database 64 may further store the configuration parameter(s) received from the mediator device 110 during the mediation service.

The apparatus may further comprise a communication controller 54 managing communications in the apparatus and controlling the operation of the radio interfaces 52, 56. The communication controller 54 may comprise a mediation controller 58 configured to carry out the mediation service before establishing a connection with the access node 100. The mediation controller 58 may be activated upon receiving the wake-up frame from the mediator device 110 through the wake-up radio interface 56. The mediation controller 58 may then configure the main radio interface 52 to scan for a predefined wireless network of the mediator device 110. Upon detecting the discovery frame advertising a mediation service, the mediation controller 58 may control the main radio interface 52 to transmit a frame subscribing to the mediation service. Thereafter, the mediation controller 58 may carry out the mediation service during a service period allocated to the apparatus by the mediator device 110. As described above, the mediation controller 58 may receive the start time of the service period through the main radio interface 52 from the mediator device 110. Upon successfully completing the service period and receiving the configuration parameter(s) enabling connection establishment with the access node 100, the mediation controller 58 may activate a connection manager 57 configured to carry out the connection establishment with the access node 100, e.g. the association procedure.

In an embodiment, the apparatus comprises at least one processor and at least one memory 60 including a computer program code 62, 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 wireless device 112, 114 according to any one of the embodiments of Figures 3 to 5. According to an aspect, when the at least one processor executes the computer program code, the computer program code causes the apparatus to carry out the functionalities according to any one of the embodiments of Figures 3 to 5. According to another embodiment, the apparatus comprises the at least one processor and at least one memory 20 including a computer program code 22, wherein the at least one processor and the computer program code 22 perform the at least some of the functionalities of the wireless device 112, 114 according to any one of the embodiments of Figures 3 to 5. 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 wireless device 112, 114. According to yet another embodiment, the apparatus carrying out the embodiments of the invention in the wireless device 112, 114 comprises a circuitry including at least one processor and at least one memory 20 including computer program code 22. When activated, the circuitry causes the apparatus to perform the at least some of the functionalities of the wireless device 112, 114 according to any one of the embodiments of Figures 3 to 5.

Above, embodiments of the main radio interface and the WUR interface have been described mainly in a context where they are defined as separate hardware interfaces. From another perspective, the interface may be understood as logical interfaces of radio links. The main radio interface may be a first end point of a first radio link (e.g. a main radio link) between wireless devices. The second radio interface (e.g. the WUR interface) may be a second end point of a second radio link (e.g. the WUR link) between the wireless devices. The first radio link may be used by a first radio device, e.g. a main radio device, and the second radio link may be used by a second radio device, e.g. a WUR radio device. The main radio interface and the WUR interface may have dedicated hardware. In another embodiment, the main radio interface and the WUR interface may share at least some hardware of the apparatus.

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 5 may also be carried out in the form of one or more computer processes defined by one or more computer program. A separate computer program may be provided in each apparatus that executes functions of the processes described in connection with the Figures. The computer program(s) 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 networks defined above but also to other wireless networks. The protocols used, the specifications of the wireless networks and their network elements develop rapidly. Such development may require extra changes to the described
5 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
10 within the scope of the claims.

Claims

1. A method comprising:

5 determining, by a mediator device configured to facilitate connection establishment to an access node, a first start time for transferring at least one configuration parameter, wherein the at least one configuration parameter shall be transferred between the mediator device and a first apparatus on a first frequency channel, and wherein the at least one configuration parameter is for a connection establishment between the first apparatus and the access node on a second frequency channel;

10

determining, by the mediator device, a second start time for transferring at least one configuration parameter for a connection establishment between a second apparatus and the access node on the second frequency channel, wherein the at least one configuration parameter shall be transferred between the mediator device and the second apparatus on the first frequency channel, and wherein the second start time is determined on the basis of the first start time and an estimated duration of the connection establishment between the first apparatus and the access node; and

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beginning, by the mediator device, a service period with the second apparatus at the second start time and transmitting, by the mediator device during the service period, at least one frame comprising said at least one configuration parameter.

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2. The method of claim 1, further comprising transmitting, by the mediator device before the service period, an allocation message on the first frequency channel to at least the second apparatus, wherein the allocation message indicates at least the second start time.

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3. The method of claim 2, wherein the allocation message further indicates the first start time.

4. The method of claim 2, further comprising transmitting, by the mediator device before the service period, another allocation message on the first frequency channel to at least the second apparatus, wherein the other allocation message indicates at least the first start time.

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5. The method of any preceding claim, wherein the mediator device arranges the second start time to occur at a time instant when the first apparatus performs the connection establishment with the access node.

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6. The method of claim 5, wherein the service period ends after the first apparatus has completed the connection establishment.
7. The method of any preceding claim, further comprising transmitting, by the mediator device when the first apparatus and the second apparatus are in a power-save mode, a wake-up frame waking up both the first apparatus and the second apparatus from the power-save mode.
8. The method of claim 7, wherein the mediator device is associated to a wireless network broadcasting a periodic beacon signal, and wherein the mediator device transmits the wake-up frame during a latter half of a beacon transmission period as determined starting from a transmission of a beacon signal.
9. The method of any preceding claim, wherein the at least one configuration parameter comprises a network identifier of a wireless network of the access node and a security parameter for accessing the wireless network.
10. The method of any preceding claim, further comprising:
- transmitting, by the mediator device before the service period, a service discovery frame advertising availability of a mediation service for facilitating the connection establishment to the access node;
- receiving, by the mediator device from the first apparatus and the second apparatus, at least one frame responding to the service discovery frame; and
- upon receiving the at least one frame, performing said determining the first start time and the second start time.
11. A method comprising:
- subscribing, by a first apparatus, to a mediation service on a first frequency channel and provided by a mediator device configured to facilitate connection establishment to an access node of a wireless network;
- beginning, by the first apparatus, a service period of the mediation service with the mediator

device on the first frequency channel at a first start time dependent on a second start time of a service period of a second apparatus and further on an estimated duration of a connection establishment between the second apparatus and the access node;

5 receiving, by the first apparatus from the mediator device during the service period on the first frequency channel, at least one frame comprising at least one configuration parameter facilitating said connection establishment to the access node; and

10 upon receiving the at least one configuration parameter, connecting by the first apparatus to the access node on a second frequency channel different from the first frequency channel.

12. The method of claim 10, wherein the first apparatus receives the at least one configuration parameter while the second apparatus is performing the connection establishment with the access node.

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13. The method of claim 10 or 11, further comprising by the first apparatus before said associating:

20 entering a power-save mode in which a main radio interface of the first apparatus is disabled and a wake-up radio interface of the first apparatus is enabled; and

25 receiving, in the power-save mode from the mediator device, a wake-up frame via the wake-up radio interface of the first apparatus and, in response to the reception of the wake-up frame, powering up the main radio interface and using the main radio interface to associate to the wireless network.

14. The method of any preceding claim 10 to 12, further comprising by the first apparatus:

30 receiving the first start time from the mediator device in a frame before beginning the service period; and

entering a power-save mode after receiving the first start time and before beginning the service period.

35 15. A mediator device, for facilitating connection establishment to an access node, 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 mediator device to:

- 5 determine a first start time for transferring at least one configuration parameter, wherein the at least one configuration parameter shall be transferred between the mediator device and a first apparatus on a first frequency channel, and wherein the at least one configuration parameter is for a connection establishment between the first apparatus and the access node on a second frequency channel;
- 10 determine a second start time for transferring at least one configuration parameter for a connection establishment between a second apparatus and the access node on the second frequency channel, wherein the at least one configuration parameter shall be transferred between the mediator device and the second apparatus on the first frequency channel, and
- 15 wherein the second start time is determined on the basis of the first start time and an estimated duration of the connection establishment between the first apparatus and the access node; and
- 20 begin a service period with the second apparatus at the second start time and transmitting, by the mediator device during the service period, at least one frame comprising said at least one configuration parameter.
16. The mediator device of claim 15, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the mediator device
- 25 to transmit, before the service period, an allocation message on the first frequency channel to at least the second apparatus, wherein the allocation message indicates at least the second start time.
17. The mediator device of claim 16, wherein the allocation message further indicates the first
- 30 start time.
18. The mediator device of claim 16, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the mediator device
- 35 to transmit, before the service period, another allocation message on the first frequency channel to at least the second apparatus, wherein the other allocation message indicates at

least the first start time.

- 5 19. The mediator device of any preceding claim 15 to 18, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the mediator device to arrange the second start time to occur at a time instant when the first apparatus performs the connection establishment with the access node.
- 10 20. The mediator device of claim 19, wherein the service period ends after the first apparatus has completed the connection establishment.
- 15 21. The mediator device of any preceding claim 15 to 20, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the mediator device to transmit, when the first apparatus and the second apparatus are in a power-save mode, a wake-up frame waking up both the first apparatus and the second apparatus from the power-save mode.
- 20 22. The mediator device of claim 21, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the mediator device to associate to a wireless network broadcasting a periodic beacon signal, and to transmit the wake-up frame during a latter half of a beacon transmission period as determined starting from a transmission of a beacon signal.
- 25 23. The mediator device of any preceding claim 15 to 22, wherein the at least one configuration parameter comprises a network identifier of a wireless network of the access node and a security parameter for accessing the wireless network.
- 30 24. The mediator device of any preceding claim, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the mediator device to:
- 35 transmit, before the service period, a service discovery frame advertising availability of a mediation service for facilitating the connection establishment to the access node;
- receive, from the first apparatus and the second apparatus, at least one frame responding to the service discovery frame; and

upon receiving the at least one frame, perform said determining the first start time and the second start time.

5 25. The mediator device of any preceding claim 15 to 24, further comprising at least one radio interface providing the mediator device with radio communication capability.

26. An apparatus comprising:
at least one processor; and
at least one memory including a computer program code, wherein the at least one memory
10 and the computer program code are configured, with the at least one processor, to cause the apparatus to:
subscribe to a mediation service on a first frequency channel and provided by a mediator device configured to facilitate connection establishment to an access node of a wireless network;

15 begin a service period of the mediation service with the mediator device on the first frequency channel at a first start time dependent on a second start time of a service period of another apparatus and further on an estimated duration of a connection establishment between said another apparatus and the access node;

20 receive, from the mediator device during the service period on the first frequency channel, at least one frame comprising at least one configuration parameter facilitating said connection establishment to the access node; and

25 upon receiving the at least one configuration parameter, connect to the access node on a second frequency channel different from the first frequency channel.

27. The apparatus of claim 26, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to receive the at least
30 one configuration parameter while said another apparatus is performing the connection establishment with the access node.

28. The apparatus of claim 26 or 27, further comprising a main radio interface and a wake-up radio interface, and wherein the at least one memory and the computer program code are
35 configured, with the at least one processor, to cause the apparatus to perform at least the following before said connecting:

enter a power-save mode in which the main radio interface of the apparatus is disabled and the wake-up radio interface of the apparatus is enabled; and

5 receive, in the power-save mode from the mediator device, a wake-up frame via the wake-up radio interface and, in response to the reception of the wake-up frame, power up the main radio interface and using the main radio interface to associate to the wireless network.

10 29. The apparatus of any preceding claim 26 to 28, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to:

receive the first start time from the mediator device in a frame before beginning the service period; and

15 enter a power-save mode after receiving the first start time and before beginning the service period.

20 30. The apparatus of any preceding claim 26 to 29, comprising at least one radio interface providing the apparatus with radio communication capability.

31. An apparatus comprising means for carrying out all the steps of the method according to any preceding claim 1 to 14.

25 32. 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 14.

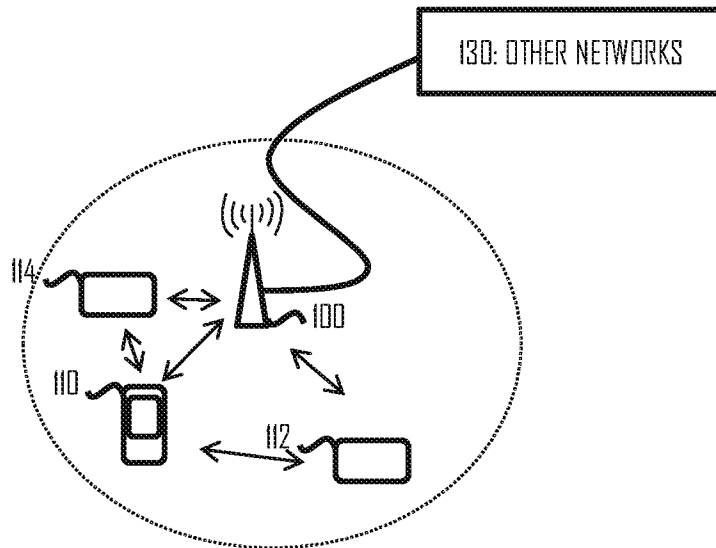


Fig 1

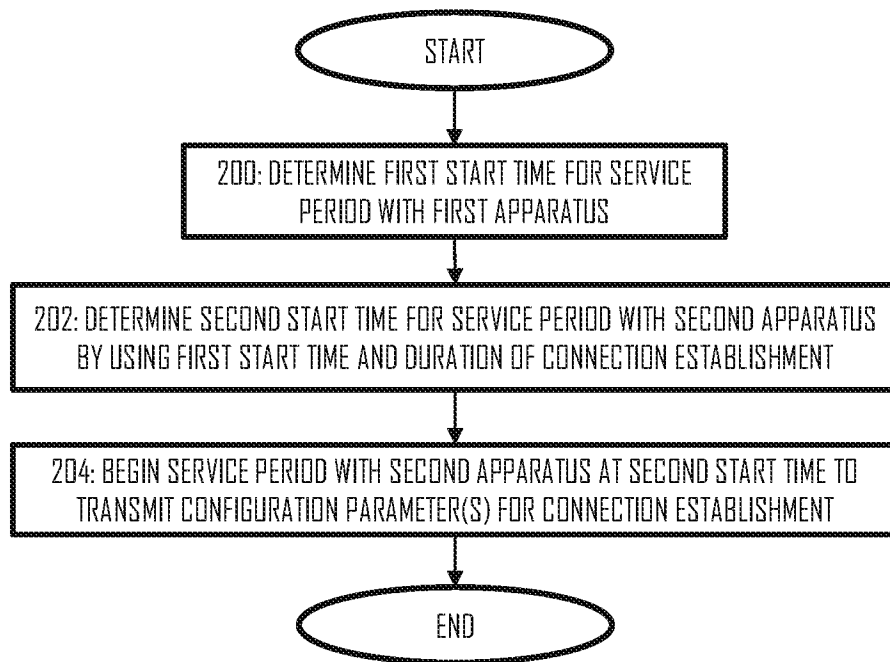


Fig 2

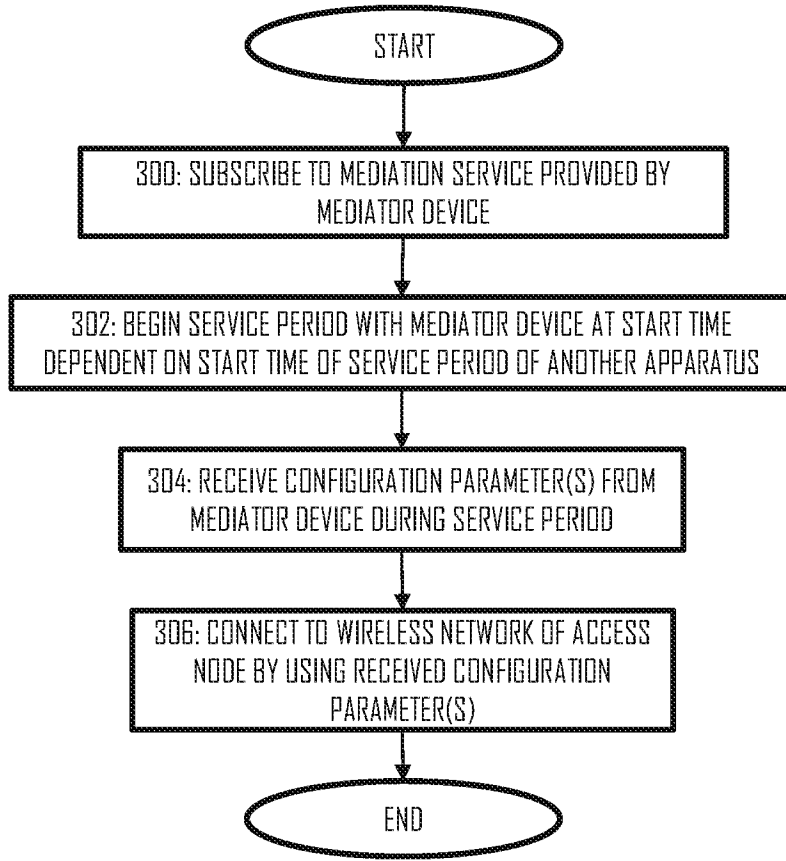


Fig 3

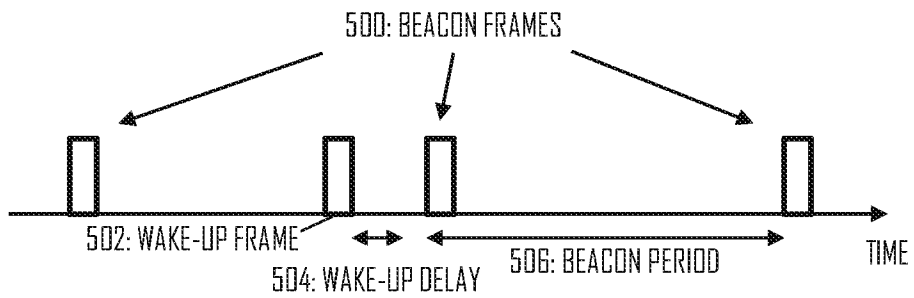


Fig 5

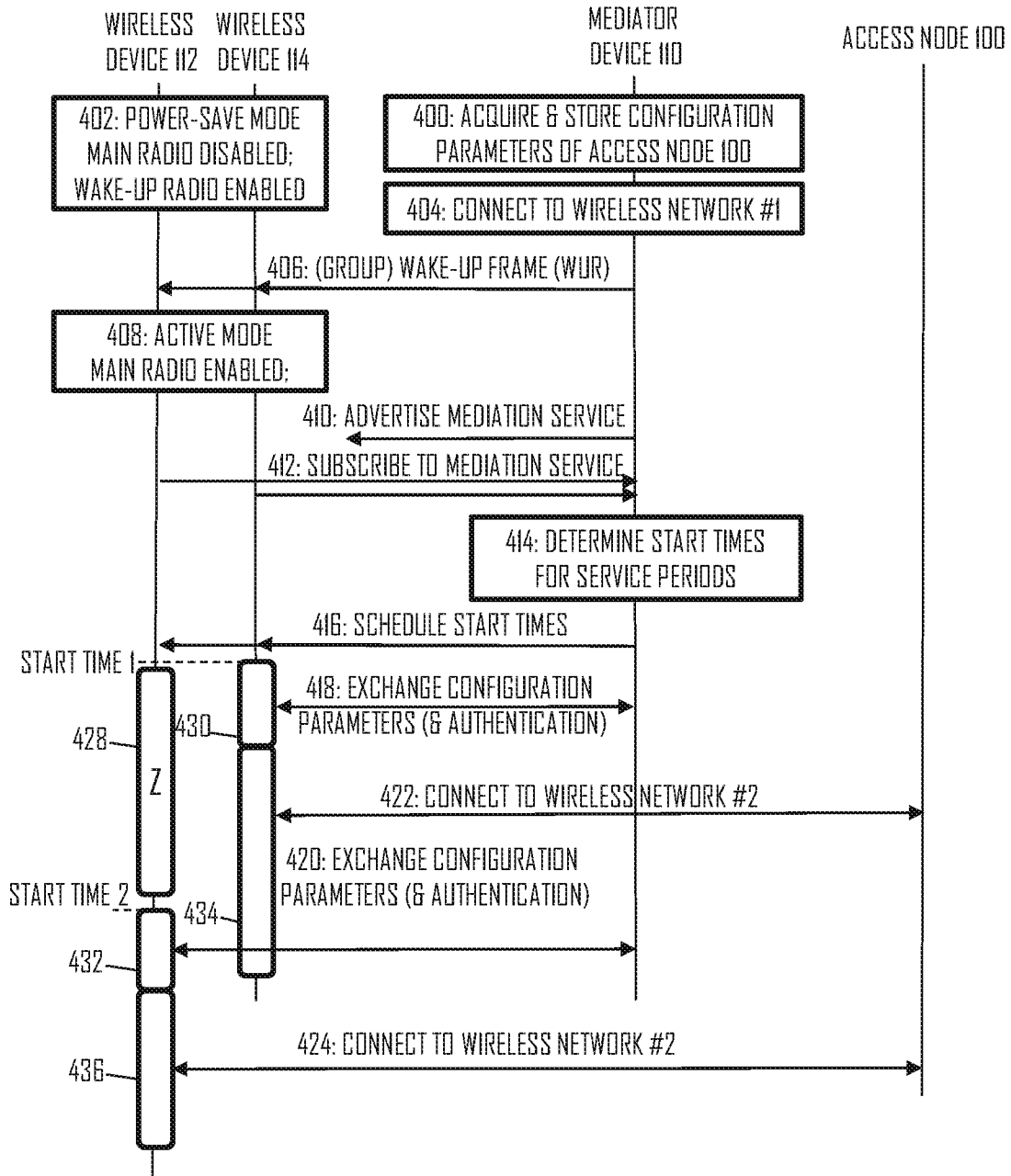


Fig 4

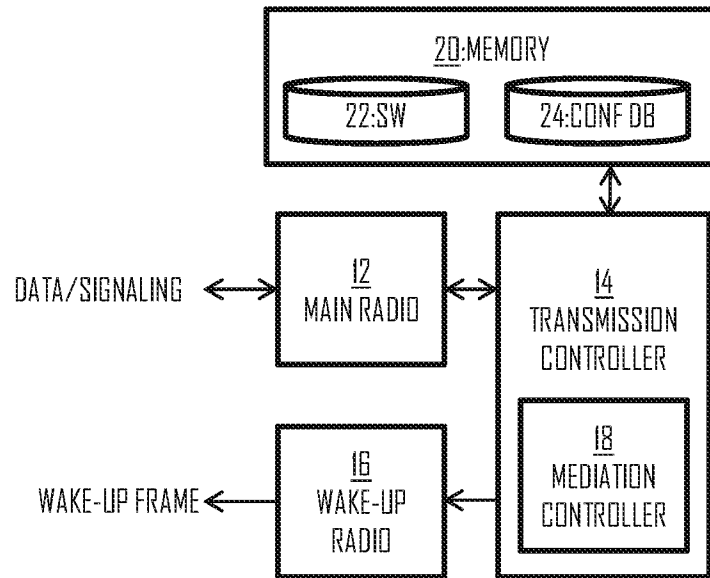


Fig 6

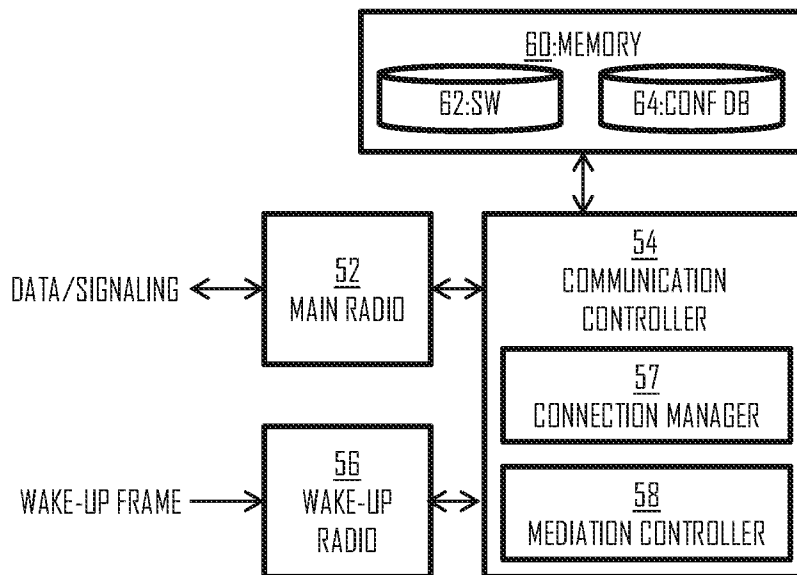


Fig 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2017/026074

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H04B 3/36; H04B 7/14; H04B 17/02; H04W 16/02 (2017.01)

CPC - H04W 16/02; H04W 16/14; H04W 72/0453; H04W 88/04 (2017.02)

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)

See Search History document

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

USPC - 370/315; 455/16; 455/509 (keyword delimited)

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

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2013/0079009 A1 (AUMANN et al) 28 March 2013 (28.03.2013) entire document	1-6, 15-20
A	US 2007/0070954 A1 (KIM et al) 29 March 2007 (29.03.2007) entire document	1-6, 15-20
A	WO 2010/070459 A1 (ACCELERADIO LTD. et al) 24 June 2010 (24.06.2010) entire document	1-6, 15-20
A	US 2009/0116457 A1 (HAARTSEN) 07 May 2009 (07.05.2009) entire document	1-6, 15-20
A	US 2010/0273468 A1 (BIENAS et al) 28 October 2010 (28.10.2010) entire document	1-6, 15-20
A	US 2011/0211219 A1 (BRADLEY et al) 01 September 2011 (01.09.2011) entire document	1-6, 15-20
A	US 2009/0280819 A1 (BRISEBOIS et al) 12 November 2009 (12.11.2009) entire document	1-6, 15-20
A	LEVIL et al. System architecture options for the QoS MOS system. December 2010. [retrieved on 2017-07-20]. Retrieved from the Internet:<URL: http://www.ict-qosmos.eu/fileadmin/documents/Dissemination/Deliverables/files/DelPub/QoS MOS_WP2_D22.pdf >. entire document.	1-6, 15-20
A	US 2005/0256963 A1 (PROCTOR JR. et al) 17 November 2005 (17.11.2005) entire document	1-6, 15-20
A	WO 2014/082064 A1 (THYNC, INC.) 30 May 2014 (30.05.2014) entire document	1-6, 15-20

 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

20 July 2017

Date of mailing of the international search report

08 AUG 2017

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, VA 22313-1450

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Blaine R. Copenheaver

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PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2017/026074

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.: 7-10, 12-14, 21-25, 29-32
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 extra sheet(s).

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 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.:
1-6, 15-20

- 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.

Continued from Box No. III Observations where unity of invention is lacking

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claims 1-6,15-20, drawn to facilitating connection establishment to an access node.

Group II, claims 11,26-28, drawn to subscribing, by a first apparatus, to a mediation service on a first frequency channel.

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical feature of the Group I invention: determining, by the mediator device, a second start time for transferring at least one configuration parameter for a connection establishment between a second apparatus and the access node on the second frequency channel as claimed therein is not present in the invention of Group II. The special technical feature of the Group II invention: upon receiving the at least one configuration parameter, connecting by the first apparatus to the access node on a second frequency channel different from the first frequency channel as claimed therein is not present in the invention of Group I.

Groups I and II lack unity of invention because even though the inventions of these groups require the technical feature of a mediator device configured to facilitate connection establishment to an access node, a first start time for transferring at least one configuration parameter, wherein the at least one configuration parameter shall be transferred between the mediator device and a first apparatus on a first frequency channel, this technical feature is not a special technical feature as it does not make a contribution over the prior art.

Specifically, US 2013/0079009 A1 (AUMANN et al) 28 March 2013 (28.03.2013) teaches a mediator device configured to facilitate connection establishment to an access node (Para. 22), a first start time for transferring at least one configuration parameter (Paras. 65-66), wherein the at least one configuration parameter shall be transferred between the mediator device and a first apparatus on a first frequency channel (Paras. 242-245).

Since none of the special technical features of the Group I or II inventions are found in more than one of the inventions, unity of invention is lacking.