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(54) **METHOD AND SYSTEM FOR UTILIZING OUT OF BAND SIGNALING FOR CALIBRATION AND CONFIGURATION OF A MESH NETWORK OF EHF TRANSCEIVERS/REPEATERS**

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H04B 7/26 (2006.01)

H04W 84/18 (2009.01)

(52) **U.S. Cl.**

CPC **H04B 7/2606** (2013.01); **H04W 84/18** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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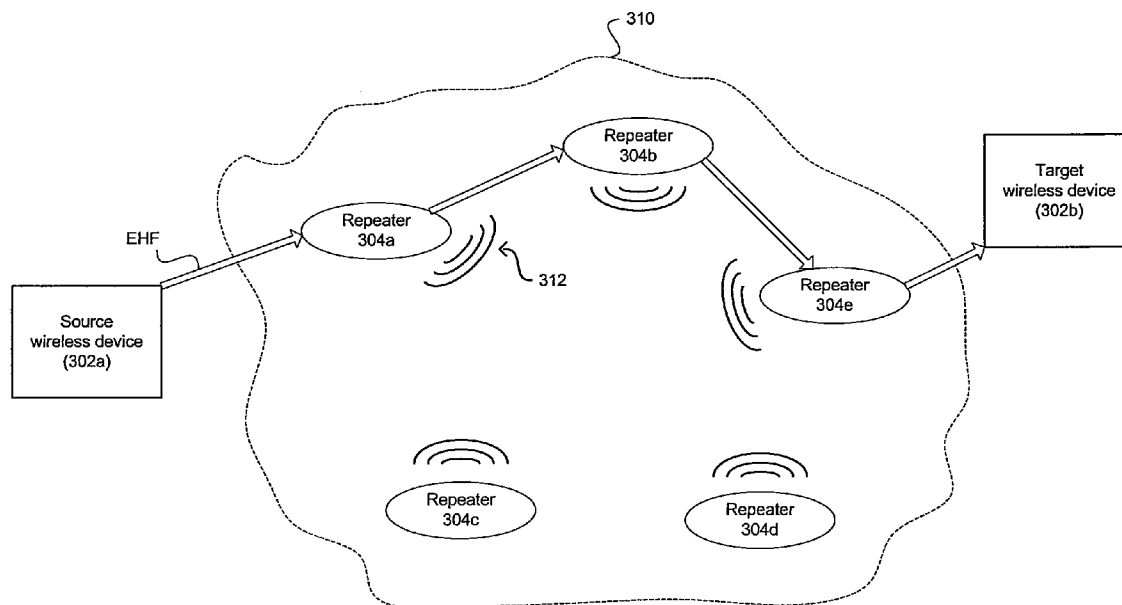
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(57) **ABSTRACT**

A plurality of repeater devices, each of which may enable forwarding extreme high frequency (EHF) communication between EHF-enabled wireless devices, may form a repeater mesh network. Some or all of the plurality of repeater devices may utilize non-extremely high frequency (non-EHF) control connection in communicating with other repeater devices in the repeater mesh network. The non-EHF control connections may be utilized in establishing, configuring, and/or managing the repeater mesh network. The non-EHF control connections may be also be utilized to enable sending, requesting, and/or receiving periodic and/or dynamic control information. The non-EHF control connections may also be utilized while forming, and/or managing forwarding routes of EHF communication via the repeater mesh network, to enable negotiating and/or setting different isolation techniques among the repeater devices, such as polarization isolation, spatial isolation, and/or use of different frequencies.

22 Claims, 4 Drawing Sheets



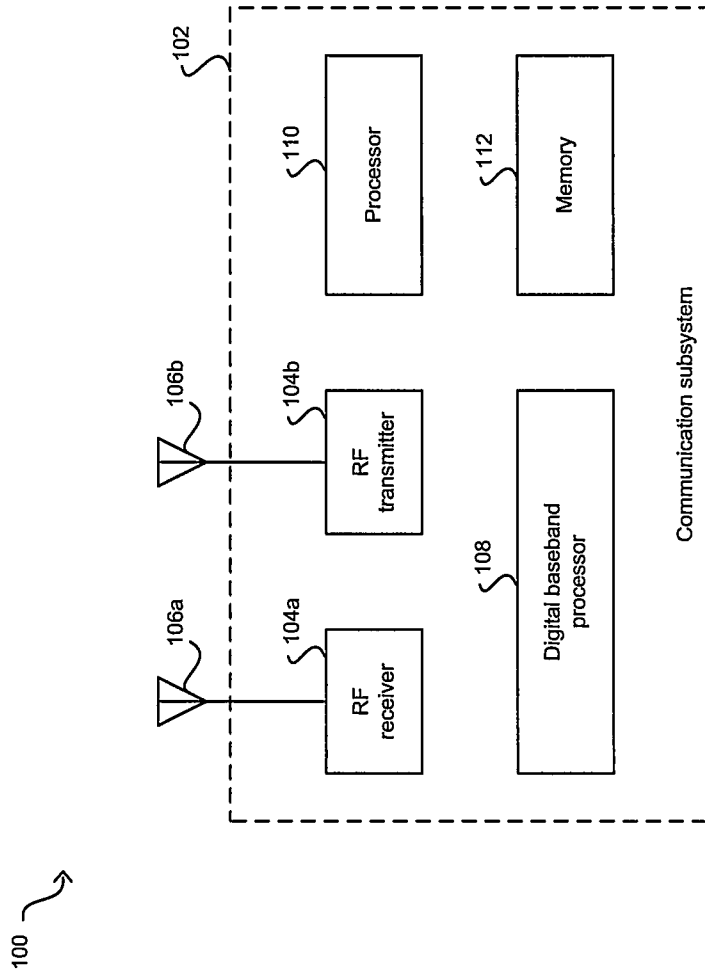


FIG. 1

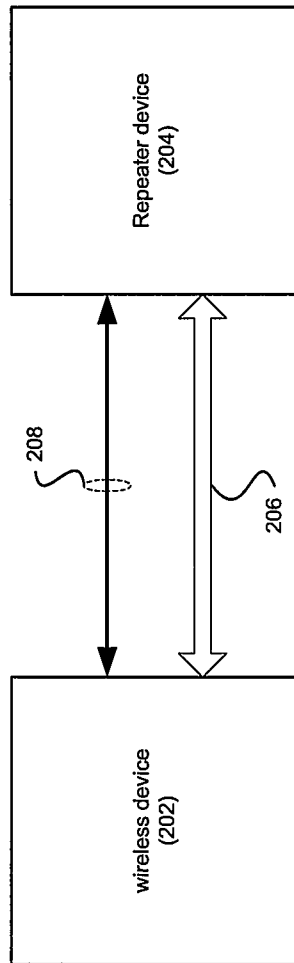


FIG. 2

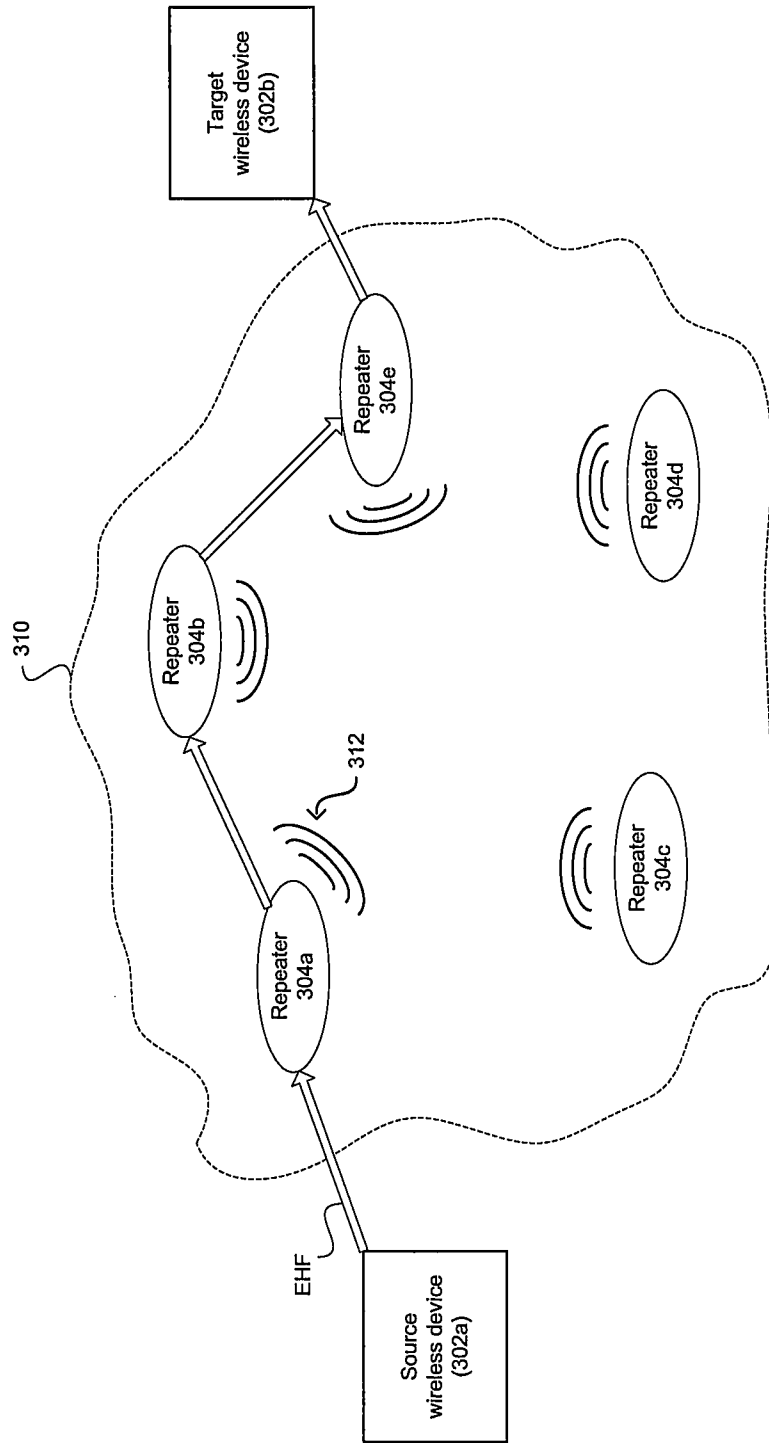


FIG. 3

400 →

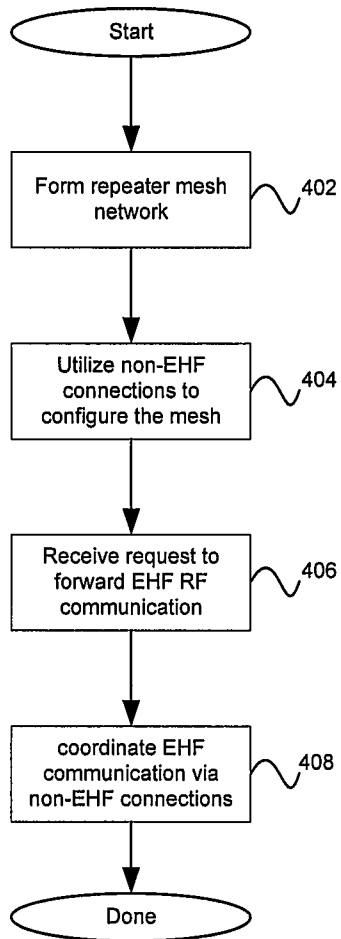


FIG. 4

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**METHOD AND SYSTEM FOR UTILIZING
OUT OF BAND SIGNALING FOR
CALIBRATION AND CONFIGURATION OF A
MESH NETWORK OF EHF
TRANSCIEVERS/REPEATERS**

CROSS-REFERENCE TO RELATED
APPLICATIONS/INCORPORATION BY
REFERENCE

[Not Applicable].

FEDERALLY SPONSORED RESEARCH OR
DEVELOPMENT

[Not Applicable].

MICROFICHE/COPYRIGHT REFERENCE

[Not Applicable].

FIELD OF THE INVENTION

Certain embodiments of the invention relate to wireless communication. More specifically, certain embodiments of the invention relate to a method and system for utilizing out of band signaling for calibration and configuration of a mesh network of EHF transceivers/repeaters.

BACKGROUND OF THE INVENTION

In 2001, the Federal Communications Commission (FCC) designated a large contiguous block of 7 GHz bandwidth for communications in the 57 GHz to 64 GHz spectrum. This frequency band was designated for use on an unlicensed basis, that is, the spectrum is accessible to anyone, subject to certain basic, technical restrictions such as maximum transmission power and certain coexistence mechanisms. The communications taking place in this band are often referred to as '60 GHz communications.' With respect to accessibility of this designated portion of the spectrum, 60 GHz communications is similar to other forms of unlicensed spectrum use, for example Wireless LANs (WLAN) or Bluetooth in the 2.4 GHz ISM bands. However, communications at 60 GHz may be significantly different in aspects other than accessibility. For example, 60 GHz signals may provide markedly different communications channel and propagation characteristics, at least due to the fact that 60 GHz radiation is partly absorbed by oxygen in the air, leading to higher attenuation with distance. On the other hand, since a very large bandwidth of 7 GHz is available, very high data rates may be achieved. Among the applications for 60 GHz communications are wireless personal area networks, wireless high-definition television signal, for example from a set top box to a display, or Point-to-Point links.

Further limitations and disadvantages of conventional and traditional approaches will become apparent to one of skill in the art, through comparison of such systems with some aspects of the present invention as set forth in the remainder of the present application with reference to the drawings.

BRIEF SUMMARY OF THE INVENTION

A system and/or method is provided for utilizing out of band signaling for calibration and configuration of a mesh network of EHF transceivers/repeaters, substantially as

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shown in and/or described in connection with at least one of the figures, as set forth more completely in the claims.

These and other advantages, aspects and novel features of the present invention, as well as details of an illustrated embodiment thereof, will be more fully understood from the following description and drawings.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF
THE DRAWINGS

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FIG. 1 is a block diagram illustrating an exemplary communication subsystem, which may be utilized in accordance with an embodiment of the invention.

FIG. 2 is a block diagram illustrating a repeater device utilized to forward EHF RF communication between two wireless devices, which may be utilized in accordance with the invention.

FIG. 3 is a block diagram illustrating a mesh network of EHF repeaters that utilize Non-EHF intra-mesh control connections for configuring and managing the mesh network, which may be utilized in accordance with an embodiment of the invention.

FIG. 4 is an exemplary flow diagram illustrating use of Non-EHF intra-mesh connections in a mesh network of EHF repeaters, in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Certain embodiments of the invention may be found in a method and system for utilizing out of band signaling for calibration and configuration of a mesh network of EHF transceivers/repeaters. A plurality of repeater devices, each of which may enable forwarding extreme high frequency (EHF) communication between EHF-enabled wireless devices, may form a repeater mesh network. Some or all of the plurality of repeater devices may utilize non-extremely high frequency (non-EHF) control connection, comprising non-EHF wireless protocols such as Bluetooth, ZigBee, WiFi, and/or ultra-wideband (UWB), in communicating with other repeater devices in the repeater mesh network. The non-EHF control connections may be utilized in establishing, configuring, and/or managing the repeater mesh network. Some or all of the plurality of repeater devices may utilize the non-EHF control connection to send, request, and/or receive periodic and/or dynamic control information. The non-EHF control connections may also be utilized while forming, and/or managing forwarding routes of EHF communication via the repeater mesh network, wherein these connection may enable negotiating and/or setting different isolation techniques among the repeater devices, while forming routes within the repeater mesh network, to reduce and/or prevent interference that might be caused by EHF RF signals received and/or transmitted by repeater devices in the repeater mesh network. These techniques may comprise polarization isolation, spatial isolation, and/or use of different frequencies.

FIG. 1 is a block diagram illustrating an exemplary communication subsystem, in accordance with an embodiment of the invention. Referring to FIG. 1, there is shown a communication subsystem 102, an RF receiver 104a, an RF transmitter 104b, a receive antenna 106a, a transmit antenna 106b, a digital baseband processor 108, a processor 110, and a memory 112.

The communication subsystem 102 may comprise the RF receiver 104a, the RF transmitter 104b, the receive antenna 106a, the transmit antenna 106b, the digital baseband processor 108, the processor 110, the memory 112, and may also

comprise additional suitable logic, circuitry, and/or code that may enable receiving, transmitting, and processing of RF signals. For example, the communication subsystem **102** may be integrated or located within a wireless device to enable operations in a wireless system, such as the cellular network and/or digital video broadcast network.

The receive antenna **106a** may comprise suitable logic, circuitry, and/or code that may enable reception of RF signals; receive antenna **106a** may be communicatively coupled to the RF receiver **104a**. The RF receiver **104a** may comprise suitable logic, circuitry, and/or code that may enable processing of received RF signals. The RF receiver **104a** may enable receiving extremely high frequency (EHF) signals at, for example, approximately 60 GHz. In this regard, the RF receiver **104a** may be enabled to generate signals, such as local oscillator signals, for the reception and processing of EHF signals. The RF receiver **104a** may down-convert received RF signals to a baseband frequency signal. The RF receiver **104a** may perform direct down-conversion of the received RF signals to a baseband frequency signal, for example. In some instances, the RF receiver **104a** may enable analog-to-digital conversion of the baseband signal components before transferring the components to the digital baseband processor **108**. In other instances, the RF receiver **104a** may transfer the baseband signal components in analog form. The receive antenna **106a** and the RF receiver **104a** may also enable reception of non-EHF RF signals. For example, the receive antenna **106a** and the RF receiver **104a** may enable receiving and/or processing of Bluetooth RF signals.

The transmit antenna **106b** may comprise suitable logic, circuitry, and/or code that may enable transmission of RF signals; the transmit antenna **106b** may be communicatively coupled to the RF transmitter **104b**. The RF transmitter **104b** may comprise suitable logic, circuitry, and/or code that may enable processing of RF signals for transmission. The RF transmitter **104b** may enable transmission of extremely high frequency (EHF) signals at, for example, approximately 60 GHz. In this regard, the RF transmitter **104b** may be enabled to generate signals, such as local oscillator signals, for the transmission and processing of EHF signals. The RF transmitter **104b** may up-convert the baseband frequency signal to an RF signals. The RF transmitter **104b** may perform direct up-conversion of the baseband frequency signal to RF signals of approximately 60 GHz, for example. In some instances, the RF transmitter **104b** may enable digital-to-analog conversion of the baseband signal components received from the digital baseband processor **108** before up conversion. In other instances, the RF transmitter **104b** may receive baseband signal components in analog form. The transmit antenna **106b** and the RF transmitter **104b** may also enable transmission of non-EHF RF signals. For example, the transmit antenna **106b** and the RF transmitter **104b** may enable transmitting and/or processing of Bluetooth RF signals.

The digital baseband processor **108** may comprise suitable logic, circuitry, and/or code that may enable processing and/or handling of baseband frequency signals. In this regard, the digital baseband processor **108** may process or handle signals received from the RF receiver **104a** and/or signals to be transferred to the RF transmitter **104b**. The digital baseband processor **108** may also provide control and/or feedback information to the RF receiver **104a** and to the RF transmitter **104b** based on information from the processed signals. The digital baseband processor **108** may communicate information and/or data from the processed signals to the processor **110** and/or to the memory **112**. Moreover, the digital baseband processor **108** may receive information from the pro-

cessor **110** and/or to the memory **112**, which may be processed and transferred to the RF transmitter **104b** for transmission to the network.

The processor **110** may comprise suitable logic, circuitry, and/or code that may enable control and/or data processing operations for the communication subsystem **102**. The processor **110** may be utilized to control at least a portion of the RF receiver **104a**, the RF transmitter **104b**, the digital baseband processor **108**, and/or the memory **112**. In this regard, the processor **110** may generate at least one signal for controlling operations within the communication subsystem **102**. The processor **110** may also enable executing of applications that may be utilized by the communication subsystem **102**. For example, the processor **110** may execute applications that may enable displaying and/or interacting with content received via RF signals in the communication subsystem **102**.

The memory **112** may comprise suitable logic, circuitry, and/or code that may enable storage of data and/or other information utilized by the communication subsystem **102**. For example, the memory **112** may be utilized for storing processed data generated by the digital baseband processor **108** and/or the processor **110**. The memory **112** may also be utilized to store information, such as configuration information, that may be utilized to control the operation of at least one block in the communication subsystem **102**. For example, the memory **112** may comprise information necessary to configure the RF receiver **104a** to enable receiving signals in the appropriate frequency band.

In operation, the communication subsystem **102** may enable communication via RF interfaces. The communication subsystem **102** may be integrated within a wireless device to enable communication via an EHF interface, for example the 60 GHz band. For example, the communication subsystem **102** may receive RF signals operating in the 60 GHz band via the receive antenna **106a**; wherein the RF receiver **104a** may enable initial processing of the received signal. The communication subsystem **102** may transmit RF signals operating in the 60 GHz band via the RF transmitter **104b** and the transmit antenna **106b**. The digital baseband processor **108**, the processor **110**, and the memory **112** may enable performing control and/or related operation during transmission and/or reception of RF signals. For example, the memory **112** may be utilized to store and/or fetch data that may be received and/or transmitted via 60 GHz RF signals. The digital **108** may enable performing signal processing operation such as analog-to-digital conversion, encoding/decoding of received and/or transmitted data via the 60 GHz RF signals. The processor **110** may enable controlling of the operations of the communication subsystem **102**. For example, the processor **110** may enable operating of the transmit and/or the receive antennas to enable aligning during 60 GHz RF communications.

In addition to EHF communications, which may have limited operational range compared with lower frequency RF interfaces, the communication subsystem **102** may be enabled to utilize other wireless interfaces and/or protocols. For example, the communication subsystem **102** may be enabled to utilize such wireless interfaces as Bluetooth to perform Bluetooth RF communications. Accordingly, the receive antenna **106a**, the RF receiver **104a**, and/or other components within the communication subsystem **102** may enable reception of non-EHF RF signals, for example, Bluetooth RF signals. Similarly, the transmit antenna **106b**, the RF transmitter **104b**, and/or other components within the communication subsystem **102** may enable transmission of non-EHF RF signals, for example, Bluetooth RF signals. The non-EHF interfaces that may be supported in the communi-

cation subsystem **102** may be utilized to send information regarding the communication subsystem **102**. For example, a Bluetooth connection may be utilized to send information regarding the capability of the communication subsystem **102** and/or to receive messages containing information regarding preferred setting that may be utilized while performing EHF communication.

In an embodiment of the invention, repeater devices may be utilized to extend the range of EHF communication between wireless devices within the communication system **100**. EHF communication may generally have limited range, typically operating only in “line-of-sight” settings. Consequently, it may be desirable to utilize other devices, for example, repeater devices, to extend the range of communication between EHF-enabled devices. Additionally, because utilizing a single repeater device may not yield substantial increase in the range of EHF RF communication, a group of repeater devices, forwarding EHF RF signals in chain-like configuration, may be utilized.

To facilitate utilizing a plurality of repeater devices, control connections may be utilized by one or more of the plurality of the repeater devices to enable the repeater devices to coordinate the EHF forwarding operations. Because of the limited range of the EHF interface, non-extremely high frequency (non-EHF) connection, with higher range may be utilized. For example, Bluetooth, ZigBee, WiFi, and/or ultra-wideband (UWB) connections may be utilized to coordinate among the plurality of repeater devices. Accordingly, the communication system **100** may enable utilizing non-EHF interface. The communication subsystem **102** may enable generation and/or processing of non-EHF signals. Non-EHF signals may be transmitted and/or received via the receive antenna **106a** and/or the transmit antenna **106b**. In an alternate embodiment of the invention, dedicated and/or distinct antenna components may be utilized to transmit and/or receive non-EHF signals.

FIG. 2 is a block diagram illustrating a repeater device utilized to forward 60 GHz communication between two wireless devices, which may be utilized in accordance with an embodiment of the invention. Referring to FIG. 2, there is shown a wireless device **202**, a repeater device **204**, an EHF connection **206**, and a control connection **208**.

The wireless device **202** may each comprise suitable logic, circuitry, and/or code that may enable receiving, transmitting, and processing of RF signals. For example, the wireless device **202** may comprise the communication subsystem **102**, substantially as described in FIG. 1.

The repeater device **204** may comprise suitable logic, circuitry, and/or code that may enable reception and/or transmission of EHF signals to facilitate forwarding EHF signals transmitted by the wireless device **202**. Additionally, the repeater device **204** may comprise suitable logic, circuitry, and/or code that may enable establishing and/or utilizing control connection **208** with the wireless device **202** via non-EHF interface, for example, Bluetooth, ZigBee, WiFi, and/or ultra-wideband (UWB).

The EHF connection **206** may comprise a radio (RF) and/or wireless link that may be based on an EHF protocol that may comprise the 60 GHz interface. The control connection **208** may comprise a radio (RF) and/or wireless link that may be based on a non-EHF protocol that may comprise Bluetooth, ZigBee, WiFi, and/or ultra-wideband (UWB). The control connection **208** may be utilized to communicate control messages, for example, between the wireless device **202** and the repeater device **204**.

In operation, the repeater device **204** may enable forwarding EHF RF signals transmitted and/or received by the wire-

less device **202** via the EHF connection **206**. EHF communication may generally have limited range, typically operating only in “line-of-sight” settings. Consequently, it may desirable to utilize other devices, for example, repeater devices such as the repeater device **204**, to extend the range of communication between EHF-enabled devices.

The wireless device **202** may utilize the communication subsystem **102** to enable transmission and/or reception of EHF RF signals via the EHF connection **206**. The repeater device **204** may be utilized because EHF RF signals may have limited operational range. The wireless device **202**, and/or the repeater device **204** may utilize the control connection **208** during EHF communication between devices. The control connections **208** may enable exchanging control messages, data, and/or information that may enable facilitating EHF communication via the EHF connection **206**. For example, the control connection **208** may enable the wireless device **202** to determine whether the repeater device **204** may be utilized to forward EHF RF signal transmitted by wireless device **202**. Alternatively, the repeater device **204** may utilize the control connection **206** to notify the wireless device **202** of an impending EHF communication targeted for the wireless device **202**.

While it may be desirable to utilize the repeater device **204** to forward EHF RF signals transmitted and/or received by the wireless device **202**, the operational effectiveness of the repeater device **204** may be limited by the operational limitations of EHF communication since the main purpose for utilizing the repeater device **204** may be receiving and transmitting EHF RF signals. Consequently, it may be desirable to utilize a plurality of repeater devices, similar to the repeater device **204**, which may be enabled, in their totality, to provide a substantial increase in the EHF communication range of the wireless device **202**.

To facilitate utilizing a plurality of repeater devices, control connections may be utilized by one or more of the plurality of the repeater devices to enable the repeater devices to coordinate the EHF forwarding operations. Because of the limited range of the EHF interface, non-extremely high frequency (non-EHF) connection, with higher range may be utilized. For example, Bluetooth, ZigBee, WiFi, and/or ultra-wideband (UWB) connections may be utilized to coordinate among the plurality of repeater devices. Accordingly, because the repeater device **204** may be enabled to utilize one or more non-EHF interfaces, the repeater device **204** may be enabled to generate and/or process of non-EHF signals that may be transmitted and/or received to communication and/or coordinate with other repeater devices via non-EHF interfaces.

FIG. 3 is a block diagram illustrating a mesh network of EHF repeaters that utilize Non-EHF intra-mesh control connections for configuring and managing the mesh network, which may be utilized in accordance with an embodiment of the invention. Referring to FIG. 3, there is there is shown, a source wireless device **302a**, a target wireless devices **302b**, a plurality of EHF repeater devices **304a**, **304b**, **304c**, **304d**, and **304e**, a repeater mesh network **310**, and a non-EHF interface **312**.

The source wireless device **302a** and the target wireless device **302b** may each comprise suitable logic, circuitry, and/or code that may enable receiving, transmitting, and processing of RF signals. For example, the source wireless device **302a** and the target wireless device **302b** may each be comprised substantially similar to the wireless device **202**, as described in FIG. 2.

Each of the plurality of EHF repeater devices **304a**, **304b**, **304c**, **304d**, **304e**, and **304f** may comprise suitable logic, circuitry, and/or code that may enable reception and/or trans-

mission of EHF signals, and may be utilized to facilitate forwarding EHF RF signals between EHF-enabled devices. For example, each of the plurality of repeater devices **304a**, **304b**, **304c**, **304d**, and **304e** may be comprised substantially similar to the repeater device **204**, as described in FIG. 2. Additionally, each of the plurality of repeater devices **304a**, **304b**, **304c**, **304d**, **304a**, and **304f** may be enabled to utilize transmission and/or reception of non-EHF signals to enable coordinating and/or communication with other repeater and/or wireless devices within operations proximity.

The repeater mesh network **310** may comprise a plurality of EHF repeater devices, for example, the plurality of EHF repeater devices **304a**, **304b**, **304c**, **304d**, and **304e**, and may comprise suitable logic, circuitry, and/or code that may enable the plurality of EHF repeater devices **304a**, **304b**, **304c**, **304d**, and **304e** to forward EHF communication, and to utilize non-EHF signals to enable communicating and/or coordinating among the plurality of repeater devices.

The non-EHF interface **312** may comprise radio frequency (RF) and/or wireless links, which may be based on a non-extremely high frequency (non-EHF) non-EHF protocol. The non-EHF interface **312** may be utilized by each of the plurality of repeater devices **304a**, **304b**, **304c**, **304d**, and **304e** to enable non-EHF communication among repeater devices in the repeater mesh network **310**. For example, the non-EHF interface **312** may comprise Bluetooth, ZigBee, WiFi, and/or ultra-wideband (UWB) signals transmitted and/or received by each of the plurality of repeater devices **304a**, **304b**, **304c**, **304d**, and **304e** while communicating with other repeater devices.

In operation, the plurality of repeater devices **304a**, **304b**, **304c**, **304d**, and **304e** may establish the repeater mesh network **310**. The repeater mesh network **306** may enable forwarding EHF RF communication via the plurality of repeater devices **304a**, **304b**, **304c**, **304d**, and **304e**, wherein routes comprised of some or all of the plurality of the repeater devices **304a**, **304b**, **304c**, **304d**, and **304e** may be utilized to route EHF RF signals via the repeater mesh network **310**. For example, the repeater devices **304a**, **304b**, and **304e** may be utilized to establish a route for forwarding of EHF signals via the repeater mesh network **310**. The repeater mesh network **310** may be formed when repeater devices, for example the plurality of repeater devices **304a**, **304b**, **304c**, **304d**, and **304e**, are in close proximity of each other to enable EHF forwarding operations. Each of the plurality of repeater devices **304a**, **304b**, **304c**, **304d**, and **304e** may be enabled to detect the presence of other repeater devices in its vicinity.

During establishment, initial configuration, and/or management of the repeater mesh network **310**, each of the plurality of repeater devices **304a**, **304b**, **304c**, **304d**, and **304e** may utilize the non-EHF interface **312** to communicate with other repeater devices. Use of the non-EHF interface **312** may be desirable for various reasons. First, because EHF communications may generally have limited range, the plurality of repeater devices **304a**, **304b**, **304c**, **304d**, and **304e** may utilize non-EHF wireless protocols, for example, Bluetooth, WiFi, and/or WiMAX, which may enable the devices to communicate over greater ranges than available via EHF interfaces. Second, use of non-EHF interface **312** may also be desirable because use of EHF interfaces, for intra-mesh communication, may cause interference during EHF forwarding operations, and/or it may potentially use up some of bandwidth that otherwise may have been available during EHF forwarding operations. Finally, use of certain types of non-EHF protocols, for example Bluetooth and/or ZigBee, may enable utilizing already existing detection and/or coupling functionality.

Use of the non-EHF interface **312** may enable each of the plurality of repeater devices **304a**, **304b**, **304c**, **304d**, and **304e** to determine presence and/or availability of repeater devices that may be utilized during EHF forwarding operations. For example, during establishment of the repeater mesh network **310**, where the repeater device **304a** may determine the presence of the repeater devices **304b**, **304c**, and **304e**. The repeater devices **304a** may utilize control connections via the non-EHF interface **312** to couple itself to the detected repeater devices to facilitate the creation of the repeater mesh network **310**. Additionally, where the repeater device **304a** may not be able to detect, and/or to couple itself directly to the repeater device **304d**, the **304d** may still be integrated into the repeater mesh network **310** via the repeater devices **304c** and/or **304e**. The repeater device **304a** may receive messages from other repeater devices reporting presence and/or availability of the repeater device **304d** for forwarding EHF signals in the repeater mesh network **310**.

After initial formation of the repeater mesh network **310**, each of the plurality of repeater devices **304a**, **304b**, **304c**, **304d**, and **304e** may continue to utilize the non-EHF interface **312** to enable management of the repeater mesh network **312**. Each of the plurality of repeater devices **304a**, **304b**, **304c**, **304d**, and **304e** may be setup to utilize the non-EHF interface **312** to communicate to the other devices in the repeater mesh network **310** dynamic updates pertaining to presence and/or availability of the repeater device for EHF forwarding operations based on occurrence of specific conditions and/or events. For example, the repeater devices **304a** may utilize the non-EHF interface **312** to broadcast to the remaining repeater devices in the repeater devices in the repeater mesh network **310** "notification" messages indicating that the repeater device **304a** may be performing EHF forwarding operation. The repeater devices may utilize such information to determine whether the repeater device **304a** may be completely or partially unavailable for performing similar operations. Alternatively, the repeater mesh network **310** may be configured, via the non-EHF interface **312**, to enable each of the plurality of repeater devices **304a**, **304b**, **304c**, **304d**, and **304e** may utilize the non-EHF interface **312** to communicate to the other devices in the repeater mesh network **310** periodic updates pertaining to presence and/or availability of the repeater device for EHF forwarding operations, for example.

The non-EHF interface **312** may also be utilized to perform EHF forwarding via the repeater mesh network **310**. Each of the plurality of repeater devices **304a**, **304b**, **304c**, **304d**, and **304e** may utilize the non-EHF interface **312** to exchange information and/or control messages that may enable the repeater devices to determine, individually and/or collectively, routing paths within the repeater mesh network **310** while transmitting and/or receiving EHF RF signals. For example, the source wireless device **302a** may request, via the repeater device **304a**, forwarding of EHF communication to the target wireless device **302b**. The repeater device **304a** may determine, based on pre-existing information, and/or by utilizing the non-EHF interface **312** to send and/or receive reporting messages, that the end wireless devices **302b** may be reached via the repeater devices **302b** and **302e**. Consequently, the repeater device **304a** may utilize the non-EHF interface **312** to ascertain the availability of repeater devices **302b** and **302e** for performing EHF forwarding operations between the source wireless device **302a** and the target wireless device **302b**.

Once forwarding routes via the repeater mesh network **310** are determined, the non-EHF interface **312** may also be utilized to facilitate and/or optimize the forwarding of EHF communication. For example, to improve the effectiveness of

the repeater mesh network 310, different isolation techniques may be utilized in one or more of repeater devices that may form routes within the repeater mesh network 310, to reduce and/or prevent interference that might be caused by EHF RF signals received and/or transmitted by repeater devices in the repeater mesh network 310. These techniques may comprise spatial isolation, and/or polarization isolation, and/or use of different EHF frequencies. One of more of the plurality of repeater devices 304a, 304b, 304c, 304d, and 304e may utilize the non-EHF interface 312 to negotiate and/or assign proper polarization, spatial transmission, and/or frequency allocation settings utilized by repeater devices that may be utilized in forming the routes and/or may potentially interfere with EHF communication performed via the forwarding routes. The non-EHF interface 312 may also enable continued management of an on-going EHF communication forwarding via the repeater mesh network 310, wherein one or more of the plurality of repeater devices 304a, 304b, 304c, 304d, and 304e, comprising repeater devices that may not be actively participating in the EHF communication forwarding, may continue to send and/or request reporting control message regarding status of the EHF communication and/or occurrence of conditions that may affect the EHF communication and/or availability of repeater devices utilized in the forwarding routes.

FIG. 4 is an exemplary flow diagram illustrating use of Non-EHF intra-mesh connections in a mesh network of EHF repeaters, in accordance with an embodiment of the invention. Referring to FIG. 4, there is shown a flow chart 400 comprising a plurality of exemplary steps. In step 402, a plurality of repeater devices may form a repeater mesh network for forwarding extremely high frequency (EHF) communication between wireless devices. For example, the plurality of repeater devices 304a, 304b, 304c, 304d, and 304e may establish the repeater mesh network 310; which may enable forwarding EHF RF communication via routes that may comprise some or all of the repeater devices. Non-extremely high frequency (non-EHF) connections that may be established between the repeater devices may be utilized during forming of the repeater mesh network. For example, during establishment of the repeater mesh network 310, some or all of plurality of repeater devices 304a, 304b, 304c, 304d, and 304e may utilize control connections via the non-EHF interface 312 to discover and/or couple themselves together to facilitate the creation of the repeater mesh network 310.

In step 404, non-EHF connections may be utilized in a repeater mesh network to configure and/or manage the repeater mesh network. For example, after initial formation of the repeater mesh network 310, each of the plurality of repeater devices 304a, 304b, 304c, 304d, and 304e may utilize the non-EHF interface 312 to enable management of the repeater mesh network 312. Each of the plurality of repeater devices 304a, 304b, 304c, 304d, and 304e may be setup to utilize the non-EHF interface 312 to communicate to the other devices in the repeater mesh network 310 dynamic updates pertaining to presence and/or availability of the repeater device for EHF forwarding operations. Alternatively, the repeater mesh network 310 may be configured, via the non-EHF interface 312, to enable each of the plurality of repeater devices 304a, 304b, 304c, 304d, and 304e may utilize the non-EHF interface 312 to communicate to the other devices in the repeater mesh network 310 periodic updates pertaining, for example, to presence and/or availability of the repeater device for EHF forwarding operations.

In step 406, a request to forward EHF RF communication via a repeater mesh network may be received. An EHF-enabled wireless device, which may be located in the vicinity of

a repeater device in the repeater mesh network, may attempt to forward EHF RF signals via the repeater mesh network. For example, the source wireless device 302a may request, via the repeater device 304a, forwarding of EHF communication to the target wireless device 302b.

In step 408, EHF communication forwarded via a repeater mesh network may be facilitated, coordinated and/or managed by utilizing non-EHF control connections. For example, the non-EHF interface 312 may be utilized to enable the plurality of repeater devices 304a, 304b, 304c, 304d, and 304e to exchange information and/or control messages that may enable forming of routing paths within the repeater mesh network 310. Once forwarding routes via the repeater mesh network 310 are determined, the non-EHF interface 312 may also be utilized to coordinate and/or manage the forwarding of EHF communication. For example, some or all of the plurality devices 304a, 304b, 304c, 304d, and 304e may utilize the non-EHF interface 312 to negotiate and/or assign polarization isolation, spatial isolation, and/or frequency allocation settings, that may reduce and/or prevent interference that might be caused by EHF RF signals received and/or transmitted by repeater devices in the repeater mesh network 310. The non-EHF interface 312 may also enable continued management of an on-going EHF communication forwarding via the repeater mesh network 310. For example, some or all of the plurality of repeater devices 304a, 304b, 304c, 304d, and 304e may continue to send and/or request reporting control message regarding status of the EHF communication and/or occurrence of conditions that may affect the EHF communication and/or availability of repeater devices utilized in the forwarding routes.

Various embodiments of the invention may comprise a method and system for utilizing out of band signaling for calibration and configuration of a mesh network of EHF transceivers/repeaters. The plurality of repeater devices 304a, 304b, 304c, 304d, and 304e, each of which may enable forwarding extreme high frequency (EHF) communication between EHF-enabled wireless devices, may form the repeater mesh network 310. The non-extremely high frequency (non-EHF) control interface 310, comprising non-EHF protocols such as Bluetooth, ZigBee, WiFi, and/or ultrawideband (UWB), may be utilized by some or all of the plurality of repeater devices 304a, 304b, 304c, 304d, and 304e in communicating with other repeater devices in the repeater mesh network 310. Non-EHF control connections, via the non-EHF interface 312, may be utilized in establishing, configuring, and/or managing the repeater mesh network. Some or all of the plurality of repeater devices 304a, 304b, 304c, 304d, and 304e may utilize the non-EHF control connection to send, request, and/or receive periodic and/or dynamic control information. The non-EHF control connections may also be utilized while forming, and/or managing forwarding routes of EHF communication via the repeater mesh network 310. The non-EHF control connections may enable negotiating and/or setting different isolation techniques that may be utilized, while forming routes within the repeater mesh network 310, to reduce and/or prevent interference that might be caused by EHF RF signals received and/or transmitted by repeater devices in the repeater mesh network 310. These techniques may comprise polarization isolation, spatial isolation, and/or use of different frequencies.

Another embodiment of the invention may provide a machine-readable storage, having stored thereon, a computer program having at least one code section executable by a machine, thereby causing the machine to perform the steps as

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described herein for utilizing out of band signaling for calibration and configuration of a mesh network of EHF transceivers/repeaters.

Accordingly, the present invention may be realized in hardware, software, or a combination of hardware and software. The present invention may be realized in a centralized fashion in at least one computer system, or in a distributed fashion where different elements are spread across several interconnected computer systems. Any kind of computer system or other apparatus adapted for carrying out the methods described herein is suited. A typical combination of hardware and software may be a general-purpose computer system with a computer program that, when being loaded and executed, controls the computer system such that it carries out the methods described herein.

The present invention may also be embedded in a computer program product, which comprises all the features enabling the implementation of the methods described herein, and which when loaded in a computer system is able to carry out these methods. Computer program in the present context means any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either directly or after either or both of the following: a) conversion to another language, code or notation; b) reproduction in a different material form.

While the present invention has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the present invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present invention without departing from its scope. Therefore, it is intended that the present invention not be limited to the particular embodiment disclosed, but that the present invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. A method for wireless communication, the method comprising:

participating in a repeater mesh network comprising a plurality of repeater devices that extend a range of extremely high frequency (EHF) signals communicated between two or more wireless devices;

managing said repeater mesh network utilizing control connections that are established between two or more of said plurality of repeater devices, wherein at least one of said control connections utilizes a second interface that is separate from a first interface utilized for forwarding said EHF signals; and

coordinating and/or managing, via said control connections, use of isolation techniques in one or more of said plurality of repeater devices to enable forwarding of the EHF signals.

2. The method according to claim **1**, wherein said EHF signals comprise 60 GHz signals.

3. The method according to claim **1**, wherein said control connections comprise non-extremely high frequency (non-EHF) connections.

4. The method according to claim **3**, wherein said non-EHF connections comprise Bluetooth, ZigBee, WiFi, and/or ultra-wideband (UWB) connections.

5. The method according to claim **1**, wherein said isolation techniques comprise a spatial isolation, a polarization isolation, and/or a use of different frequencies.

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6. The method according to claim **1**, further comprising: exchanging, via said control connections, control and/or configuration information among said plurality of repeater devices.

7. The method according to claim **6**, further comprising: performing said exchange of control and/or configuration information among said plurality of repeater devices during an initial configuration of said mesh network, periodically, and/or dynamically based on an occurrence of events and/or conditions in said plurality of repeater devices.

8. A non-transitory computer readable medium having a computer program recorded thereon, the computer program configured to perform a method of wireless communication when executed on a computer, the method comprising:

participating in a repeater mesh network among a plurality of repeater devices that extend a range of extremely high frequency (EHF) signals communicated between two or more wireless devices;

managing said repeater mesh network utilizing control connections that are established between two or more of said plurality of repeater devices, wherein at least one of said control connections utilizes a second interface that is separate from a first interface utilized for forwarding said EHF signals; and

exchanging, via said control connections, control and/or configuration information among said plurality of repeater devices.

9. The non-transitory computer readable medium according to claim **8**, wherein said EHF signals comprise 60 GHz signals.

10. The non-transitory computer readable medium according to claim **8**, wherein said control connections comprise non-extremely high frequency (non-EHF) connections.

11. The non-transitory computer readable medium according to claim **8**, wherein said non-EHF connections comprise Bluetooth, ZigBee, WiFi, and/or ultra-wideband (UWB) connections.

12. The non-transitory computer readable medium according to claim **8**, the method further comprising:

coordinating and/or managing, via said control connections, use of isolation techniques in one or more of said plurality of repeater devices to enable forwarding of the EHF signals.

13. The non-transitory computer readable medium according to claim **12**, wherein said isolation techniques comprise a spatial isolation, a polarization isolation, and/or a use of different frequencies.

14. The non-transitory computer readable medium according to claim **8**, the method further comprising:

performing said exchange of control and/or configuration information among said plurality of repeater devices during an initial configuration of said mesh network, periodically, and/or dynamically based on an occurrence of events and/or conditions in said plurality of repeater devices.

15. A system for wireless communication, the system comprising:

one or more processors in a repeater device that enable participation in a repeater mesh network comprising a plurality of repeater devices that includes said repeater device, the one or more processors in the repeater device being configured to:

extend a range of extremely high frequency (EHF) signals communicated between a plurality of wireless devices;

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enable management of said repeater mesh network utilizing control connections that are established between said repeater device and one or more of said plurality of repeater devices, wherein at least one of said control connections utilizes a second interface that is separate from a first interface utilized for forwarding said EHF signals; and

enable coordination and/or management, via said control connections, of use of isolation techniques in one or more of said plurality of repeater devices to enable forwarding of the EHF signals.

16. The system according to claim 15, wherein said EHF signals comprise 60 GHz signals.

17. The system according to claim 15, wherein said control connections comprise non-extremely high frequency (non-EHF) connections.

18. The system according to claim 17, wherein said non-EHF connections comprise Bluetooth, ZigBee, WiFi, and/or ultra-wideband (UWB) connections.

19. The system according to claim 15, wherein said isolation techniques comprise a spatial isolation, a polarization isolation, and/or a use of different frequencies.

20. The system according to claim 15, wherein said one or more processors is configured to enable exchange, via said control connections, of control and/or configuration information.

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21. The system according to claim 20, wherein said one or more processors is configured to enable performance of said exchange of control and/or configuration information during an initial configuration of said mesh network, periodically, and/or dynamically based on an occurrence of events and/or conditions in said plurality of repeater devices.

22. A system for wireless communication, the system comprising:

one or more processors in a repeater device that enable management of a repeater mesh network utilizing control connections that are established between two or more of a plurality of repeater devices, wherein:

said repeater mesh network comprises said plurality of repeater devices and extends a range of extremely high frequency (EHF) signals communicated between a plurality of wireless devices, said plurality of repeater devices including said repeater device,

at least one of said control connections is established using a second interface that is separate from a first interface utilized for forwarding said EHF signals, and

said one or more processors in the repeater device is configured to enable exchange, via said control connections, of control and/or configuration information.

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