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(54) **METHOD AND APPARATUS THAT FACILITATES INTERFERENCE REDUCTION IN WIRELESS SYSTEMS**

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CPC ..... **H04L 27/2647** (2013.01); **H04L 25/023** (2013.01); **H04L 25/0206** (2013.01)

(58) **Field of Classification Search**

CPC ..... H04L 27/2647; H04L 25/0206; H04L 25/023

See application file for complete search history.

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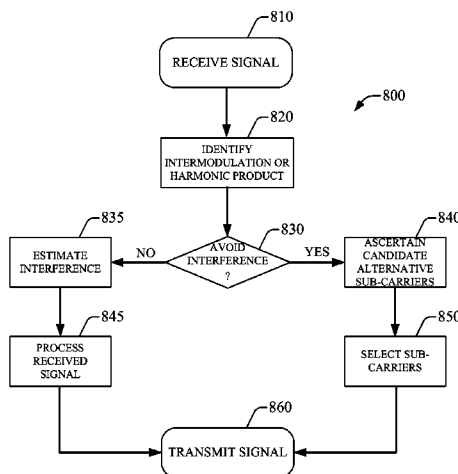
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(57) **ABSTRACT**

Techniques for managing interference in a wireless communication system are disclosed. In one aspect, an estimated interference associated with data transmission over a plurality of subcarriers on an uplink is determined. The estimated interference may relate to intermodulation products associated with a parallel transmission over the plurality of subcarriers. Based at least partly on the estimated interference, data received on the downlink can be processed, and subcarriers can be selected for data transmission on the uplink. Additionally, resources can be assigned to a wireless device according to the estimated interference.

**36 Claims, 12 Drawing Sheets**



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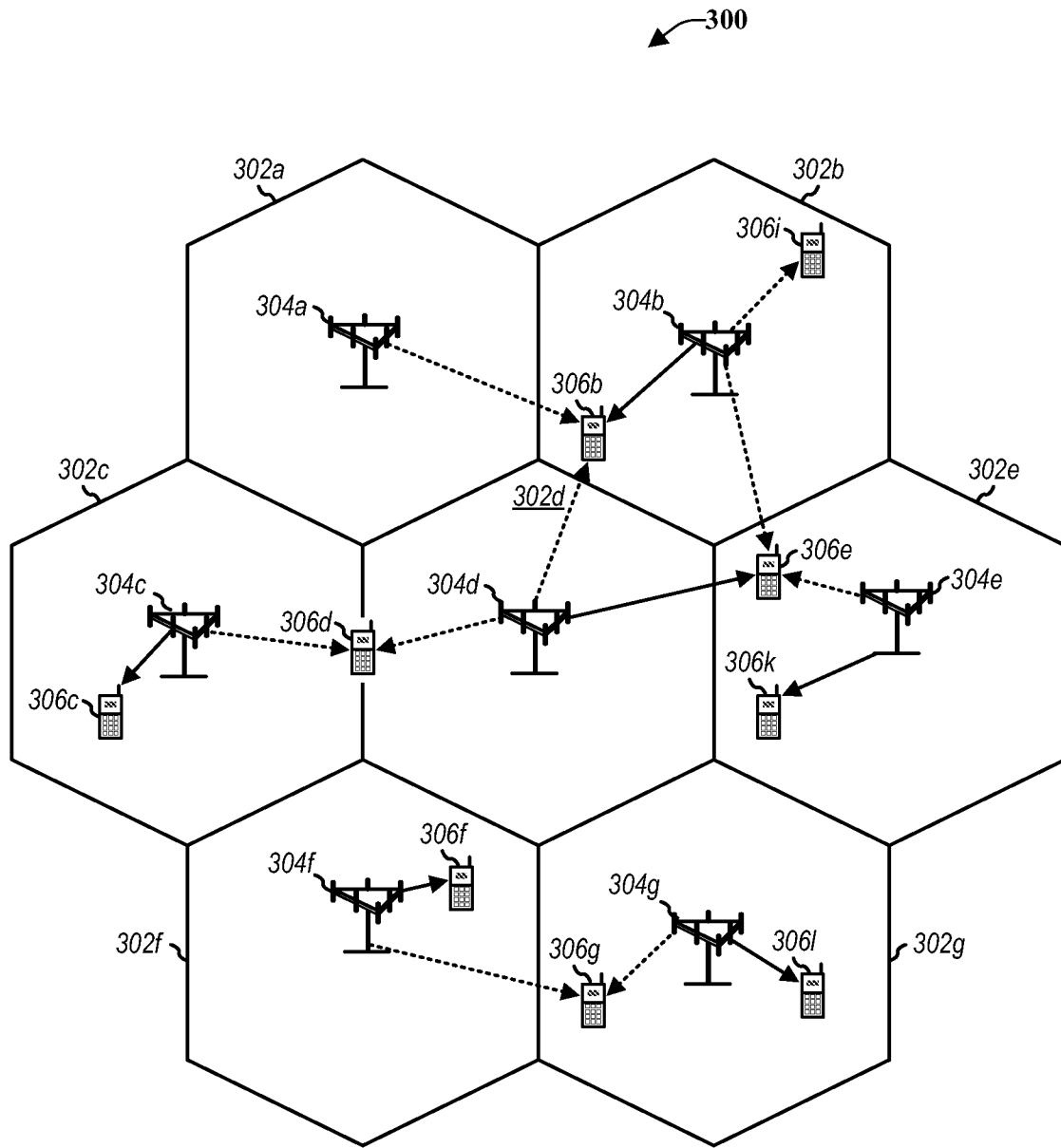
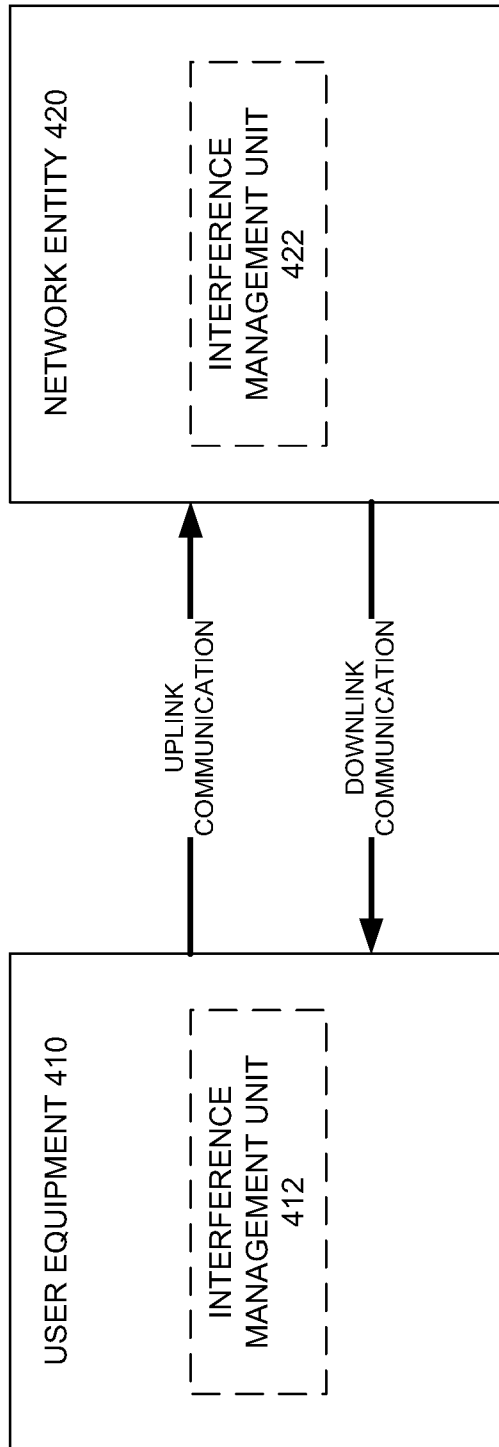
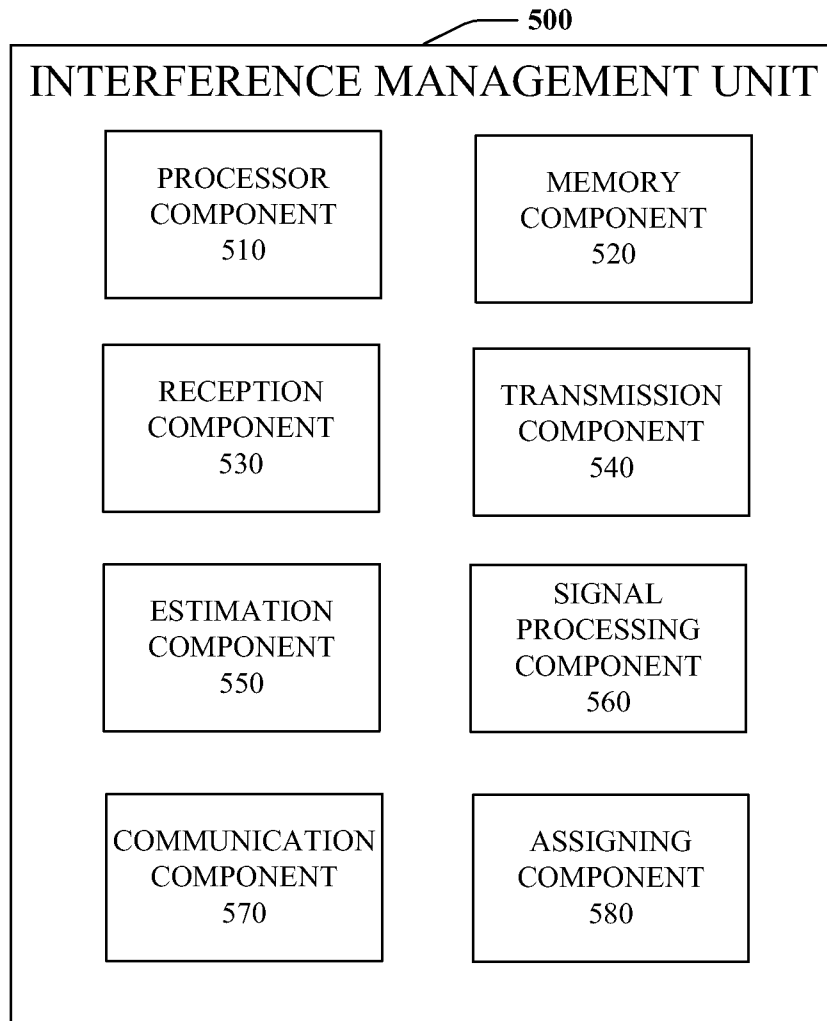


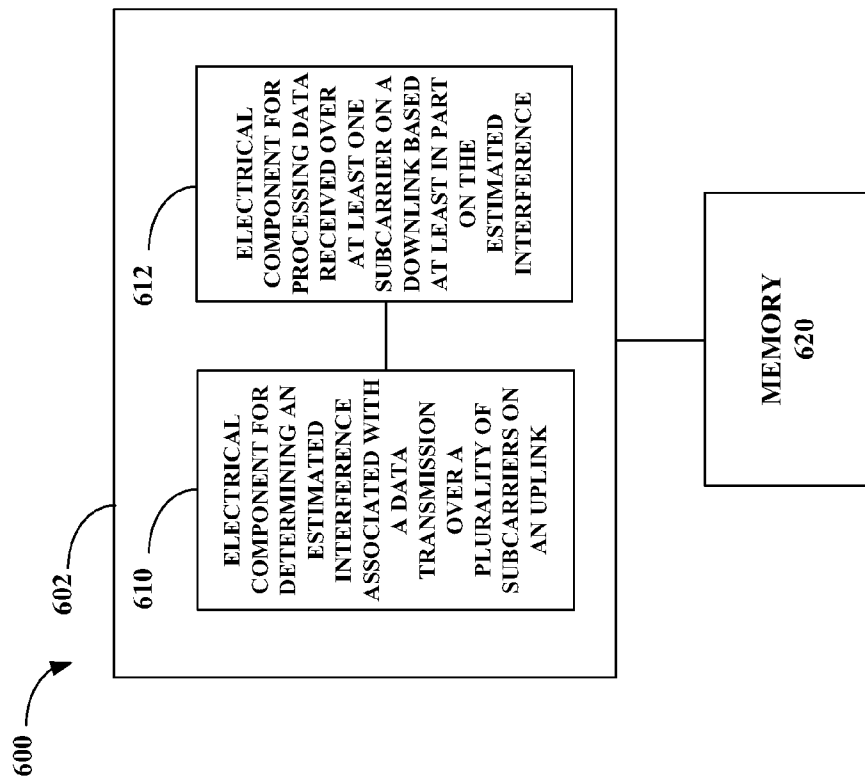
FIG. 3



**FIG. 4**

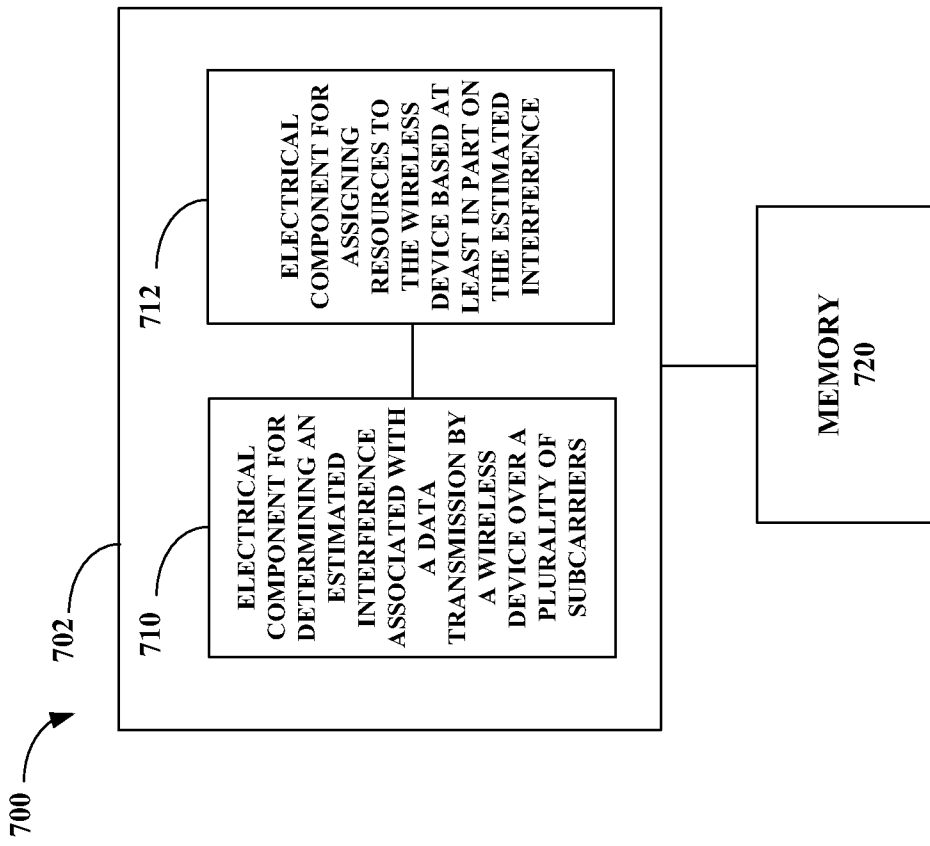


**FIG. 5**



**FIG. 6**





**FIG. 7**

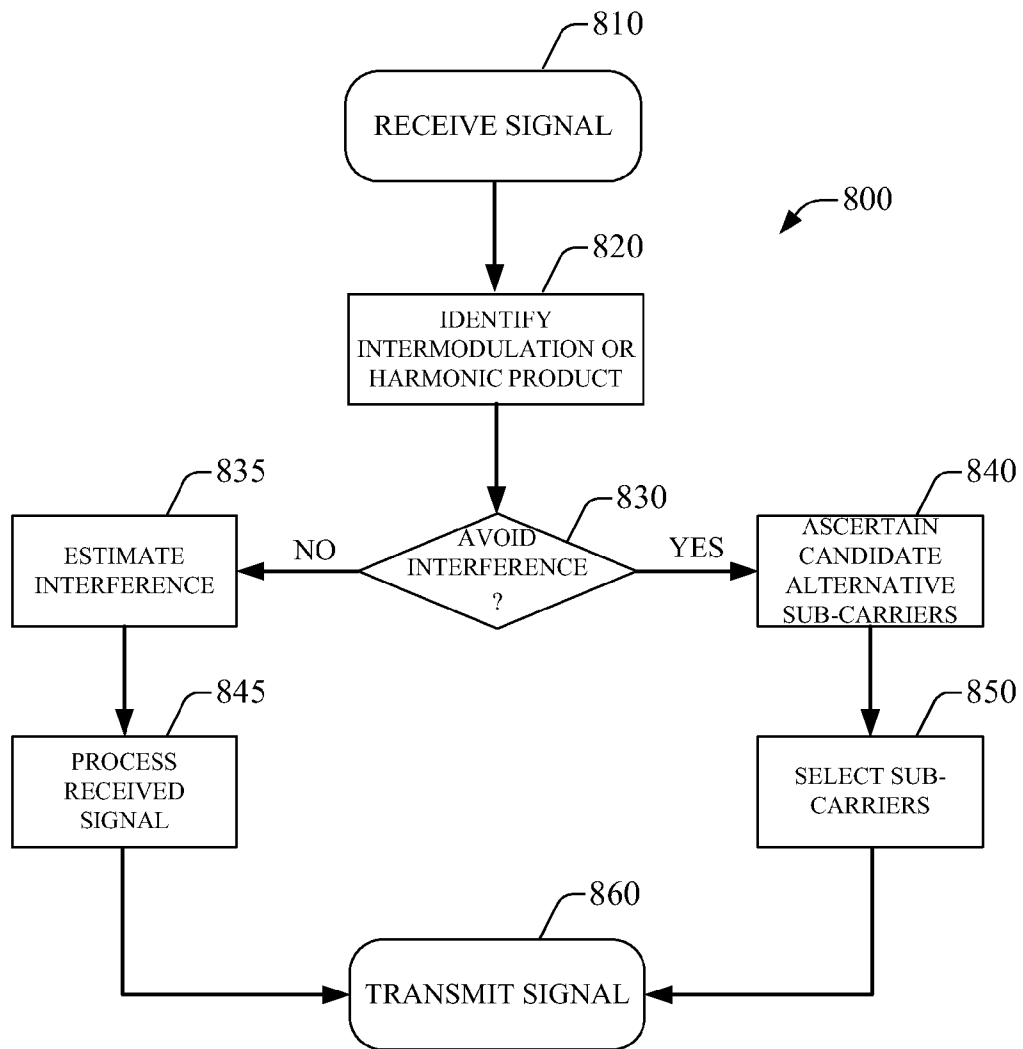


FIG. 8

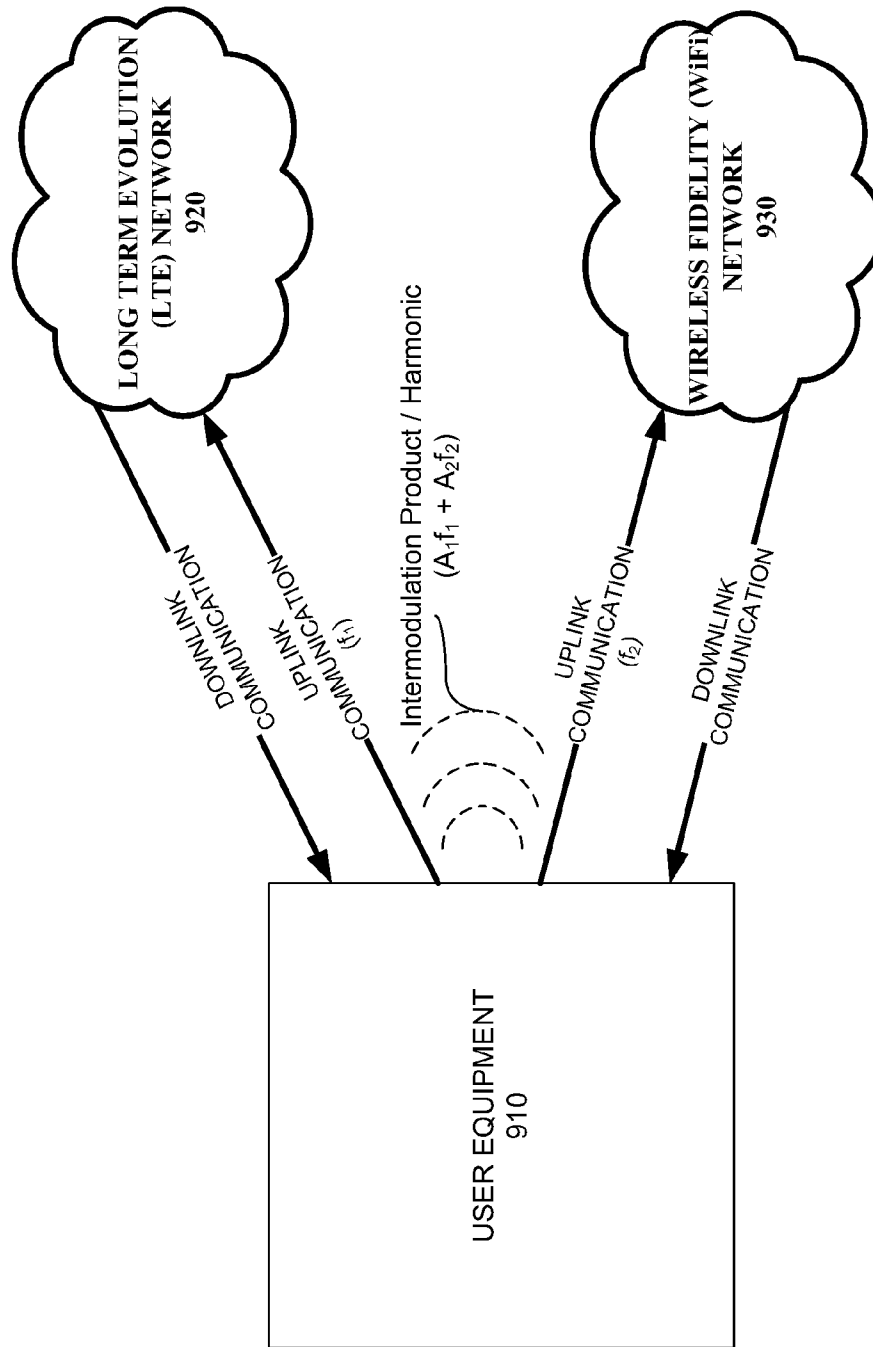


FIG. 9

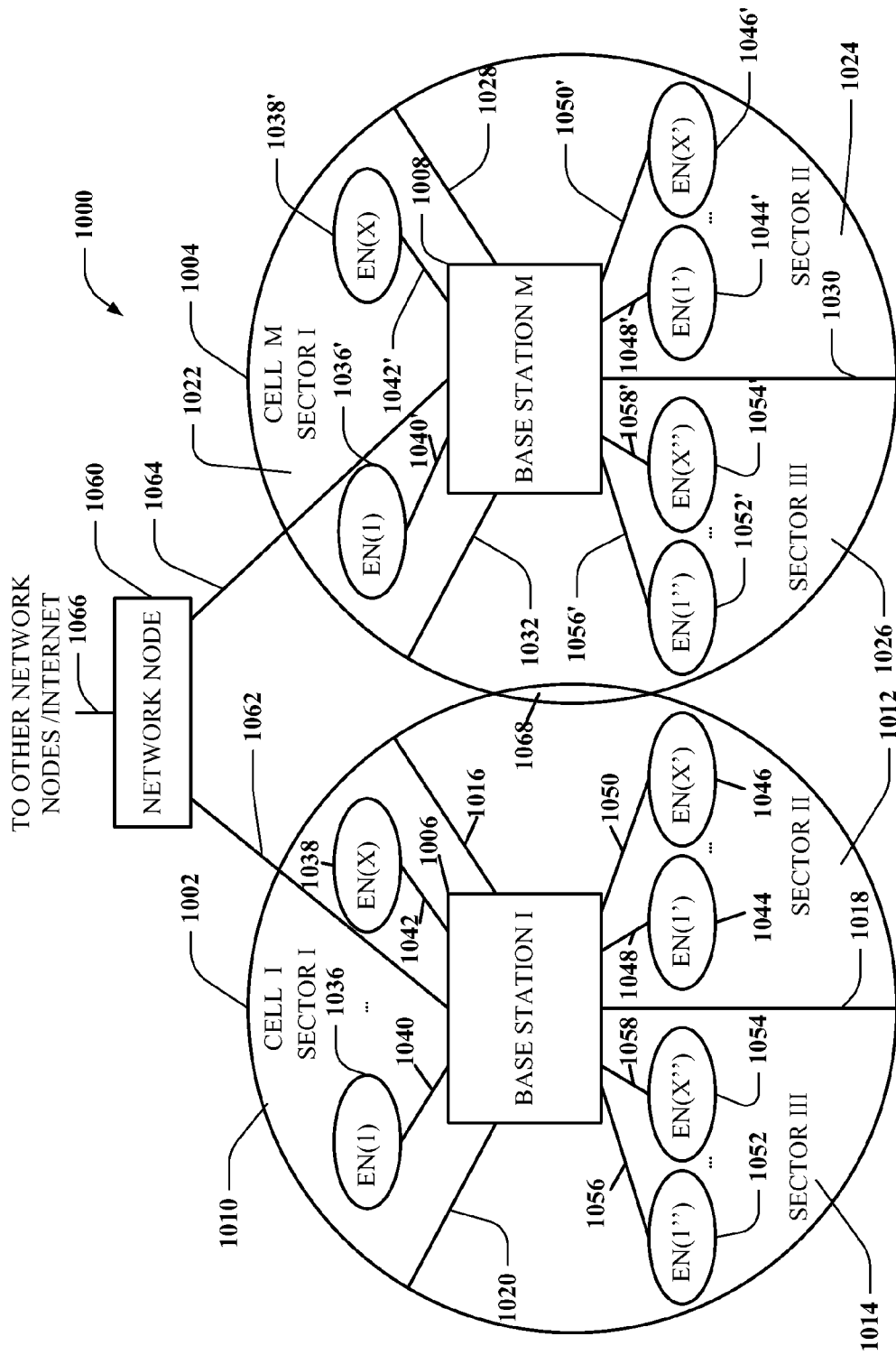


FIG. 10

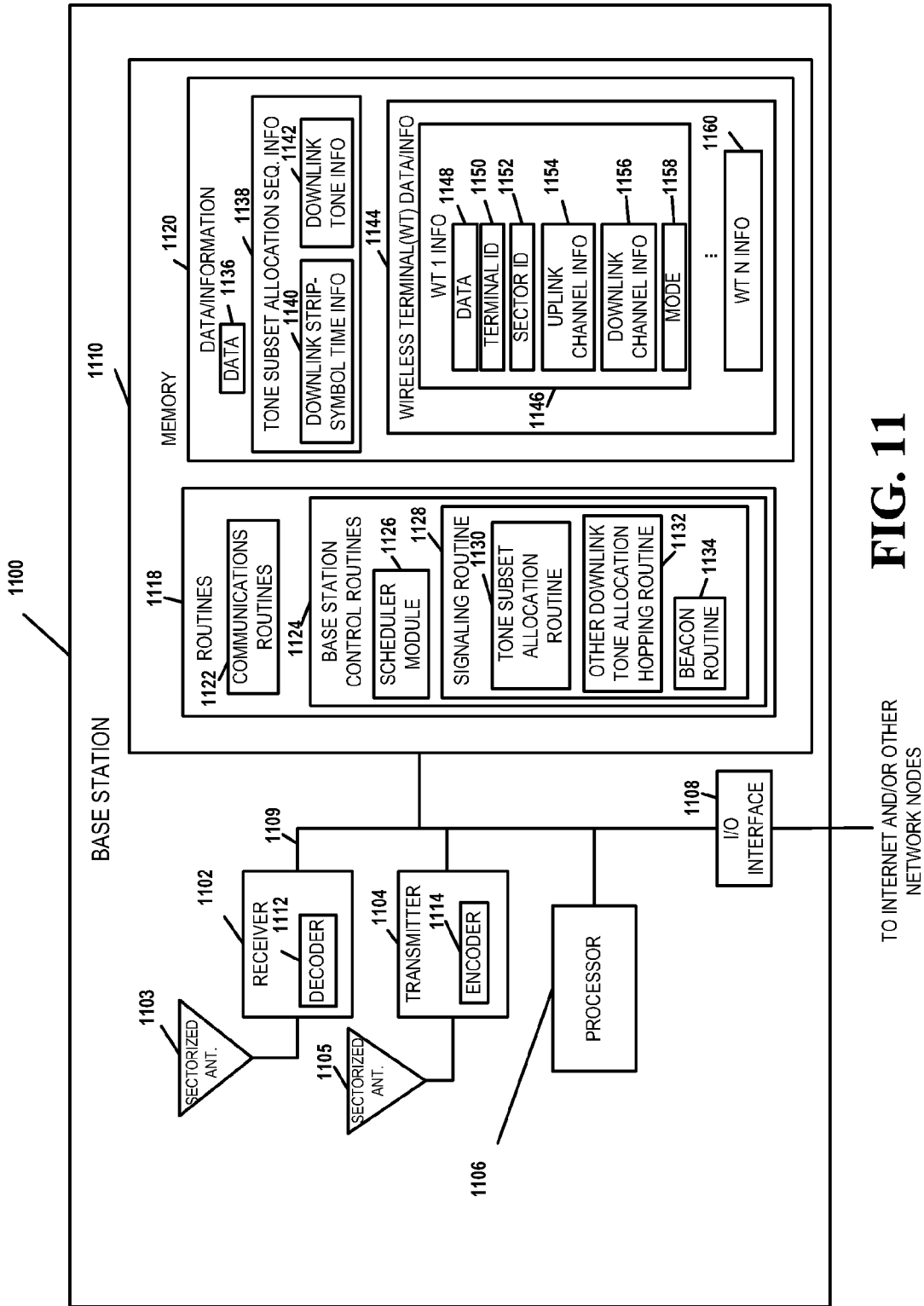


FIG. 11

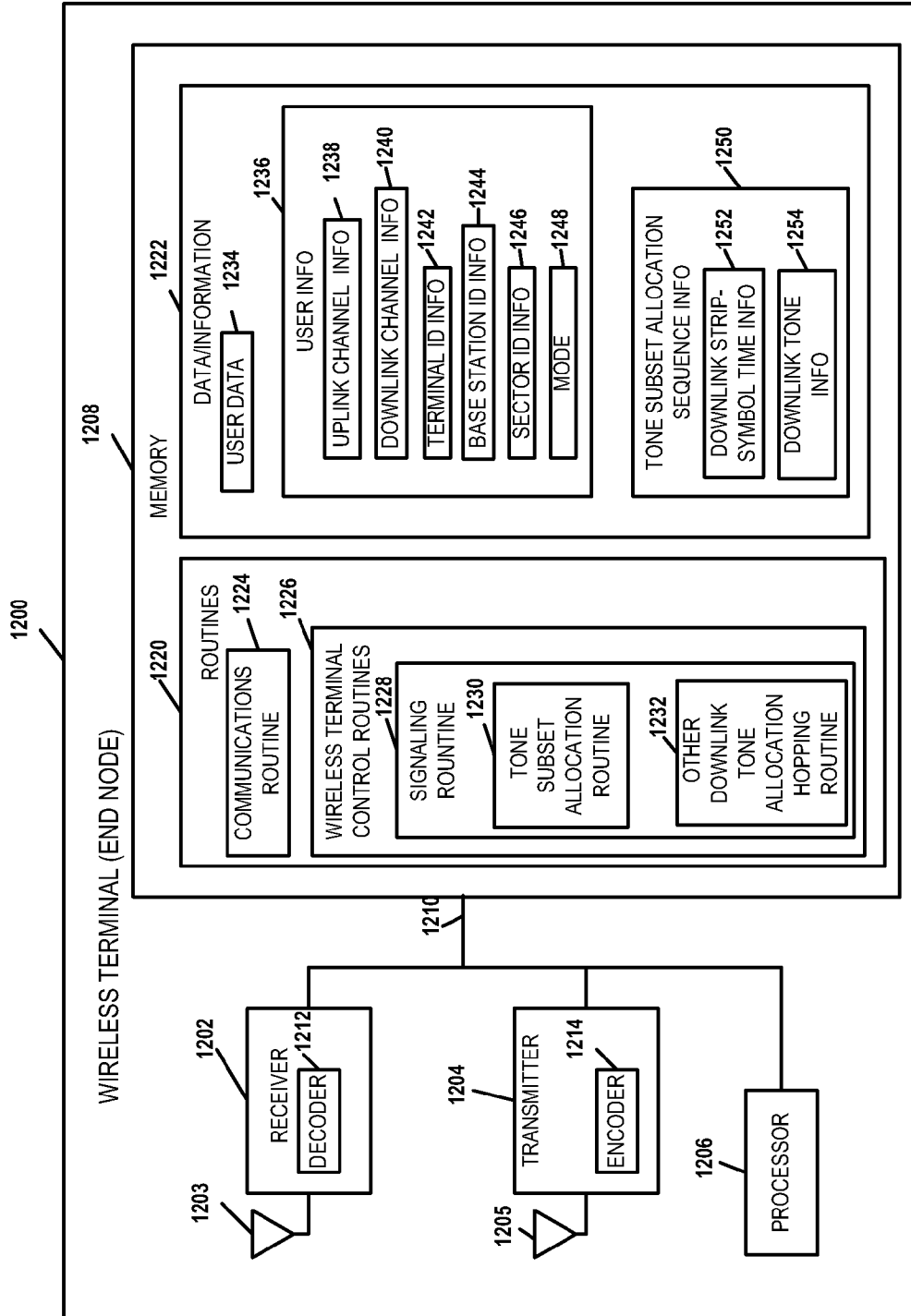


FIG. 12

# METHOD AND APPARATUS THAT FACILITATES INTERFERENCE REDUCTION IN WIRELESS SYSTEMS

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Patent Application Ser. No. 61/220,983 entitled "METHOD AND APPARATUS FACILITATING INTERFERENCE MITIGATION FOR NON-CONTIGUOUS TRANSMISSIONS," which was filed Jun. 26, 2009. The aforementioned application is herein incorporated by reference in its entirety.

## BACKGROUND

### I. Field

The following description relates generally to wireless communications, and more particularly to methods and apparatuses that facilitate interference reduction.

### II. Background

Wireless communication systems are widely deployed to provide various types of communication content such as voice, data, and so on. These systems may be multiple-access systems capable of supporting communication with multiple users by sharing the available system resources (e.g., bandwidth and transmit power). Examples of such multiple-access systems include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, 3GPP Long Term Evolution (LTE) systems, and orthogonal frequency division multiple access (OFDMA) systems.

Generally, a wireless multiple-access communication system can simultaneously support communication for multiple wireless terminals. Each terminal communicates with one or more base stations via transmissions on forward and reverse links. The forward link (or downlink) refers to the communication link from the base stations to the terminals, and the reverse link (or uplink) refers to the communication link from the terminals to the base stations. This communication link may be established via a single-in-single-out, multiple-in-signal-out or a multiple-in-multiple-out (MIMO) system.

A MIMO system employs multiple ( $N_T$ ) transmit antennas and multiple ( $N_R$ ) receive antennas for data transmission. A MIMO channel formed by the  $N_T$  transmit and  $N_R$  receive antennas may be decomposed into  $N_S$  independent channels, which are also referred to as spatial channels, where  $N_S \leq \min\{N_T, N_R\}$ . Each of the  $N_S$  independent channels corresponds to a dimension. The MIMO system can provide improved performance (e.g., higher throughput and/or greater reliability) if the additional dimensionalities created by the multiple transmit and receive antennas are utilized.

## SUMMARY

The following presents a simplified summary of one or more embodiments in order to provide a basic understanding of such embodiments. This summary is not an extensive overview of all contemplated embodiments, and is intended to neither identify key or critical elements of all embodiments nor delineate the scope of any or all embodiments. Its purpose is to present concepts of one or more embodiments in a simplified form as a prelude to the more detailed description that is presented later.

In accordance with one or more embodiments and corresponding disclosure thereof, various aspects are described in

connection with reducing interference in wireless communication systems. In one aspect, methods and computer program products are disclosed for facilitating wireless communications. Such embodiments include determining an estimated interference associated with a data transmission over a plurality of subcarriers on an uplink, and processing data received over at least one subcarrier on a downlink based at least in part on the estimated interference.

Another aspect relates to an apparatus for wireless communications. The apparatus includes a processor configured to execute computer executable components stored in a memory. The computer executable components include an estimation component and a signal processing component. The estimation component is configured to determine an estimated interference associated with a data transmission over a plurality of subcarriers on an uplink. The signal processing component is configured to process data received over at least one subcarrier on a downlink based at least in part on the estimated interference.

Additional aspects relate to an apparatus that includes means for determining an estimated interference associated with a data transmission over a plurality of subcarriers on an uplink. The apparatus also includes means for processing data received over at least one subcarrier on a downlink based at least in part on the estimated interference.

According to another aspect, methods and computer program products are disclosed for facilitating wireless communications at a base station. Such embodiments include determining an estimated interference associated with a data transmission by a wireless device over a plurality of subcarriers, and assigning resources to the wireless device based at least in part on the estimated interference.

Yet another aspect relates to an apparatus for wireless communications. The apparatus includes a processor configured to execute computer executable components stored in a memory. The computer executable components include an estimation component and an assigning component. The estimation component is configured to determine an estimated interference associated with a data transmission by a wireless device over a plurality of subcarriers. The assigning component is configured to assign resources to the wireless device based at least in part on the estimated interference.

Additional aspects relate to an apparatus that includes means for determining an estimated interference associated with a data transmission by a wireless device over a plurality of subcarriers. The apparatus also includes means for assigning resources to the wireless device based at least in part on the estimated interference.

To the accomplishment of the foregoing and related ends, the one or more embodiments comprise the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth in detail certain illustrative aspects of the one or more embodiments. These aspects are indicative, however, of but a few of the various ways in which the principles of various embodiments can be employed and the described embodiments are intended to include all such aspects and their equivalents.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an exemplary wireless communication system.

FIG. 2 illustrates aspects of an exemplary wireless network environment.

FIG. 3 depicts additional aspects of a wireless communication system.

FIG. 4 shows an exemplary user equipment and network entity.

FIG. 5 is a block diagram of an exemplary interference management unit.

FIG. 6 shows a first exemplary coupling of electrical components that effectuate interference reduction in a wireless communication system.

FIG. 7 shows a second exemplary coupling of electrical components that effectuate interference reduction in a wireless communication system.

FIG. 8 shows an example methodology for reducing interference.

FIG. 9 illustrates an exemplary communication system having multiple wireless access technologies.

FIG. 10 shows an exemplary communication system having multiple cells.

FIG. 11 is a block diagram of an exemplary base station.

FIG. 12 is a block diagram of an exemplary wireless terminal

#### DETAILED DESCRIPTION

Various embodiments are now described with reference to the drawings, wherein like reference numerals are used to refer to like elements throughout. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of one or more embodiments. It may be evident, however, that such embodiment(s) may be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form in order to facilitate describing one or more embodiments.

Techniques for reducing interference in wireless systems are described herein. Among other things, transmitting signals in the presence of interference from intermodulation and/or harmonic products of received signals is discussed. In a particular embodiment, interference caused by the intermodulation and/or harmonic products are estimated, wherein the estimated interference is then used to zero out a set of log-likelihood ratio (LLR) metrics. In another embodiment, aspects are disclosed which avoid transmitting signals via subcarriers which may contribute to interference to received signals from intermodulation and/or harmonic products (hereinafter collectively referred to as “intermodulation products”).

The techniques described herein can be used for various wireless communication systems such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal frequency division multiple access (OFDMA), single carrier-frequency division multiple access (SC-FDMA), High Speed Packet Access (HSPA), and other systems. The terms “system” and “network” are often used interchangeably. A CDMA system can implement a radio technology such as Universal Terrestrial Radio Access (UTRA), CDMA2000, etc. UTRA includes Wideband-CDMA (W-CDMA) and other variants of CDMA. CDMA2000 covers IS-2000, IS-95 and IS-856 standards. A TDMA system can implement a radio technology such as Global System for Mobile Communications (GSM). An OFDMA system can implement a radio technology such as Evolved UTRA (E-UTRA), Ultra Mobile Broadband (UMB), IEEE 802.11 (Wi-Fi™), IEEE 802.16 (WiMAX), IEEE 802.20, Flash-OFDM, etc. UTRA and E-UTRA are part of Universal Mobile Telecommunication System (UMTS). 3GPP Long Term Evolution (LTE) is a release of

UMTS that uses E-UTRA, which employs OFDMA on the downlink and SC-FDMA on the uplink.

Single carrier frequency division multiple access (SC-FDMA) utilizes single carrier modulation and frequency domain equalization. SC-FDMA has similar performance and essentially the same overall complexity as those of an OFDMA system. A SC-FDMA signal has lower peak-to-average power ratio (PAPR) because of its inherent single carrier structure. SC-FDMA can be used, for instance, in uplink communications where lower PAPR greatly benefits access terminals in terms of transmit power efficiency. Accordingly, SC-FDMA can be implemented as an uplink multiple access scheme in 3GPP Long Term Evolution (LTE) or Evolved UTRA.

High speed packet access (HSPA) can include high speed downlink packet access (HSDPA) technology and high speed uplink packet access (HSUPA) or enhanced uplink (EUL) technology and can also include HSPA+ technology. HSDPA, HSUPA and HSPA+ are part of the Third Generation Partnership Project (3GPP) specifications Release 5, Release 6, and Release 7, respectively.

High speed downlink packet access (HSDPA) optimizes data transmission from the network to the user equipment (UE). As used herein, transmission from the network to the user equipment UE can be referred to as the “downlink” (DL). Transmission methods can allow data rates of several Mbits/s. High speed downlink packet access (HSDPA) can increase the capacity of mobile radio networks. High speed uplink packet access (HSUPA) can optimize data transmission from the terminal to the network. As used herein, transmissions from the terminal to the network can be referred to as the “uplink” (UL). Uplink data transmission methods can allow data rates of several Mbit/s. HSPA+ provides even further improvements both in the uplink and downlink as specified in Release 7 of the 3GPP specification. High speed packet access (HSPA) methods typically allow for faster interactions between the downlink and the uplink in data services transmitting large volumes of data, for instance Voice over IP (VoIP), videoconferencing and mobile office applications

Fast data transmission protocols such as hybrid automatic repeat request, (HARQ) can be used on the uplink and downlink. Such protocols allow a recipient to automatically request retransmission of a packet that might have been received in error.

Various embodiments are described herein in connection with an access terminal. An access terminal can also be called a system, subscriber unit, subscriber station, mobile station, mobile, remote station, remote terminal, mobile device, user terminal, terminal, wireless communication device, user agent, user device, or user equipment (UE). An access terminal can be a cellular telephone, a cordless telephone, a Session Initiation Protocol (SIP) phone, a wireless local loop (WLL) station, a personal digital assistant (PDA), a handheld device having wireless connection capability, computing device, or other processing device connected to a wireless modem. Moreover, various embodiments are described herein in connection with a base station. A base station can be utilized for communicating with access terminal(s) and can also be referred to as an access point, Node B, Evolved Node B (eNodeB), access point base station, or some other terminology.

Referring now to the drawings, FIG. 1 illustrates a wireless communication system in accordance with various embodiments presented herein. System 100 comprises a base station 102 that can include multiple antenna groups. For example, one antenna group can include antennas 104



and **106**, another group can comprise antennas **108** and **110**, and an additional group can include antennas **112** and **114**. Two antennas are illustrated for each antenna group; however, more or fewer antennas can be utilized for each group. Base station **102** can additionally include a transmitter chain and a receiver chain, each of which can in turn comprise a plurality of components associated with signal transmission and reception (e.g., processors, modulators, multiplexers, demodulators, demultiplexers, antennas, etc.), as will be appreciated by one skilled in the art.

Base station **102** can communicate with one or more access terminals such as access terminal **116** and access terminal **122**; however, it is to be appreciated that base station **102** can communicate with substantially any number of access terminals similar to access terminals **116** and **122**. Access terminals **116** and **122** can be, for example, cellular phones, smart phones, laptops, handheld communication devices, handheld computing devices, satellite radios, global positioning systems, PDAs, and/or any other suitable device for communicating over wireless communication system **100**. As depicted, access terminal **116** is in communication with antennas **112** and **114**, where antennas **112** and **114** transmit information to access terminal **116** over a forward link **118** and receive information from access terminal **116** over a reverse link **120**. Moreover, access terminal **122** is in communication with antennas **104** and **106**, where antennas **104** and **106** transmit information to access terminal **122** over a forward link **124** and receive information from access terminal **122** over a reverse link **126**. In a frequency division duplex (FDD) system, forward link **118** can utilize a different frequency band than that used by reverse link **120**, and forward link **124** can employ a different frequency band than that employed by reverse link **126**, for example. Further, in a time division duplex (TDD) system, forward link **118** and reverse link **120** can utilize a common frequency band and forward link **124** and reverse link **126** can utilize a common frequency band.

Each group of antennas and/or the area in which they are designated to communicate can be referred to as a sector of base station **102**. For example, antenna groups can be designed to communicate to access terminals in a sector of the areas covered by base station **102**. In communication over forward links **118** and **124**, the transmitting antennas of base station **102** can utilize beamforming to improve signal-to-noise ratio of forward links **118** and **124** for access terminals **116** and **122**. Using beamforming to transmit to access terminals scattered randomly through an associated coverage can also reduce interference to access terminals in neighboring cells.

FIG. 2 shows an exemplary wireless communication system **200** having a base station **210** and an access terminal **250**. For the sake of brevity, only one base station **210** and one access terminal **250** are shown. However, it will be appreciated that system **200** can include more than one base station and/or more than one access terminal, wherein additional base stations and/or access terminals can be substantially similar or different from the exemplary base station **210** and access terminal **250** described below. In addition, it is to be appreciated that base station **210** and/or access terminal **250** can employ the systems and/or methods described herein to facilitate wireless communication there between.

At base station **210**, traffic data for a number of data streams is provided from a data source **212** to a transmit (TX) data processor **214**. According to an example, each data stream can be transmitted over a respective antenna. TX data processor **214** formats, codes, and interleaves the traffic

data stream based on a particular coding scheme selected for that data stream to provide coded data.

The coded data for each data stream can be multiplexed with pilot data using orthogonal frequency division multiplexing (OFDM) techniques. Additionally or alternatively, the pilot symbols can be frequency division multiplexed (FDM), time division multiplexed (TDM), or code division multiplexed (CDM). The pilot data is typically a known data pattern that is processed in a known manner and can be used at access terminal **250** to estimate channel response. The multiplexed pilot and coded data for each data stream can be modulated (e.g., symbol mapped) based on a particular modulation scheme (e.g., binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), M-phase-shift keying (M-PSK), M-quadrature amplitude modulation (M-QAM), etc.) selected for that data stream to provide modulation symbols. The data rate, coding, and modulation for each data stream can be determined by instructions performed or provided by processor **230**.

The modulation symbols for the data streams can be provided to a TX MIMO processor **220**, which can further process the modulation symbols (e.g., for OFDM). TX MIMO processor **220** then provides  $N_T$  modulation symbol streams to  $N_T$  transmitters (TMTR) **222a** through **222t**. In various embodiments, TX MIMO processor **220** applies beamforming weights to the symbols of the data streams and to the antenna from which the symbol is being transmitted.

Each transmitter **222** receives and processes a respective symbol stream to provide one or more analog signals, and further conditions (e.g., amplifies, filters, and upconverts) the analog signals to provide a modulated signal suitable for transmission over the MIMO channel. Further,  $N_T$  modulated signals from transmitters **222a** through **222t** are transmitted from  $N_T$  antennas **224a** through **224t**, respectively.

At access terminal **250**, the transmitted modulated signals are received by  $N_R$  antennas **252a** through **252r** and the received signal from each antenna **252** is provided to a respective receiver (RCVR) **254a** through **254r**. Each receiver **254** conditions (e.g., filters, amplifies, and down-converts) a respective signal, digitizes the conditioned signal to provide samples, and further processes the samples to provide a corresponding "received" symbol stream.

An RX data processor **260** can receive and process the  $N_R$  received symbol streams from  $N_R$  receivers **254** based on a particular receiver processing technique to provide  $N_T$  "detected" symbol streams. RX data processor **260** can demodulate, deinterleave, and decode each detected symbol stream to recover the traffic data for the data stream. The processing by RX data processor **260** is complementary to that performed by TX MIMO processor **220** and TX data processor **214** at base station **210**.

A processor **270** can periodically determine which available technology to utilize as discussed above. Further, processor **270** can formulate a reverse link message comprising a matrix index portion and a rank value portion.

The reverse link message can comprise various types of information regarding the communication link (e.g., channel state information (CSI)) and/or the received data stream. The reverse link message can be processed by a TX data processor **238**, which also receives traffic data for a number of data streams from a data source **236**, modulated by a modulator **280**, conditioned by transmitters **254a** through **254r**, and transmitted to base station **210**.

At base station **210**, the modulated signals from access terminal **250** are received by antennas **224**, conditioned by receivers **222**, demodulated by a demodulator **240**, and processed by a RX data processor **242** to extract the reverse

link message transmitted by access terminal 250. Further, processor 230 can process the extracted message to determine which precoding matrix to use for determining the beamforming weights.

Processors 230 and 270 can direct (e.g., control, coordinate, manage, etc.) operation at base station 210 and access terminal 250, respectively. Respective processors 230 and 270 can be associated with memory 232 and 272 that store program codes and data. Processors 230 and 270 can also perform computations to derive frequency and impulse response estimates for the uplink and downlink, respectively.

Referring next to FIG. 3, an exemplary wireless communication system 300 configured to support a number of users is illustrated, in which various disclosed embodiments and aspects may be implemented. As shown in FIG. 3, by way of example, system 300 provides communication for multiple cells 302, such as, for example, macro cells 302a-302g, with each cell being serviced by a corresponding access point (AP) 304 (such as APs 304a-304g). Each cell may be further divided into one or more sectors (e.g. to serve one or more frequencies). Various access terminals (ATs) 306, including ATs 306a-306k, also known interchangeably as user equipment (UE) or mobile stations, are dispersed throughout the system. Each AT 306 may communicate with one or more APs 304 on a forward link (FL) and/or a reverse link (RL) at a given moment, depending upon whether the AT is active and whether it is in soft handoff, for example. The wireless communication system 300 may provide service over a large geographic region, for example, macro cells 302a-302g may cover a few blocks in a neighborhood.

ATs 306 can transmit on one or more carrier frequencies simultaneously. From the standpoint of ATs 306, parallel transmission on the uplink can include, among other things, non-contiguous carrier deployments or concurrent data transmission over multiple wireless access technologies (e.g., cellular, Wi-Fi, etc.). When an AT 306 is transmitting on frequencies  $f_1, f_2, \dots, f_n$ , intermodulation products are created at  $A_1 f_1 + A_2 f_2 + \dots + A_n f_n$  (e.g., locations, frequency locations) where  $A_1, A_2, \dots, A_n$  are integers, and where  $A_1 + A_2 + \dots + A_n$  is the intermodulation order. For example, third order products can be created at  $3 f_1$  or at  $2 f_1 - f_2$ . Intermodulation products are spurious waveforms that are generated due to the non-linearity of radio frequency (RF) elements such as a power amplifier in the transmit chain. If only one frequency or frequency range is involved in generating the spurious waveform, the products are commonly referred to as harmonics, whereas the products may be referred to generally as intermodulation products when more than one frequency is involved. As used herein, the term "intermodulation products" includes both harmonics and intermodulation products.

ATs 306 can receive downlink transmissions in any of the aforementioned frequency locations. For example, a downlink subcarrier may be located at  $2 f_1 - f_2$ . Intermodulation products associated with parallel data transmission on the uplink can interfere with and significantly degrade the signal-to-noise ratio (SINR) of the downlink reception. It is therefore desirable to mitigate the adverse impact of such intermodulation products on downlink subcarriers.

Turning now to FIG. 4, another exemplary wireless communication system 400 is illustrated. System 400 includes user equipment 410 (e.g., an access terminal) and network entity 420 (e.g., an access point), wherein user equipment 410 provides network entity 420 with an uplink communication, and wherein network entity 420 provides user equipment 410 with a downlink communication. As shown, user

equipment 410 may include an interference management unit 412. Network entity 420 may also include an interference management unit 422. Interference management units 412, 422 facilitate transmitting signals in the presence of intermodulation or harmonic products of received signals.

Consider the case in which  $f_1$  and  $f_2$  represent a set of subcarriers used for data transmission on an uplink, and in which the associated intermodulation products  $A f_1 + B f_2$  are in a downlink bandwidth  $W$  centered on a downlink subcarrier  $f_{DL}$ . [ $f_{DL} - W/2, f_{DL} + W/2$ ]. In this example, interference due to the intermodulation products can be high at downlink subcarrier  $f_{DL}$ . If unaccounted for in the decoding of the downlink, the decoding could fail due to the spurious log-likelihood ratios (LLRs) generated at this and other subcarriers affected by intermodulation products.

Interference management unit 412 and/or interference management unit 422 can be configured to estimate an interference to one or more downlink subcarriers from intermodulation products associated with the uplink data transmission and to compensate for the effects of such interference. For instance, it is contemplated that subcarriers can be identified where intermodulation products will be generated based on known frequency locations of an uplink data transmission. Interference management unit 412 of UE 410, for example, may process data received on the affected subcarriers by, among other things, zeroing log-likelihood ratios for modulation symbols on those subcarriers. On the other hand, interference management unit 420 of network entity 420 may assign uplink/downlink resources to UE 410 based on the estimated interference so as to mitigate the effect of the intermodulation products.

Note that it is also possible that neither  $f_1$  nor  $f_2$  is an intended transmission, but are themselves unwanted byproducts, such as a carrier leakage, an IQ image, or an intermodulation product created by a preceding component in the transmit chain. The location of these byproducts in a frequency may be predictable, in which case the same method of zeroing the LLRs or assigning resources can be applied.

Since there may be a large number of transmitted (uplink) subcarriers, calculating the locations of all relevant intermodulation products can be burdensome. Interference management unit 412 and/or interference management unit 422 can simplify such calculation by considering continuous occupied frequency intervals. For example, assume that the transmitted (uplink) subcarriers are confined in two distinct intervals  $[f_{1,Low} \dots f_{1,High}]$  and  $[f_{2,Low} \dots f_{2,High}]$  also assume that  $f_{1,High} > f_{2,Low}$ . In this example, third order intermodulation products will be located, for example, at  $[2 f_{1,Low} - f_{2,High} \dots 2 f_{1,High} - f_{2,Low}]$  and  $[2 f_{2,Low} - f_{1,High} \dots 2 f_{2,High} - f_{1,Low}]$  and also at  $[2 f_{1,Low} + f_{2,Low} \dots 2 f_{1,High} + f_{2,High}]$  and  $[2 f_{2,Low} + f_{1,Low} \dots 2 f_{2,High} + f_{1,High}]$ . This approach is also applicable when at least one of the transmitted waveforms is not orthogonal frequency-division multiplexing (OFDM), or is not composed of a set of distinct carriers, but rather includes a continuum of frequencies (e.g., in the case of CDMA, or analog signals).

Additionally or alternatively, the interference management unit 412 and/or interference management unit 422 can select a set of uplink carriers such that associated intermodulation products do not overlap with a received signal. For example, if when both WiFi and LTE-A are utilized, a WiFi uplink carrier may be selected so that the intermodulation products or harmonics do not overlap with a downlink LTE-A carrier.

It should also be noted that estimating intermodulation products can be performed by a base station and/or mobile device within a communication system. In one example, a

base station may make downlink and uplink assignments to a mobile device, and based on the uplink data transmission, the base station can schedule a downlink assignment so as to avoid the subcarriers associated with the intermodulation products. Different mobile devices can be assigned to different uplink and downlink subcarriers so that intermodulation products may be avoided for each mobile device, while making use of the entire uplink and downlink bandwidth. In another example, the mobile device may indicate to the base station the locations where the intermodulation products or harmonics may be expected (e.g. depending on the technologies it is using).

Referring next to FIG. 5, an exemplary interference management unit that facilitates interference reduction is illustrated. As shown, interference management unit **500** may include processor component **510**, memory component **520**, reception component **530**, transmission component **540**, estimation component **550**, signal processing component **560**, communication component **570**, and assigning component **580**.

In one aspect, processor component **510** is configured to execute computer-readable instructions related to performing any of a plurality of functions. Processor component **510** can be a single processor or a plurality of processors which analyze information to be communicated from interference management unit **500** and/or generate information that is utilized by memory component **520**, reception component **530**, transmission component **540**, estimation component **550**, signal processing component **560**, communication component **570**, and/or assigning component **580**. Additionally or alternatively, processor component **510** may be configured to control one or more components of interference management unit **500**.

In another aspect, memory component **520** is coupled to processor component **510** and configured to store computer-readable instructions executed by processor component **510**. Memory component **520** may also be configured to store any of a plurality of other types of data including generated by any of reception component **530**, transmission component **540**, estimation component **550**, signal processing component **560**, communication component **570**, and/or assigning component **580**. Memory component **520** can be configured in a number of different configurations, including as random access memory, battery-backed memory, hard disk, magnetic tape, etc. Various features can also be implemented upon memory component **520**, such as compression and automatic back up (e.g., use of a Redundant Array of Independent Drives configuration).

In a first exemplary embodiment, interference management unit **500** may be configured to compensate signal transmissions associated with intermodulation products which interfere with received signals. Within such embodiment, reception component **530** may be configured to determine at least one subcarrier on a first frequency, whereas transmission component **540** may be configured to identify at least two subcarriers on a second frequency. For this embodiment, a signal reception is facilitated by the at least one subcarrier, whereas a signal transmission is facilitated by the at least two subcarriers. In an aspect, the signal reception is facilitated by a first air interface technology, whereas the signal transmission is facilitated by a second air interface technology different than the first air interface technology. It is also, however, contemplated that the signal reception and the signal transmission are facilitated by a common air interface technology.

In a further aspect, signal transmissions may be facilitated by either a set of distinct carriers and/or a continuum of

frequencies. For instance, with respect to transmissions via a set of distinct carriers, the signal transmission may be an orthogonal frequency-division multiplexing (OFDM) transmission. On the other hand, for transmissions via a continuum of frequencies, the signal transmission may be a code division multiple access (CDMA) transmission or an analog transmission, for example.

As illustrated, interference management unit **500** may also include estimation component **550** and signal processing component **560**. Estimation component **550** may be configured to determine an estimated interference to at least one subcarrier associated with at least one of an intermodulation product, whereas signal processing component **560** can be configured to process the at least one subcarrier based on the estimated interference. Here, it should be noted that signal processing component **560** may be configured to utilize the estimated interference to process the at least one sub-carrier in any of a plurality of ways. For instance, signal processing component **560** may be configured to demodulate the at least one subcarrier, as well as to decode the at least one subcarrier. However, signal processing component **560** may also be configured to reset a set of log-likelihood ratio metrics associated with the at least one subcarrier. For example, signal processing component **560** may be configured to set the set of log-likelihood ratio metrics to zero.

Interference management unit **500** may be configured to avoid transmitting signals via subcarriers which reduce interference to received signals from intermodulation products. In one aspect, reception component **530** may be configured to determine at least one subcarrier on a first frequency, whereas transmission component **540** can be configured to perform a selection of at least two subcarriers on a second frequency. The transmission component **540** can perform the selection so as to avoid an overlap between the at least one subcarrier and at least one of an intermodulation product or a harmonic product associated with the at least two subcarriers. Communication component **570** can be configured to transmit on the at least two subcarriers via an uplink communication in the case of user equipment **410** or via a downlink communication in the case of network entity **420**. For instance, communication component **570** may be configured to provide an uplink communication via the at least two subcarriers, wherein the signal reception facilitated by reception component **530** is associated with a downlink. Within such embodiment, transmission component **540** may be configured to select the at least two subcarriers based on an assignment provided by a network. Alternatively, communication component **570** may be configured to provide a downlink communication via the at least two subcarriers, wherein the signal reception facilitated by reception component **530** is associated with an uplink.

In a particular embodiment, interference management unit **500** resides within user equipment (e.g., user equipment **410**). In one aspect, estimation component **550** may be configured to determine an estimated interference associated with a data transmission over a plurality of subcarriers on an uplink, whereas signal processing component **560** may be configured to process data received over at least one subcarrier on a downlink based at least in part on the estimated interference. Here, it should be noted that estimation component **550** may be configured to ascertain the estimated interference in any of a plurality of ways. For instance, estimation component **550** may be configured to determine a set of intermodulation products associated with the plurality of subcarriers. Indeed, within such embodiment, estimation component **550** may be further configured to identify the at least one subcarrier as having a frequency within a

range of frequencies related to the set of intermodulation products associated with the plurality of subcarriers. For this embodiment, signal processing component **560** may be configured to zero a log-likelihood ratio (LLR) for modulation symbols of the at least one subcarrier.

When implementing interference management unit **500** within user equipment (e.g., user equipment **410**), it should also be noted that communication component **570** may include any of multiple further configurations as well. For instance, communication component **570** may be configured to suspend the data transmission on at least one of the plurality of subcarriers based at least in part on the estimated interference. For this particular embodiment, communication component **570** may be further configured to suspend the data transmission in response to a scheduling from a base station (e.g., network entity **420**). In another embodiment, communication component **570** may be configured to transmit a set of information relating to the estimated interference to a base station (e.g., network entity **420**), wherein the set of information may, for example, comprise frequency locations of intermodulation products associated with the plurality of subcarriers.

Various other aspects directed towards implementing interference management unit **500** within user equipment (e.g., user equipment **410**) are also contemplated. For instance, transmission component **540** may be configured to select a subcarrier for transmitting data on the uplink based at least in part on the estimated interference. Also, with respect to particular subcarrier characteristics, it should be noted that the plurality of subcarriers may comprise a plurality of discontinuous subcarriers available for a parallel data transmission on the uplink. It is also contemplated that the plurality of subcarriers may comprise a first set of subcarriers associated with a first wireless access technology and second set of subcarriers associated with a second wireless access technology. For example, the first wireless access technology may comprise a long term evolution system, whereas the second wireless access technology may comprise a code division multiple access (CDMA) system or a wireless fidelity (WiFi) system. In another embodiment, interference management unit **500** resides within a network entity (e.g., network entity **420**). In one aspect, estimation component **550** may be configured to ascertain an estimated interference associated with a data transmission by a wireless device over a plurality of subcarriers, whereas assigning component **580** may be configured to assign resources to the wireless device based at least in part on the estimated interference. Here, it should be noted that either of estimation component **550** or assigning component **580** may have any of multiple further configurations. For instance, estimation component **550** may be further configured to determine a set of intermodulation products associated with the plurality of subcarriers, and assigning component **580** may be further configured to schedule the wireless device on either an uplink subcarrier or a downlink subcarrier.

When implementing interference management unit **500** within a network entity (e.g., network entity **420**), it should also be noted that communication component **570** may include any of multiple further configurations as well. For instance, communication component **570** may be configured to receive an indication from the wireless device relating to frequency locations of intermodulation products associated with the plurality of subcarriers, wherein estimation component **550** may be configured to ascertain the estimated interference based at least in part on the indication received from the wireless device. For this particular embodiment, the frequency locations of intermodulation products associ-

ated with the plurality of subcarriers may be related to data transmissions of the wireless device over at least a first wireless access technology and a second wireless access technology. For instance, the first wireless access technology may comprise a long term evolution system, whereas the second wireless access technology may be a code division multiple access (CDMA) system or a wireless fidelity (WiFi) system.

Turning to FIG. 6, illustrated is a system **600** that facilitates an interference reduction according to an embodiment. System **600** and/or instructions for implementing system **600** can reside within user equipment (e.g., user equipment **410**). As depicted, system **600** includes functional blocks that can represent functions implemented by a processor using instructions and/or data from a computer readable storage medium. System **600** includes a logical grouping **602** of electrical components that can act in conjunction. As illustrated, logical grouping **602** can include an electrical component for estimating an estimated interference associated with a data transmission over a plurality of subcarriers on an uplink **610**. Logical grouping **602** can also include an electrical component for processing data received over at least one subcarrier on a downlink based at least in part on the estimated interference **612**. Additionally, system **600** can include a memory **620** that retains instructions and/or data for executing functions associated with electrical components **610** and **612**. While shown as being external to memory **620**, it is to be understood that electrical components **610** and **612** can exist within memory **620**.

Referring next to FIG. 7, illustrated is another exemplary system **700** that facilitates interference reduction. System **700** and/or instructions for implementing system **700** can physically reside within a network entity (e.g., network entity **420**), for instance, wherein system **700** includes functional blocks that can represent functions implemented by a processor using instructions and/or data from a computer readable storage medium. System **700** includes a logical grouping **702** of electrical components that can act in conjunction similar to logical grouping **602** in system **600**. As illustrated, logical grouping **702** can include an electrical component for estimating an estimated interference associated with a data transmission by a wireless device over a plurality of subcarriers **710**. Logical grouping **702** can also include an electrical component for assigning resources to the wireless device based at least in part on the estimated interference **712**. Additionally, system **700** can include a memory **720** that retains instructions and/or data for executing functions associated with electrical components **710** and **712**. While shown as being external to memory **720**, it is to be understood that electrical components **710** and **712** can exist within memory **720**.

Referring next to FIG. 8, an example process is shown for facilitating an interference reduction in wireless communications. As illustrated, process **800** includes a series of operations that may be performed by a wireless terminal or network entity. For instance, process **800** may be implemented by employing a processor to execute computer executable instructions stored on a computer readable storage medium to implement the series of operations.

In an aspect, process **800** begins with a signal being received at **810**. At **820**, intermodulation or harmonic products within the received signal are identified. Once the intermodulation or harmonic products have been identified, process **800** determines, at **830**, whether intermodulation or harmonic products may cause interference that should be avoided in a subsequent signal transmission.

If the interference is to be avoided, processing proceeds to **840** where candidate alternative sub-carriers for transmission are ascertained. In one aspect, sub-carriers which do not overlap with the intermodulation or harmonic products of the received signal are identified. Once the candidate sub-carriers are identified, particular sub-carriers are selected for transmission at **850**. At **860**, a signal is transmitted using the selected sub-carriers.

However, if it is determined at **830** that the interference is not to be avoided by selection of sub-carriers, processing proceeds to **835** where the interference caused by the intermodulation or harmonic products is estimated. The received signal is then processed at **845** based at least in part on the estimated interference and at **860** a signal is transmitted. Here, it should be noted that such processing may, for example, include demodulating and/or decoding the received signal according to the estimated interference. The processing may also include resetting a set of log-likelihood ratio metrics associated with the received signal, wherein the resetting comprises setting the set of log-likelihood ratio metrics to zero.

In a particular aspect, it should be noted that intermodulation products and/or harmonics may result from multicarrier communications involving different types of wireless networks. In FIG. 9, an exemplary system is illustrated in which user equipment **910** transmits uplink communications to each of long term evolution (LTE) network **920** and Wi-Fi network **930**. For this particular example, the uplink communication transmitted to long term evolution (LTE) network **920** is transmitted via a first frequency  $f_1$ , whereas the uplink communication transmitted to WiFi network **930** is transmitted via a second frequency  $f_2$ . As illustrated, such uplink transmissions may create intermodulation products and/or harmonics  $A_1f_1+A_2f_2$ , which may interfere with downlink communications received from either of long term evolution (LTE) network **920** or wireless fidelity (WiFi) network **930**.

#### Exemplary Communication System

Referring next to FIG. 10, an exemplary communication system **1000** having multiple cells (e.g., cell **1002**, cell **1004**) is illustrated. Here, it should be noted that neighboring cells **1002**, **1004** overlap slightly, as indicated by cell boundary region **1068**, thereby creating potential for signal interference between signals transmitted by base stations in neighboring cells. Each cell **1002**, **1004** of system **1000** includes three sectors. Cells which have not been subdivided into multiple sectors ( $N=1$ ), cells with two sectors ( $N=2$ ) and cells with more than 3 sectors ( $N>3$ ) can also be utilized. Cell **1002** includes a first sector, sector I **1010**, a second sector, sector II **1012**, and a third sector, sector III **1014**. Each sector **1010**, **1012**, and **1014** has two sector boundary regions; each boundary region is shared between two adjacent sectors.

Interference between signals transmitted by base stations in neighboring sectors can occur in boundary regions. Line **1016** represents a sector boundary region between sector I **1010** and sector II **1012**; line **1018** represents a sector boundary region between sector II **1012** and sector III **1014**; line **1020** represents a sector boundary region between sector III **1014** and sector I **1010**. Similarly, cell M **1004** includes a first sector, sector I **1022**, a second sector, sector II **1024**, and a third sector, sector III **1026**. Line **1028** represents a sector boundary region between sector I **1022** and sector II **1024**; line **1030** represents a sector boundary region between sector II **1024** and sector III **1026**; line **1032** represents a boundary region between sector III **1026** and sector I **1022**. Cell I **1002** includes a base station (BS), base

station I **1006**, and a plurality of end nodes (ENs) in each sector **1010**, **1012**, **1014**. Sector I **1010** includes EN(1) **1036** and EN(X) **1038** coupled to BS **1006** via wireless links **1040**, **1042**, respectively; sector II **1012** includes EN(1') **1044** and EN(X') **1046** coupled to BS **1006** via wireless links **1048**, **1050**, respectively; sector III **1014** includes EN(1'') **1052** and EN(X'') **1054** coupled to BS **1006** via wireless links **1056**, **1058**, respectively. Similarly, cell M **1004** includes base station M **1008**, and a plurality of end nodes (ENs) in each sector **1022**, **1024**, and **1026**. Sector I **1022** includes EN(1) **1036'** and EN(X) **1038'** coupled to BS M **1008** via wireless links **1040'**, **1042'**, respectively; sector II **1024** includes EN(1') **1044'** and EN(X') **1046'** coupled to BS M **1008** via wireless links **1048'**, **1050'**, respectively; sector III **1026** includes EN(1'') **1052'** and EN(X'') **1054'** coupled to BS **1008** via wireless links **1056'**, **1058'**, respectively.

System **1000** also includes a network node **1060** which is coupled to BS I **1006** and BS M **1008** via network links **1062**, **1064**, respectively. Network node **1060** is also coupled to other network nodes, e.g., other base stations, AAA server nodes, intermediate nodes, routers, etc. and the Internet via network link **1066**. Network links **1062**, **1064**, **1066** may be, e.g., fiber optic cables. Each end node, e.g. EN **1036** may be a wireless terminal including a transmitter as well as a receiver. The wireless terminals, e.g., EN(1) **1036** may move through system **1000** and may communicate via wireless links with the base station in the cell in which the EN is currently located. The wireless terminals, (WTs), e.g. EN(1) **1036**, may communicate with peer nodes, e.g., other WTs in system **1000** or outside system **1000** via a base station, e.g. BS **1006**, and/or network node **1060**. WTs, e.g., EN(1) **1036** may be mobile communications devices such as cell phones, personal data assistants with wireless modems, etc. Respective base stations perform tone subset allocation using a different method for the strip-symbol periods, from the method employed for allocating tones and determining tone hopping in the rest symbol periods, e.g., non strip-symbol periods. The wireless terminals use the tone subset allocation method along with information received from the base station, e.g., base station slope ID, sector ID information, to determine tones that they can employ to receive data and information at specific strip-symbol periods. The tone subset allocation sequence is constructed, in accordance with various aspects to spread inter-sector and inter-cell interference across respective tones. Although the subject system was described primarily within the context of cellular mode, it is to be appreciated that a plurality of modes may be available and employable in accordance with aspects described herein.

#### Exemplary Base Station

FIG. 11 illustrates an example base station **1100**. Base station **1100** implements tone subset allocation sequences, with different tone subset allocation sequences generated for respective different sector types of the cell. Base station **1100** may be used as any one of base stations **1006**, **1008** of the system **1000** of FIG. 10. The base station **1100** includes a receiver **1102**, a transmitter **1104**, a processor **1106**, e.g., CPU, an input/output interface **1108** and memory **1110** coupled together by a bus **1109** over which various elements **1102**, **1104**, **1106**, **1108**, and **1110** may interchange data and information.

Sectorized antenna **1103** coupled to receiver **1102** is used for receiving data and other signals, e.g., channel reports, from wireless terminals transmissions from each sector within the base station's cell. Sectorized antenna **1105** coupled to transmitter **1104** is used for transmitting data and other signals, e.g., control signals, pilot signal, beacon

signals, etc. to wireless terminals **1200** (see FIG. **12**) within each sector of the base station's cell. In various aspects, base station **1100** may employ multiple receivers **1102** and multiple transmitters **1104**, e.g., an individual receivers **1102** for each sector and an individual transmitter **1104** for each sector. Processor **1106**, may be, e.g., a general purpose central processing unit (CPU). Processor **1106** controls operation of base station **1100** under direction of one or more routines **1118** stored in memory **1110** and implements the methods. I/O interface **1108** provides a connection to other network nodes, coupling the BS **1100** to other base stations, access routers, AAA server nodes, etc., other networks, and the Internet. Memory **1110** includes routines **1118** and data/information **1120**.

Data/information **1120** includes data **1136**, tone subset allocation sequence information **1138** including downlink strip-symbol time information **1140** and downlink tone information **1142**, and wireless terminal (WT) data/info **1144** including a plurality of sets of WT information: WT **1** info **1146** and WT **N** info **1160**. Each set of WT info, e.g., WT **1** info **1146** includes data **1148**, terminal ID **1150**, sector ID **1152**, uplink channel information **1154**, downlink channel information **1156**, and mode information **1158**.

Routines **1118** include communications routines **1122** and base station control routines **1124**. Base station control routines **1124** includes a scheduler module **1126** and signaling routines **1128** including a tone subset allocation routine **1130** for strip-symbol periods, other downlink tone allocation hopping routine **1132** for the rest of symbol periods, e.g., non strip-symbol periods, and a beacon routine **1134**.

Data **1136** includes data to be transmitted that will be sent to encoder **1114** of transmitter **1104** for encoding prior to transmission to WTs, and received data from WTs that has been processed through decoder **1112** of receiver **1102** following reception. Downlink strip-symbol time information **1140** includes the frame synchronization structure information, such as the superslot, beaconslot, and ultraslot structure information and information specifying whether a given symbol period is a strip-symbol period, and if so, the index of the strip-symbol period and whether the strip-symbol is a resetting point to truncate the tone subset allocation sequence used by the base station. Downlink tone information **1142** includes information including a carrier frequency assigned to the base station **1100**, the number and frequency of tones, and the set of tone subsets to be allocated to the strip-symbol periods, and other cell and sector specific values such as slope, slope index and sector type.

Data **1148** may include data that WT1 **1200** has received from a peer node, data that WT **1** **1200** desires to be transmitted to a peer node, and downlink channel quality report feedback information. Terminal ID **1150** is a base station **1100** assigned ID that identifies WT **1** **1200**. Sector ID **1152** includes information identifying the sector in which WT1 **1200** is operating. Sector ID **1152** can be used, for example, to determine the sector type. Uplink channel information **1154** includes information identifying channel segments that have been allocated by scheduler **1126** for WT1 **1200** to use, e.g., uplink traffic channel segments for data, dedicated uplink control channels for requests, power control, timing control, etc. Each uplink channel assigned to WT1 **1200** includes one or more logical tones, each logical tone following an uplink hopping sequence. Downlink channel information **1156** includes information identifying channel segments that have been allocated by scheduler **1126** to carry data and/or information to WT1 **1200**, e.g., downlink traffic channel segments for user data. Each downlink channel assigned to WT1 **1200** includes one or more logical

tones, each following a downlink hopping sequence. Mode information **1158** includes information identifying the state of operation of WT1 **1200**, e.g. sleep, hold, on.

Communications routines **1122** are utilized by base station **1100** to perform various communications operations and implement various communications protocols. Base station control routines **1124** are used to control the base station **1100** to perform basic base station functional tasks, e.g., signal generation and reception, scheduling, and to implement the steps of the method of some aspects including transmitting signals to wireless terminals using the tone subset allocation sequences during the strip-symbol periods.

Signaling routine **1128** controls the operation of receiver **1102** with its decoder **1112** and transmitter **1104** with its encoder **1114**. The signaling routine **1128** is responsible controlling the generation of transmitted data **1136** and control information. Tone subset allocation routine **1130** constructs the tone subset to be used in a strip-symbol period using the method of the aspect and using data/info **1120** including downlink strip-symbol time info **1140** and sector ID **1152**. The downlink tone subset allocation sequences will be different for each sector type in a cell and different for adjacent cells. The WTs **1200** receive the signals in the strip-symbol periods in accordance with the downlink tone subset allocation sequences; the base station **1100** uses the same downlink tone subset allocation sequences in order to generate the transmitted signals. Other downlink tone allocation hopping routine **1132** constructs downlink tone hopping sequences, using information including downlink tone information **1142**, and downlink channel information **1156**, for the symbol periods other than the strip-symbol periods. The downlink data tone hopping sequences are synchronized across the sectors of a cell. Beacon routine **1134** controls the transmission of a beacon signal, e.g., a signal of relatively high power signal concentrated on one or a few tones, which may be used for synchronization purposes, e.g., to synchronize the frame timing structure of the downlink signal and therefore the tone subset allocation sequence with respect to an ultra-slot boundary.

#### Exemplary Wireless Terminal

FIG. **12** illustrates an example wireless terminal (end node) **1200** which can be used as any one of the wireless terminals (end nodes), e.g., EN(1) **1036**, of the system **1000** shown in FIG. **10**. Wireless terminal **1200** implements the tone subset allocation sequences. The wireless terminal **1200** includes a receiver **1202** including a decoder **1212**, a transmitter **1204** including an encoder **1214**, a processor **1206**, and memory **1208** which are coupled together by a bus **1210** over which the various elements **1202**, **1204**, **1206**, **1208** can interchange data and information. An antenna **1203** used for receiving signals from a base station (and/or a disparate wireless terminal) is coupled to receiver **1202**. An antenna **1205** used for transmitting signals, e.g., to a base station (and/or a disparate wireless terminal) is coupled to transmitter **1204**.

The processor **1206**, e.g., a CPU controls the operation of the wireless terminal **1200** and implements methods by executing routines **1220** and using data/information **1222** in memory **1208**.

Data/information **1222** includes user data **1234**, user information **1236**, and tone subset allocation sequence information **1250**. User data **1234** may include data, intended for a peer node, which will be routed to encoder **1214** for encoding prior to transmission by transmitter **1204** to a base station, and data received from the base station which has been processed by the decoder **1212** in receiver **1202**. User information **1236** includes uplink channel information **1238**,

downlink channel information **1240**, terminal ID information **1242**, base station ID information **1244**, sector ID information **1246**, and mode information **1248**. Uplink channel information **1238** includes information identifying uplink channels segments that have been assigned by a base station for wireless terminal **1200** to use when transmitting to the base station. Uplink channels may include uplink traffic channels, dedicated uplink control channels, e.g., request channels, power control channels and timing control channels. Each uplink channel includes one or more logic tones, each logical tone following an uplink tone hopping sequence. The uplink hopping sequences are different between each sector type of a cell and between adjacent cells. Downlink channel information **1240** includes information identifying downlink channel segments that have been assigned by a base station to WT **1200** for use when the base station is transmitting data/information to WT **1200**. Downlink channels may include downlink traffic channels and assignment channels, each downlink channel including one or more logical tone, each logical tone following a downlink hopping sequence, which is synchronized between each sector of the cell.

User info **1236** also includes terminal ID information **1242**, which is a base station-assigned identification, base station ID information **1244** which identifies the specific base station that WT has established communications with, and sector ID info **1246** which identifies the specific sector of the cell where WT **1200** is presently located. Base station ID **1244** provides a cell slope value and sector ID info **1246** provides a sector index type; the cell slope value and sector index type may be used to derive tone hopping sequences. Mode information **1248** also included in user info **1236** identifies whether the WT **1200** is in sleep mode, hold mode, or on mode.

Tone subset allocation sequence information **1250** includes downlink strip-symbol time information **1252** and downlink tone information **1254**. Downlink strip-symbol time information **1252** include the frame synchronization structure information, such as the superslot, beaconslot, and ultraslot structure information and information specifying whether a given symbol period is a strip-symbol period, and if so, the index of the strip-symbol period and whether the strip-symbol is a resetting point to truncate the tone subset allocation sequence used by the base station. Downlink tone info **1254** includes information including a carrier frequency assigned to the base station, the number and frequency of tones, and the set of tone subsets to be allocated to the strip-symbol periods, and other cell and sector specific values such as slope, slope index and sector type.

Routines **1220** include communications routines **1224** and wireless terminal control routines **1226**. Communications routines **1224** control the various communications protocols used by WT **1200**. Wireless terminal control routines **1226** controls basic wireless terminal **1200** functionality including the control of the receiver **1202** and transmitter **1204**. Wireless terminal control routines **1226** include the signaling routine **1228**. The signaling routine **1228** includes a tone subset allocation routine **1230** for the strip-symbol periods and an other downlink tone allocation hopping routine **1232** for the rest of symbol periods, e.g., non strip-symbol periods. Tone subset allocation routine **1230** uses user data/info **1222** including downlink channel information **1240**, base station ID info **1244**, e.g., slope index and sector type, and downlink tone information **1254** in order to generate the downlink tone subset allocation sequences in accordance with some aspects and process received data transmitted from the base station. Other downlink tone allocation hop-

ping routine **1232** constructs downlink tone hopping sequences, using information including downlink tone information **1254**, and downlink channel information **1240**, for the symbol periods other than the strip-symbol periods. Tone subset allocation routine **1230**, when executed by processor **1206**, is used to determine when and on which tones the wireless terminal **1200** is to receive one or more strip-symbol signals from the base station **1100**. The uplink tone allocation hopping routine **1232** uses a tone subset allocation function, along with information received from the base station, to determine the tones in which it should transmit on.

In one or more exemplary embodiments, the functions described may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Computer-readable media includes both computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A storage media may be any available media that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code in the form of instructions or data structures and that can be accessed by a computer. Also, any connection is properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of medium. Disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk and blu-ray disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above should also be included within the scope of computer-readable media.

When the embodiments are implemented in program code or code segments, it should be appreciated that a code segment can represent a procedure, a function, a subprogram, a program, a routine, a subroutine, a module, a software package, a class, or any combination of instructions, data structures, or program statements. A code segment can be coupled to another code segment or a hardware circuit by passing and/or receiving information, data, arguments, parameters, or memory contents. Information, arguments, parameters, data, etc. can be passed, forwarded, or transmitted using any suitable means including memory sharing, message passing, token passing, network transmission, etc. Additionally, in some aspects, the steps and/or actions of a method or algorithm can reside as one or any combination or set of codes and/or instructions on a machine readable medium and/or computer readable medium, which can be incorporated into a computer program product.

For a software implementation, the techniques described herein can be implemented with modules (e.g., procedures, functions, and so on) that perform the functions described herein. The software codes can be stored in memory units and executed by processors. The memory unit can be implemented within the processor or external to the processor, in which case it can be communicatively coupled to the processor via various means as is known in the art.



For a hardware implementation, the processing units can be implemented within one or more application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, micro-controllers, microprocessors, other electronic units designed to perform the functions described herein, or a combination thereof

What has been described above includes examples of one or more embodiments. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing the aforementioned embodiments, but one of ordinary skill in the art may recognize that many further combinations and permutations of various embodiments are possible. Accordingly, the described embodiments are intended to embrace all such alterations, modifications and variations that fall within the spirit and scope of the appended claims. Furthermore, to the extent that the term “includes” is used in either the detailed description or the claims, such term is intended to be inclusive in a manner similar to the term “comprising” as “comprising” is interpreted when employed as a transitional word in a claim.

As used herein, the term to “infer” or “inference” refers generally to the process of reasoning about or inferring states of the system, environment, and/or user from a set of observations as captured via events and/or data. Inference can be employed to identify a specific context or action, or can generate a probability distribution over states, for example. The inference can be probabilistic—that is, the computation of a probability distribution over states of interest based on a consideration of data and events. Inference can also refer to techniques employed for composing higher-level events from a set of events and/or data. Such inference results in the construction of new events or actions from a set of observed events and/or stored event data, whether or not the events are correlated in close temporal proximity, and whether the events and data come from one or several event and data sources.

Furthermore, as used in this application, the terms “component,” “module,” “system,” and the like are intended to refer to a computer-related entity, either hardware, firmware, a combination of hardware and software, software, or software in execution. For example, a component can be, but is not limited to being, a process running on a processor, a processor, an object, an executable, a thread of execution, a program, and/or a computer. By way of illustration, both an application running on a computing device and the computing device can be a component. One or more components can reside within a process and/or thread of execution and a component can be localized on one computer and/or distributed between two or more computers. In addition, these components can execute from various computer readable media having various data structures stored thereon. The components can communicate by way of local and/or remote processes such as in accordance with a signal having one or more data packets (e.g., data from one component interacting with another component in a local system, distributed system, and/or across a network such as the Internet with other systems by way of the signal).

What is claimed is:

**1.** A method of wireless communication, comprising:  
determining an estimated interference associated with a data transmission over a plurality of subcarriers on an uplink;  
transmitting a set of information relating to the estimated interference to a base station, wherein the set of infor-

mation comprises frequency locations of intermodulation products associated with the plurality of subcarriers; and

processing data received over at least one subcarrier on a downlink based at least in part on the estimated interference, wherein processing data received over the at least one subcarrier comprises zeroing a log-likelihood ratio (LLR) for modulation symbols of the at least one subcarrier.

**2.** The method of claim **1**, wherein determining the estimated interference comprises determining intermodulation products associated with the plurality of subcarriers.

**3.** The method of claim **2** wherein determining the estimated interference comprises identifying the at least one subcarrier as having a frequency within a range of frequencies related to the intermodulation products.

**4.** The method of claim **1**, further comprising suspending the data transmission on at least one of the plurality of subcarriers based at least in part on the estimated interference.

**5.** The method of claim **4**, wherein suspending the data transmission is responsive to a scheduling from a base station.

**6.** The method of claim **1**, further comprising selecting a subcarrier for transmitting data on the uplink based at least in part on the estimated interference.

**7.** The method of claim **1**, wherein the plurality of subcarriers comprise a first set of subcarriers associated with a first wireless access technology and second set of subcarriers associated with a second wireless access technology.

**8.** The method of claim **7**, wherein the first wireless access technology comprises a long term evolution (LTE) system and the second wireless access technology is one of a code division multiple access (CDMA) system or a WiFi system.

**9.** The method of claim **1**, wherein the plurality of subcarriers comprise a plurality of discontinuous subcarriers available for a parallel data transmission on the uplink.

**10.** An wireless communications apparatus, comprising:

a processor configured to execute computer executable components stored in a memory, including:

an estimation component configured to determine an estimated interference associated with a data transmission over a plurality of subcarriers on an uplink;  
a communication component configured to transmit a set of information relating to the estimated interference to a base station, wherein the set of information comprises frequency locations of intermodulation products associated with the plurality of subcarriers; and

a signal processing component configured to process data received over at least one subcarrier on a downlink based at least in part on the estimated interference and configured to zero a log-likelihood ratio (LLR) for modulation symbols of the at least one subcarrier.

**11.** The apparatus of claim **10**, wherein the estimation component is configured to determine intermodulation products associated with the plurality of subcarriers.

**12.** The apparatus of claim **11**, wherein the estimation component is configured to identify the at least one subcarrier as having a frequency within a range of frequencies related to intermodulation products.

**13.** The apparatus of claim **10**, further comprising a communication component configured to suspend the data transmission on at least one of the plurality of subcarriers based at least in part on the estimated interference.



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14. The apparatus of claim 13, wherein the communication component is configured to suspend the data transmission in response to a scheduling from a base station.

15. The apparatus of claim 10, further comprising a transmission component configured to select a subcarrier for transmitting data on the uplink based at least in part on the estimated interference.

16. The apparatus of claim 10, wherein the plurality of subcarriers comprise a first set of subcarriers associated with a first wireless access technology and second set of subcarriers associated with a second wireless access technology.

17. The apparatus of claim 16, wherein the first wireless access technology comprises a long term evolution (LTE) system and the second wireless access technology is one of a code division multiple access (CDMA) system or a WiFi system.

18. The apparatus of claim 10, wherein the plurality of subcarriers comprise a plurality of discontinuous subcarriers available for a parallel data transmission on the uplink.

19. A computer program product that facilitates wireless communication, comprising:

a non-transitory computer-readable storage medium comprising code for causing at least one computer to:

determine an estimated interference associated with a data transmission over a plurality of subcarriers on an uplink;

transmit a set of information relating to the estimated interference to a base station, wherein the set of information comprises frequency locations of intermodulation products associated with the plurality of subcarriers; and

process data received over at least one subcarrier on a downlink based at least in part on the estimated interference by zeroing a log-likelihood ratio (LLR) for modulation symbols of the at least one subcarrier.

20. An wireless communications apparatus, the apparatus comprising:

means for determining an estimated interference associated with a data transmission over a plurality of subcarriers on an uplink;

means for transmitting a set of information relating to the estimated interference to a base station, wherein the set of information comprises frequency locations of intermodulation products associated with the plurality of subcarriers; and

means for processing data received over at least one subcarrier on a downlink based at least in part on the estimated interference, wherein the means for processing data received over the at least one subcarrier comprises means for zeroing a log-likelihood ratio (LLR) for modulation symbols of the at least one subcarrier.

21. A method of wireless communication, comprising: determining an estimated interference associated with a data transmission by a wireless device over a plurality of subcarriers;

receiving an indication from the wireless device relating to frequency locations of intermodulation products associated with the plurality of subcarriers; and assigning resources to the wireless device based at least in part on the estimated interference.

22. The method of claim 21, wherein determining the estimated interference comprises determining intermodulation products associated with the plurality of subcarriers.

23. The method of claim 21, wherein determining the estimated interference is based at least in part on the indication received from the wireless device.

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24. The method of claim 23, wherein the frequency locations of the intermodulation products are related to data transmissions of the wireless device over at least a first wireless access technology and a second wireless access technology.

25. The method of claim 24, wherein the first wireless access technology comprises a long term evolution (LTE) system and the second wireless access technology is one of a code division multiple access (CDMA) system or a WiFi system.

26. The method of claim 21, wherein assigning resources to the wireless device comprises scheduling the wireless device on an uplink subcarrier.

27. The method of claim 21, wherein assigning resources to the wireless device comprises scheduling the wireless device on a downlink subcarrier.

28. An wireless communications apparatus, comprising: a processor configured to execute computer executable components stored in a memory, the components including:

an estimation component configured to determine an estimated interference associated with a data transmission by a wireless device over a plurality of subcarriers;

a communication component configured to receive an indication from the wireless device relating to frequency locations of intermodulation products associated with the plurality of subcarriers; and

an assigning component configured to assign resources to the wireless device based at least in part on the estimated interference.

29. The apparatus of claim 28, wherein the estimation component is configured to determine intermodulation products associated with the plurality of subcarriers.

30. The apparatus of claim 28, wherein the estimation component is configured to determine the estimated interference based at least in part on the indication received from the wireless device.

31. The apparatus of claim 30, wherein the frequency locations of the intermodulation products are related to data transmissions of the wireless device over at least a first wireless access technology and a second wireless access technology.

32. The apparatus of claim 31, wherein the first wireless access technology comprises a long term evolution system and the second wireless access technology is one of a code division multiple access (CDMA) system or a WiFi system.

33. The apparatus of claim 28, wherein the assigning component is configured to schedule the wireless device on an uplink subcarrier.

34. The apparatus of claim 28, wherein the assigning component is configured to schedule the wireless device on a downlink subcarrier.

35. A computer program product that facilitates wireless communication, comprising:

a non-transitory computer-readable storage medium comprising code for causing at least one computer to:

determine an estimated interference associated with a data transmission by a wireless device over a plurality of subcarriers;

receive an indication from the wireless device relating to frequency locations of intermodulation products associated with the plurality of subcarriers; and assign resources to the wireless device based at least in part on the estimated interference.

36. A wireless communications apparatus, comprising:  
means for determining an estimated interference associ-  
ated with a data transmission by a wireless device over  
a plurality of subcarriers;  
means for receiving an indication from the wireless 5  
device relating to frequency locations of intermodula-  
tion products associated with the plurality of subcarri-  
ers; and  
means for assigning resources to the wireless device  
based at least in part on the estimated interference. 10

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