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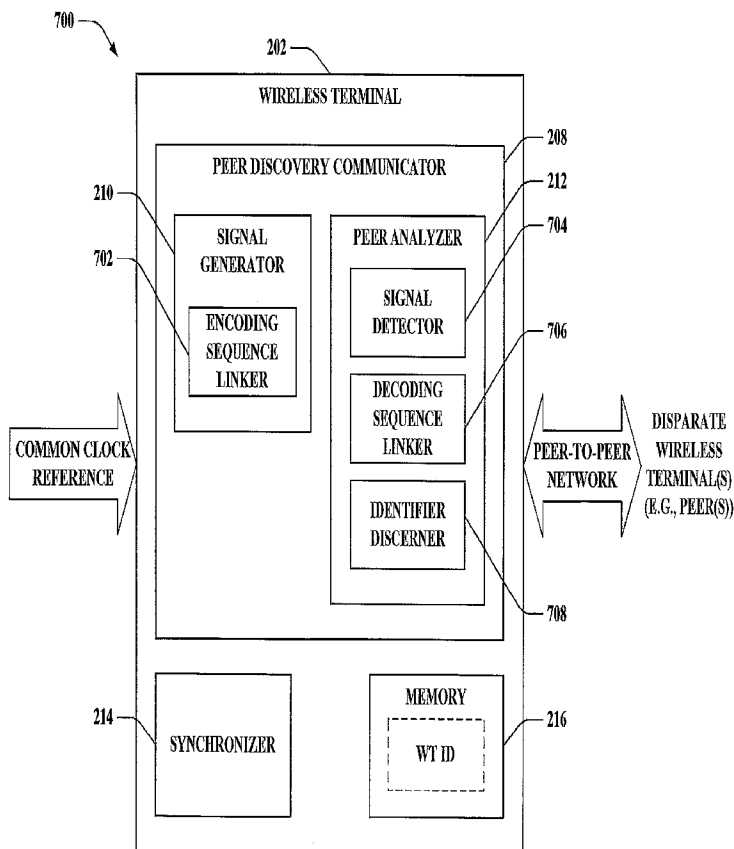
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(54) Title: ENCODING BEACON SIGNALS TO PROVIDE IDENTIFICATION IN PEER-TO-PEER COMMUNICATION



(57) Abstract: Systems and methodologies are described that facilitate encoding and/or decoding signals utilized to identify a wireless terminal during peer discovery interval(s). Substantially any type of function that constrains encoding and/or decoding within a peer-to-peer network may be utilized. For example, a reversible function may be employed that enables a receiving peer to discern an identifier of a transmitting peer over a series of peer discovery intervals. Pursuant to another example, an irreversible function may be utilized whereby a receiving peer may be unable to decipher the identifier of the transmitting peer from a received signal; however, expected signal formats of buddy peers may be compared to the received signal to determine a presence of one of the buddy peers in a vicinity.

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ENCODING BEACON SIGNALS TO PROVIDE IDENTIFICATION IN PEER-TO-PEER COMMUNICATION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent application Serial No. 60/758,010 entitled "METHODS AND APPARATUS FOR FACILITATING IDENTIFICATION, SYNCHRONIZATION OR ACQUISITION USING BEACON SIGNALS" which was filed January 11, 2006; U.S. Provisional Patent application Serial No. 60/758,011 entitled "METHODS AND APPARATUS FOR USING BEACON SIGNALS FOR IDENTIFICATION, SYNCHRONIZATION OR ACQUISITION IN AN AD HOC WIRELESS NETWORK" which was filed January 11, 2006; U.S. Provisional Patent application Serial No. 60/758,012 entitled "METHODS AND APPARATUS FOR USING BEACON SIGNALS IN A COGNITIVE RADIO NETWORK" which was filed January 11, 2006; U.S. Provisional Patent application Serial No. 60/845,052 entitled "POWER ALLOCATION SCHEME" which was filed September 15, 2006; U.S. Provisional Patent application Serial No. 60/845,051 entitled "BEACONS IN A MIXED WIRELESS COMMUNICATION SYSTEM" which was filed September 15, 2006; and U.S. Provisional Patent application Serial No. 60/863,304 entitled "BEACONS IN A MIXED COMMUNICATION SYSTEM" which was filed October 27, 2006. The entireties of the aforementioned applications are herein incorporated by reference.

BACKGROUND

I. Field

[0002] The following description relates generally to wireless communications, and more particularly to identifying peers based on encoded signals in a peer-to-peer network.

II. Background

[0003] Wireless communication systems are widely deployed to provide various types of communication; for instance, voice and/or data may be provided *via* such wireless communication systems. A typical wireless communication system, or

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network, can provide multiple users access to one or more shared resources. For instance, a system may use a variety of multiple access techniques such as Frequency Division Multiplexing (FDM), Time Division Multiplexing (TDM), Code Division Multiplexing (CDM), Orthogonal Frequency Division Multiplexing (OFDM), and others.

[0004] Common wireless communication systems employ one or more base stations that provide a coverage area. A typical base station can transmit multiple data streams for broadcast, multicast and/or unicast services, wherein a data stream may be a stream of data that can be of independent reception interest to a wireless terminal. A wireless terminal within the coverage area of such base station can be employed to receive one, more than one, or all the data streams carried by the composite stream. Likewise, a wireless terminal can transmit data to the base station or another wireless terminal.

[0005] Wireless communication systems leverage various portions of wireless spectrum for transferring data. However, wireless spectrum is an expensive and valuable resource. For example, significant costs may be incurred by a company desiring to operate a wireless communication system over a portion of the wireless spectrum (*e.g.*, within the licensed spectrum). Further, conventional techniques typically provide inefficient utilization of wireless spectrum. According to a common illustration, the spectrum allocated for wide area network cellular communication oftentimes is not uniformly utilized across time and space; thus, a significant subset of spectrum may be unused in a given geographic location or in a given time interval.

[0006] According to another example, wireless communication systems oftentimes employ peer-to-peer or *ad hoc* architectures whereby a wireless terminal may transfer signals directly to another wireless terminal. As such, signals need not traverse through a base station; rather, wireless terminals within range of each other may discover and/or communicate directly. However, conventional peer-to-peer networks typically operate in an asynchronous manner whereby peers may effectuate differing tasks at a particular time. Consequently, peers may encounter difficulty associated with identifying and/or communicating with disparate peers within range, power may be inefficiently utilized, and so forth.

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SUMMARY

[0007] 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 sole purpose is to present some concepts of one or more embodiments in a simplified form as a prelude to the more detailed description that is presented later.

[0008] In accordance with one or more embodiments and corresponding disclosure thereof, various aspects are described in connection with facilitating encoding and/or decoding of signals utilized to identify a wireless terminal during peer discovery interval(s). Substantially any type of function that constrains encoding and/or decoding within a peer-to-peer network may be utilized. For example, a reversible function may be employed that enables a receiving peer to discern an identifier of a transmitting peer over a series of peer discovery intervals. Pursuant to another example, an irreversible function may be utilized whereby a receiving peer may be unable to decipher the identifier of the transmitting peer from a received signal; however, expected signal formats of buddy peers may be compared to the received signal to determine a presence of one of the buddy peers in a vicinity.

[0009] According to related aspects, a method that facilitates operating a wireless terminal in a peer-to-peer network is described herein. The method may include receiving a sequence of first signals across a series of peer discovery intervals, wherein the first signals are generated by a disparate wireless terminal using a predetermined hash function to which wireless terminals in the peer-to-peer network abide. Further, the method may comprise deriving an identifier from the sequence of first signals across the series of peer discovery intervals.

[0010] Another aspect relates to a wireless communications apparatus. The wireless communications apparatus may include a memory that retains instructions related to detecting a sequence of first signals during a series of peer discovery intervals, wherein the first signals are generated by a peer using a predetermined hash function that constrains peers in a peer-to-peer environment, and deriving an identifier from the sequence of first signals across the series of peer discovery intervals. Further, the

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wireless communications apparatus may include a processor, coupled to the memory, configured to execute the instructions retained in the memory.

[0011] Yet another aspect relates to a wireless communications apparatus that enables utilizing a reversible function in connection with peer discovery signals in a peer-to-peer network. The wireless communications apparatus may include means for receiving a sequence of signals across a series of peer discovery intervals, the signals being generated by a disparate wireless terminal using a predetermined reversible function to which wireless terminals in a peer-to-peer network abide. Moreover, the wireless communications apparatus may include means for deriving an identifier from the sequence of signals across the series of peer discovery intervals.

[0012] Still another aspect relates to a machine-readable medium having stored thereon machine-executable instructions for receiving a sequence of first signals across a series of peer discovery intervals, wherein the first signals are generated by a disparate wireless terminal using a predetermined hash function to which wireless terminals in the peer-to-peer network abide; and deriving an identifier from the sequence of first signals across the series of peer discovery intervals.

[0013] In accordance with another aspect, an apparatus in a wireless communication system may include a processor, wherein the processor may be configured to receive a sequence of signals across a series of peer discovery intervals, wherein the signals are generated by a disparate wireless terminal using a predetermined hash function to which wireless terminals in the peer-to-peer network abide. The processor may also be configured to derive an identifier from the sequence of signals across the series of peer discovery intervals.

[0014] 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 may be employed and the described embodiments are intended to include all such aspects and their equivalents.

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BRIEF DESCRIPTION OF THE DRAWINGS

- [0015] FIG. 1 is an illustration of a wireless communication system in accordance with various aspects set forth herein.
- [0016] FIG. 2 is an illustration of an example system that enables mutual identification of peers in a peer-to-peer network.
- [0017] FIG. 3 is an illustration of an example timing diagram of a peer discovery interval.
- [0018] FIG. 4 is an illustration of an example time-frequency grid associated with transmission during a peer discovery interval.
- [0019] FIG. 5 is an illustration of an example system that utilizes a function for encoding peer discovery signals communicated and evaluated in a peer-to-peer network.
- [0020] FIG. 6 is an illustration of an example graphical depiction of an evaluation of detected signals (*e.g.*, beacon signals) effectuated by a peer analyzer of a wireless terminal in a peer-to-peer environment.
- [0021] FIG. 7 is an illustration of an example system that enables employing a reversible function for generating a peer discovery signal, where utilization of the reversible function allows identifiers to be deciphered from received signals in a peer-to-peer network.
- [0022] FIG. 8 is an illustration of an example graphical depiction of an evaluation of a linked sequence of peer discovery signals generated with a reversible function.
- [0023] FIG. 9 is an illustration of an example methodology that facilitates identifying a wireless terminal in a peer-to-peer network that employs a reversible function for encoding peer discovery signals.
- [0024] FIG. 10 is an illustration of an example methodology that facilitates decoding a sequence of signals obtained from a peer in a peer-to-peer environment.
- [0025] FIG. 11 is an illustration of an example methodology that facilitates identifying a disparate wireless terminal in a peer-to-peer network.
- [0026] FIG. 12 is an illustration of an example methodology that facilitates analyzing signals obtained during a peer discovery interval in a peer-to-peer network.
- [0027] FIG. 13 is an illustration of an example communication system implemented in accordance with various aspects including multiple cells.

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[0028] FIG. 14 is an illustration of an example base station in accordance with various aspects.

[0029] FIG. 15 is an illustration of an example wireless terminal (*e.g.*, mobile device, end node, ...) implemented in accordance with various aspects described herein.

[0030] FIG. 16 is an illustration of an example system that enables utilizing a reversible function in connection with peer discovery signals in a peer-to-peer network.

[0031] FIG. 17 is an illustration of an example system that enables utilizing an irreversible function in connection with encoding and/or decoding peer discovery signals in a peer-to-peer network.

DETAILED DESCRIPTION

[0032] 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.

[0033] 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 may 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 may 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 may 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).

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[0034] Furthermore, various embodiments are described herein in connection with a wireless terminal. A wireless terminal can also be called a system, subscriber unit, subscriber station, mobile station, mobile, mobile device, remote station, remote terminal, access terminal, user terminal, terminal, wireless communication device, user agent, user device, or user equipment (UE). A wireless terminal may 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 may be utilized for communicating with wireless terminal(s) and may also be referred to as an access point, Node B, or some other terminology.

[0035] Moreover, various aspects or features described herein may be implemented as a method, apparatus, or article of manufacture using standard programming and/or engineering techniques. The term "article of manufacture" as used herein is intended to encompass a computer program accessible from any computer-readable device, carrier, or media. For example, computer-readable media can include but are not limited to magnetic storage devices (*e.g.*, hard disk, floppy disk, magnetic strips, *etc.*), optical disks (*e.g.*, compact disk (CD), digital versatile disk (DVD), *etc.*), smart cards, and flash memory devices (*e.g.*, EPROM, card, stick, key drive, *etc.*). Additionally, various storage media described herein can represent one or more devices and/or other machine-readable media for storing information. The term "machine-readable medium" can include, without being limited to, wireless channels and various other media capable of storing, containing, and/or carrying instruction(s) and/or data.

[0036] Referring now to **Fig. 1**, a wireless communication system 100 is illustrated in accordance with various embodiments presented herein. System 100 may comprise one or more wireless terminals 102. Although two wireless terminals 102 are depicted, it is to be appreciated that system 100 may include substantially any number of wireless terminals 102. Wireless terminals 102 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. Wireless terminals 102 can communicate directly with each other *via* a local area peer-to-peer (P2P) network (*e.g.*,

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ad hoc network). Peer-to-peer communication may be effectuated by directly transferring signals between wireless terminals 102; thus, the signals need not traverse through a base station (*e.g.*, base station 104). The peer-to-peer network may provide short range, high data rate communication (*e.g.*, within a home, office, *etc.* type setting).

[0037] Further, system 100 may support a wide area network (WAN). System 100 may include a base station 104 (*e.g.*, access point) and/or any number of disparate base stations (not shown) in one or more sectors that receive, transmit, repeat, *etc.* wireless communication signals to each other and/or to one or more wireless terminals 102. Base station 104 can comprise 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, ...) as will be appreciated by one skilled in the art. Wireless terminal(s) 102 may transmit signals to and/or receive signals from base station 104 when communicating *via* the wide area infra-structure network supported by system 100.

[0038] Peer-to-peer communication between wireless terminals 102 may be synchronous. For example, wireless terminals 102 may utilize a common clock reference to synchronize performance of distinct functions. Wireless terminals 102 may obtain timing signals from base station 104 (and/or a transmitter (not shown) that provides less functionality) utilized to synchronize operation of wireless terminals 102. Wireless terminal 102 may obtain timing signals from other sources, for instance, GPS satellites. According to an illustration, time may be meaningfully partitioned in a peer-to-peer network for functions such as peer discovery, paging, and traffic. Further, it is contemplated that each peer-to-peer network may set its own time.

[0039] Before communication of traffic in a peer-to-peer network can take place, wireless terminals 102 (*e.g.*, peers) may detect and identify each other. The process by which this mutual detection and identification between peers takes place may be referred to as peer discovery. System 100 may support peer discovery by providing that peers desiring to establish peer-to-peer communication periodically transmit short messages and listen to the transmissions of others. For example, each one of the wireless terminals 102 (*e.g.*, sending wireless terminal) may periodically send signals to the other wireless terminal(s) 102 (*e.g.*, receiving wireless terminal(s)) in the peer-to-peer network so that the receiving wireless terminal(s) may identify the sending wireless

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terminal when the receiving wireless terminal(s) are in vicinity of the sending wireless terminal. After identification, an active connection may be established.

[0040] Transmissions for peer discovery may periodically occur during specified times referred to as peer discovery intervals, the timing of which may be predetermined by a protocol and known to wireless terminals 102. Wireless terminals 102 may each transmit respective signals to identify themselves. For example, each wireless terminal 102 may send a signal during a portion of a peer discovery interval. Further, each wireless terminal 102 may monitor signals potentially transmitted by other wireless terminals 102 in a remainder of the peer discovery interval. According to an example, the signal may be a beacon signal. By way of another illustration, the peer discovery interval may include a number of symbols (*e.g.*, OFDM symbols). Each wireless terminal 102 may select at least one symbol in the peer discovery interval for transmission by that wireless terminal 102. Moreover, each wireless terminal 102 may transmit a corresponding signal in one tone in the symbol selected by that wireless terminal 102.

[0041] The local area peer-to-peer network and the wide area network may share a common wireless spectrum to effectuate communication; thus, bandwidth may be shared for transferring data *via* the disparate types of networks. For example, the peer-to-peer network and the wide area network may both communicate over the licensed spectrum. However, the peer-to-peer communication need not utilize the wide area network infrastructure.

[0042] Now turning to **Fig. 2**, illustrated is a system 200 that enables mutual identification of pccrs in a pccr-to-pccr network. System 200 includes a wireless terminal 202 that communicates directly with substantially any number of disparate wireless terminals (*e.g.*, disparate wireless terminal 1 204, ..., disparate wireless terminal X 206, where X may be any integer). Although the following provides further detail with regards to wireless terminal 202, it is to be appreciated that such illustrations may similarly apply to disparate wireless terminals 204-206.

[0043] Wireless terminal 202 may further include a peer discovery communicator 208 that effectuates encoding, sending, receiving, evaluating, *etc.* signals associated with peer discovery during a peer discovery interval (or a plurality of peer discovery intervals). Peer discovery communicator 208 may further comprise a signal generator 210 and a peer analyzer 212. Signal generator 210 may generate and/or

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transmit a signal to disparate wireless terminals 204-206, and disparate wireless terminals 204-206 may evaluate the signal to detect and identify wireless terminal 202. Further, peer analyzer 212 may receive signal(s) sent from disparate wireless terminal(s) 204-206; peer analyzer 212 may evaluate the received signal(s) to detect and identify disparate wireless terminal(s) 204-206 to which the received signal(s) correspond.

[0044] Wireless terminal 202 may additionally include a synchronizer 214 that conforms timing between wireless terminal 202 and disparate wireless terminals 204-206. Synchronizer 214 may obtain its timing from broadcast information (*e.g.*, a common clock reference) from a base station (not shown) in a vicinity of wireless terminal 202 and disparate wireless terminals 204-206. Similar synchronizers (not shown) of disparate wireless terminals 204-206 may obtain their respective timing from the same broadcast information. The broadcast information may additionally or alternatively include GPS satellite signals. The broadcast information may be periodically received by synchronizer 214. Moreover, the broadcast information may be, for example, a single-tone beacon signal, a CDMA PN (pseudo random) sequence signal, a pilot signal or other broadcast signal. Synchronizer 214 may evaluate the obtained broadcast information to determine timing information. By way of illustration, wireless terminal 202 and disparate wireless terminals 204-206 may receive and synchronize to the same broadcast information, and therefore, have a common understanding of time. The common notion of time may be utilized to partition a timeline into distinct intervals for differing types of functions such as, for instance, peer discovery, paging, and traffic, according to a predetermined pattern defined by an air interface protocol. Moreover, the timing information may be utilized by signal generator 210 to create signals for transmission during peer discovery and/or peer analyzer 212 to evaluate received signals for peer discovery.

[0045] Each wireless terminal (*e.g.*, wireless terminal 202, disparate wireless terminals 204-206) may be associated with a respective, unique identifier (WT ID). For example, wireless terminal 202 may include memory 216 that retains a unique identifier (WT ID) that corresponds to wireless terminal 202. However, it is contemplated that wireless terminal 202 may derive, obtain, *etc.* its unique identifier (WT ID) from any location (*e.g.*, local and/or remote to wireless terminal 202). Additionally, memory 216 may retain any additional type of data and/or instructions related to wireless terminal

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202. Moreover, wireless terminal 202 may include a processor (not shown) that executes instructions described herein.

[0046] Signal generator 210 may create and/or transmit a signal to disparate wireless terminals 204-206. Signal generator 210 may encode and/or send a signal in a peer discovery interval as a function of the unique identifier of wireless terminal 202 (WT ID). In accordance with an example, the signal yielded by signal generator 210 may be a single-tone beacon signal, which may provide power efficiency; thus, signal generator 210 may effectuate transmitting a particular tone on a selected OFDM symbol within a peer discovery interval. It is contemplated that more than one beacon signal may be transmitted (*e.g.*, in a plurality of OFDM symbols). For example, where the transmitted signal is a beacon signal, a selected symbol time position (*e.g.*, within the peer discovery interval) and/or a tone position may be derived by a hash function of the unique identifier of wireless terminal 202 (WT ID) and a time variable (*e.g.*, timing information obtained by synchronizer 214, time counter) identifying a current peer discovery interval. Further, wireless terminal 202 and disparate wireless terminals 204-206 may have a common value of the time variable (*e.g.*, due to synchronization achieved by listening to an infrastructure communication channel available in a geographic area).

[0047] Pursuant to another example, the identifier associated with wireless terminal 202 (WT ID) may be broadcast to peer(s) by signal generator 210 (and/or peer discovery communicator 208). Peer(s) obtaining the signal may detect and/or identify wireless terminal 202. For example, the signal yielded by signal generator 210 may be an output of an M -bit hash function whose input is the plain-text name of wireless terminal 202 (*e.g.*, WT ID) and a current counter value supplied by a base station broadcast signal (*e.g.*, common clock reference). The counter value, for instance, may be constant during a current peer discovery interval and may be decodable by all peers. The counter value may vary (*e.g.*, increment in a modulo sense) from one peer discovery interval to another. Further, the hash function may be specified *a priori* by a protocol and known to the peers.

[0048] By way of example, wireless terminal 202 may be located in a peer-to-peer network that includes disparate wireless terminal 1 204 and disparate wireless terminal X 206. Synchronizer 214 may determine timing associated with peer-to-peer communications (*e.g.*, based upon a received common clock reference). Further, at a

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time partitioned for peer discovery, signal generator 210 may broadcast a signal (*e.g.*, generated based upon an ID of the originating wireless terminal 202 and/or a current time) to disparate wireless terminals within range (*e.g.*, disparate wireless terminals 204-206). The signal may be received and utilized by disparate wireless terminals 204-206 to detect wireless terminal 202 and/or determine an identity of wireless terminal 202. Moreover, peer analyzer 212 may obtain broadcast signals from disparate wireless terminals 204-206. Peer analyzer 212 may evaluate the obtained signals to detect disparate wireless terminals 204-206 and/or identify disparate wireless terminals 204-206.

[0049] Peer discovery effectuated by peer discovery communicator 208 may be passive. Further, peer discovery may be symmetric; thus, wireless terminal 202 may detect and identify disparate wireless terminal 1 204 and disparate wireless terminal 1 204 may detect and identify wireless terminal 202. However, it is contemplated that a first wireless terminal may detect and identify a second wireless terminal, but the second wireless terminal may fail to detect and identify the first wireless terminal. Additionally, upon detection and identification, further communication (*e.g.*, paging, traffic) between wireless terminal 202 and disparate wireless terminal(s) 204-206 may, but need not, be effectuated.

[0050] Peer analyzer 212 may maintain a list of disparate wireless terminals 204-206 that are detected to be present in the current time. The list may include all disparate wireless terminals 204-206 or may include those in a predefined buddy list of wireless terminal 202 or the user who is using wireless terminal 202. As the time goes by, the list evolves, because some disparate wireless terminals 204-206 may disappear (*e.g.*, because the corresponding users move away), or because other disparate wireless terminals 204-206 may appear (*e.g.*, because the corresponding users move close). Peer analyzer 212 may add the new disparate wireless terminals 204-206 to the list or delete disappearing disparate wireless terminals 204-206 from the list. In one embodiment, peer analyzer 212 passively maintains the list. In this case, a first peer may detect the presence of a second peer and keep the second peer in its list without informing the second peer. As a result, the second peer may not know that the first peer has already kept the second peer in the list. By symmetry, depending on wireless channel and interference condition, the second peer may also detect the presence of the first peer and keep the first peer in its list without informing the first peer. In another embodiment,

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after the first peer detects the presence of the second peer, the first peer proactively sends a signal to inform the second peer so that the second peer now knows that the first peer has already kept the second peer in the list, even though the first peer has no data traffic to communicate with the second peer yet. The first peer may selectively decide whether it sends a signal. For example, the first peer may send a signal only to another peer that is in the predefined buddy list.

[0051] Referring to **Fig. 3**, illustrated is an example timing diagram 300 of a peer discovery interval. The peer discovery interval may include a number of possible transmission times during which a wireless terminal can broadcast a signal. For instance, the peer discovery interval may include N symbols (*e.g.*, OFDM symbols), where N may be any integer. Further, each symbol may last $10\ \mu\text{s}$ and N may be 50, 100, 200, *etc.*; however, the subject claims are not so limited. Each peer within a peer-to-peer network may transmit utilizing one or more of the symbols; the peer may listen to the remainder of the symbols to detect and/or identify other peers within range. In accordance with an example where beacon signals are transmitted, a peer may transmit a first tone on a first symbol (*e.g.*, at a first time within the peer discovery interval) and a second tone on a second symbol (*e.g.*, at a second time within the peer discovery interval), where the first symbol and the second symbol may or may not be contiguous.

[0052] According to an example, the peer discovery interval may include 200 symbols. In an embodiment, all 200 symbols may be used for transmitting broadcast signals by the wireless terminals. In another embodiment, every other symbol may be utilized for transmission (*e.g.*, 100 symbols may be employed for transmission). Before the peer discovery interval, each wireless terminal that wishes to engage in peer-to-peer communication may select one or more symbols for transmission. During the selected symbol time(s), the wireless terminal transmits a message (*e.g.*, tone) to disparate wireless terminal(s) (*e.g.*, peer(s)). The message may include one tone in one of the selected transmission symbols. Further, during at least a fraction of the remaining symbol times in the peer discovery interval, the wireless terminal listens and decodes the transmissions of the disparate wireless terminal(s). Since peer-to-peer communication may employ a half-duplex mode, where a wireless terminal either transmits or receives data at a particular time but cannot transmit and receive simultaneously, the wireless terminal may transmit for 10% of the transmission times and receive for the remaining 90% of the time. By way of another example, the

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wireless terminal may transmit 30% of the time and receive 70% of the time. In accordance with an illustration, the wireless terminal may determine the transmission time(s) and/or the waveform (*e.g.*, the frequency tone transmitted in a selected transmission symbol) to transmit based upon an identifier and/or a notion of time (*e.g.*, derived from a received Beacon). The notion of time is in essence a time-varying variable. All the wireless terminals may get the same notion of time. For example, the wireless terminals may obtain a time-varying variable from the broadcast (*e.g.*, beacon) signal from the base station. The time-varying variable can be some variable transmitted in the broadcast signal. For example, the variable can be some time counter or system time, which varies over time. In this document, the notion of time is referred to as time counter. It is desired that the time counter varies from one peer discovery interval to another. By way of further example, the wireless terminal may utilize a pseudo-random number generator, whose seed can be an identifier of the wireless terminal and a current counter value supplied by a broadcast signal from a base station, to select transmission time(s) and/or the waveform. As the time counter varies, the selected transmission symbol time(s) and/or waveform may also vary from one peer discovery interval to another.

[0053] Now turning to **Fig. 4**, illustrated is an example time-frequency grid 400 associated with transmission during a peer discovery interval. The time-frequency grid 400 is the resource available for transmitting and/or receiving signals over a peer-to-peer network during a peer discovery interval. The x-axis represents time and may include N symbols (*e.g.*, where N may be any integer), and the y-axis represents frequency and may include M tones (*e.g.*, where M may be any integer). For example, the time-frequency grid 400 for a peer discovery interval may include 200 symbols and 50 tones (*e.g.*, resource of 1000); however, the claimed subject matter contemplates utilizing any size time-frequency resource.

[0054] According to an example, a wireless terminal may select a particular symbol (*e.g.*, transmission time) for transmission based upon an identifier of the wireless terminal or a user who is utilizing the wireless terminal and/or a time variable (*e.g.*, time counter) that may be commonly understood within a peer-to-peer network to identify a current peer discovery interval. Further, a particular tone corresponding to the selected symbol may be determined (*e.g.*, based upon the identifier and/or time variable). Pursuant to a further example, a hash function of the identifier and the time

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variable may yield the selected symbol position and/or tone position. Moreover, the x and y coordinates (*e.g.*, (x_1, y_1)) within grid 400, as illustrated by the shading, may provide information (*e.g.*, when evaluated by a peer receiving such signal). However, the size of the identifier may be larger than a size of data that may be communicated *via* a transmitted signal (*e.g.*, encoded with the symbol-tone position) when transmitting one symbol in one peer discovery interval. For instance, the identifier may be 32 bits or more, while a resource of 1000 may provide 10 bits of information when a wireless terminal transmits one tone on one symbol during a peer discovery interval.

[0055] By transmitting a single symbol, the alphabet employed by the wireless terminal may be $\log_2(M \cdot N)$. According to a further example, more than one symbol may be utilized by the wireless terminal for transmission during one or a plurality of (*e.g.*, successive) peer discovery intervals. Pursuant to this example, the tones (*e.g.*, Beacons) may be transmitted at different times. By way of illustration, if two Beacons are transmitted with coordinates (x_1, y_1) and (x_2, y_2) where x_1 and x_2 may be in the same peer discovery interval or two different intervals, x_1 differs from x_2 to mitigate transmitting the two Beacons concurrently. In accordance with a further example, signals transmitted during sequential peer discovery intervals may be linked together to enable identification by receiving wireless terminal(s).

[0056] Referring now to **Fig. 5**, illustrated is a system 500 that utilizes a function for encoding peer discovery signals communicated and evaluated in a peer-to-peer network. The function may be irreversible; however, it is contemplated that a reversible function may be utilized in connection with system 500. System 500 includes wireless terminal 202 that may communicate *via* a peer-to-peer network with disparate wireless terminal(s) (*e.g.*, peer(s)). Wireless terminal 202 may include peer discovery communicator 208 that enables sending and/or obtaining peer discovery signals during a peer discovery interval (*e.g.*, by leveraging signal generator 210 and peer analyzer 212). Further, wireless terminal 202 may include synchronizer 214 that obtains and analyzes a common clock reference to coordinate performance of various functions (*e.g.*, peer discovery, paging, traffic) and determine a meaningful notion of time (*e.g.*, time counter) consistent with disparate wireless terminals in the peer-to-peer network. Therefore, peers get the same timing (timing synchronized) without directly communicating with each other.

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[0057] Moreover, wireless terminal 202 may include memory 216. An identifier related to wireless terminal 202 (WT ID) may be stored in memory 216. Additionally, a known peer list (*e.g.*, buddy peer list) may be maintained in memory. The known peer list may include identifiers (*e.g.*, ID₁, ID₂, ..., ID_z, where z may be any integer) corresponding to buddy peers that may or may not be located within the peer-to-peer network (*e.g.*, within range of wireless terminal 202) at a given time. For example, a subset, none or all of the disparate wireless terminals in the peer-to-peer network with wireless terminal 202 may be buddy peers of wireless terminal 202; thus, memory 216 of wireless terminal 202 may maintain ID's corresponding to such disparate wireless terminals that are buddy peers. By way of further example, an identifier may be lacking from the known peer list in memory 216 of wireless terminal 202 for any disparate wireless terminal(s) (*e.g.*, in the peer-to-peer network with wireless terminal 202) that is not a buddy peer of wireless terminal 202.

[0058] Signal generator 210 (and/or similar signal generator(s) of disparate wireless terminal(s) in the peer-to-peer network) may employ an irreversible function (*e.g.*, irreversible hash function) to yield a peer discovery signal. Since the function is irreversible, a receiving wireless terminal may be unable to decipher the identifier from an obtained peer discovery signal; rather, a known identifier may be subjected to the same irreversible function and the output may be compared with a received signal. By way of example, signal generator 210 may utilize an identifier of wireless terminal 202 (WT ID) (*e.g.*, wireless terminal that generates the peer discovery signal) and a time variable (*e.g.*, time counter) that relates to a current peer discovery interval (*e.g.*, as determined by synchronizer 214) as input to the irreversible function to derive a symbol position and/or a tone position for the peer discovery signal. Likewise, similar signal generator(s) may employ respective identifiers that correspond to each disparate wireless terminal. Further, the encoded peer discovery signal may be broadcast over the peer-to-peer network. Thus, for example, broadcast peer discovery signal(s) yielded by signal generator(s) of the disparate wireless terminal(s) in the peer-to-peer network may be received by wireless terminal 202.

[0059] Peer analyzer 212 may further include a signal detector 502, an anticipated signal calculator 504, and/or a comparator 506. Signal detector 502 may receive signal(s) communicated over the peer-to-peer network during a peer discovery interval. For example, the received signal(s) may include peer discovery signal(s) sent

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by disparate wireless terminal(s) (*e.g.*, buddy peers or non-buddy peers), interference, and so forth.

[0060] Moreover, anticipated signal calculator 504 may generate current expected signal formats for each buddy peer. In the case of using beacon signals, anticipated signal calculator 504 may determine a coordinate pair (*e.g.*, associated with time-frequency grid 400 of **Fig. 4**) of an expected, selected symbol position (*e.g.*, x coordinate) and a corresponding expected, selected tone position (*e.g.*, y coordinate) for each buddy peer. For example, the irreversible function employed by signal generator 210 may similarly be utilized by anticipated signal calculator 504 to yield the expected coordinate pairs associated with each buddy peer. Additionally, anticipated signal calculator 504 may generate the expected coordinate pair for each buddy peer as a function of the time variable (*e.g.*, time counter) and the respective identifier corresponding to the buddy peer. It is possible that a different function may be employed for a different buddy peer. For example, suppose that wireless terminal 202 has two buddy peers. It is known to wireless terminal 202 that the first buddy peer uses a first function to generate its signal and the second buddy peer uses a second function to generate its signal. The first and the second functions may be the same or may be different. As long as the first and the second functions are predetermined and known, wireless terminal 202 can derive the expected signals from the first and the second buddy peers.

[0061] Comparator 506 compares detected signal(s) (*e.g.*, obtained with signal detector 502) with calculated, expected signal formats (*e.g.*, determined by anticipated signal calculator 504) to yield a probability associated with buddy peer(s) being in a vicinity of wireless terminal 202 (*e.g.*, buddy peer being one of the disparate wireless terminal(s) included in a shared peer-to-peer network). If a detected signal matches the expected signal format of one of the buddy peers, comparator 506 may record that there is a possibility the corresponding buddy peer may be in the vicinity (*e.g.*, within the peer-to-peer network). If the expected signal format of the same buddy peer is observed by comparator 506 in several peer discovery intervals, then the probability of the buddy peer being in the vicinity may be high. Moreover, if an expected signal format does not match any detected signal, the buddy peer corresponding to the expected signal format may be located outside of the peer-to-peer network (*e.g.*, out of range of wireless terminal 202). Further, if a detected signal does not match any expected signal format,

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this detected signal may not relate to a buddy peer; rather, the detected signal may pertain to a non-buddy peer, noise, and so forth.

[0062] According to another example, comparator 506 may consider an energy level associated with signal(s) obtained with detector 502. Pursuant to this example, comparator 506 may assign a high probability to a detected signal with a high energy level that matches an expected signal format of one of the buddy peers. Further, comparator 506 may allocate a low probability of one of the buddy peers being in the peer-to-peer network when a detected signal with a low energy level matches an expected signal format of that buddy peer.

[0063] By way of another example, a list of plain-text names of buddy peers associated with wireless terminal 202 may be maintained in memory 216 (*e.g.*, known peer list). Further, upon decoding a particular ID with signal detector 502, anticipated signal calculator 504 may hash the plain-text buddy names from memory 216 using the current counter value. If at least one of the output IDs matches the decoded ID, comparator 506 may conclude that the corresponding buddy peer is present with a certain probability. If no match is found or there are multiple matches, comparator 506 may be unable to conclude as to the presence of any buddy peers. Moreover, each peer may vary a number of bits of an output of the ID generating hash function in order to ensure that it is eventually discovered.

[0064] With reference to **Fig. 6**, illustrated is an example graphical depiction of an evaluation of detected signals (*e.g.*, beacon signals) effectuated by a peer analyzer 212 of a wireless terminal 202 in a peer-to-peer environment. Pursuant to this example, peer discovery signals may be generated by employing an irreversible function. Thus, peer analyzer 212 may be unable to calculate ID(s) from detected signals, where the ID(s) correspond to the disparate wireless terminals that broadcast each signal.

[0065] An example detected signals time-frequency resource 600 and an example anticipated buddy signals time-frequency resource 602 are illustrated; these time-frequency resources 600-602 may be similar to time-frequency resource 400 of **Fig. 4**. It is to be appreciated, however, that the claimed subject matter is not limited to these examples. Detected signals time-frequency resource 600 illustrates two detected signals (*e.g.*, obtained with signal detector 502) with symbol-tone coordinate pairs (x_1, y_1) and (x_2, y_2) . Accordingly, tone y_1 is detected on symbol x_1 and tone y_2 is detected on symbol x_2 at wireless terminal 202. The receiver may determine that a tone is

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detected in a symbol if the received power on that tone is significantly (*e.g.*, at least 5 dB) higher than the average per-tone received power.

[0066] Wireless terminal 202 may retain a buddy list in memory 216, and expected symbol-tone coordinate pairs may be calculated as a function of ID's included in the buddy list and a time counter. Anticipated buddy signals time-frequency resource 602 illustrates examples of expected symbol-tone coordinate pairs derived based on the buddy list ID's and the time counter. As shown, the expected symbol-tone coordinate pairs are (x_3, y_3) and (x_4, y_4) .

[0067] Further, by comparing detected signals resource 600 with anticipated buddy signals resource 602, it may be determined that one of the detected signals at (x_2, y_2) matches one of the anticipated signals at (x_4, y_4) . Thus, a high probability may be assigned to the buddy peer corresponding to the anticipated buddy signal at (x_4, y_4) being in the vicinity of the wireless terminal that detected the signals. Further, if the buddy peer is detected in the next peer discovery interval as well, then even higher probability may be assigned to the buddy peer being in the vicinity. Moreover, since a match for the detected signal at (x_1, y_1) is lacking, the wireless terminal may determine that such detected signal may have originated from a non-buddy peer or may be noise. Furthermore, since a match for the buddy peer associated with the anticipated buddy signal at (x_3, y_3) is lacking, the wireless terminal may determine that this buddy peer may be positioned outside of the peer-to-peer network (*e.g.*, out of range of the wireless terminal).

[0068] Now turning to **Fig. 7**, illustrated is a system 700 that enables employing a reversible function for generating a peer discovery signal, where utilization of the reversible function allows identifiers to be deciphered from received signals in a peer-to-peer network. System 700 includes wireless terminal 202 that communicates *via* the peer-to-peer network with disparate wireless terminal(s). Wireless terminal 202 may include peer discovery communicator 208, synchronizer 214 and memory 216.

[0069] Peer discovery communicator 208 (and similar peer discovery communicator(s) of disparate wireless terminal(s)) may utilize a reversible function for encoding and/or evaluating signals communicated over the peer-to-peer environment. As such, wireless terminal 202 and disparate wireless terminal(s) may abide by a function (*e.g.*, hash function) so that their unique identifiers can be discerned in one peer discovery interval or across a series of peer discovery intervals. Signal generator 210

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may employ the reversible function to yield a peer discovery signal based on an identifier of wireless terminal 202 and a time counter, and the signal may be provided to disparate wireless terminal(s) within the peer-to-peer network (*e.g.*, *via* broadcast). By leveraging the reversible function, the identifier (WT ID) may be deciphered by disparate wireless terminal(s) that detect the peer discovery signal transmitted by wireless terminal 202. For example, the reversible function may be a linear function or a non-linear function.

[0070] Signal generator 210 may include an encoding sequence linker 702 that links signal formats in successive peer discovery intervals based upon a fixed and predetermined rule (*e.g.*, reversible function). According to an example, the identifier (WT ID) may include 32 bits or more; however, a beacon signal communicated in a peer discovery interval with 200 symbols and 50 tones provides 10 bits. Thus, encoding sequence linker 702 may enable communicating the identifier by providing portions of the identifier *via* signals sent in more than one peer discovery interval. Encoding sequence linker 702 utilizes the reversible function to enable the identifier to be recognized over R peer discovery intervals, where R may be any integer (*e.g.*, less than 3, 3, less than 20, ...). For example, encoding sequence linker 702 may enable sending a first beacon during a first peer discovery interval, a second beacon during a second peer discovery interval, and so forth, where the beacons may be linked according to the reversible function.

[0071] Moreover, peer analyzer 212 may include a signal detector 704, a decoding sequence linker 706, and an identifier discerner 708. Signal detector 704 may obtain signal(s) communicated over the peer-to-peer network during peer discovery intervals. For instance, signal(s) may be generated by disparate wireless terminal(s) (*e.g.*, that employ the reversible function to generate such signals) and/or may correspond to noise or interference. According to an example, signal detector 704 may identify coordinate pairs of symbol(s) and corresponding tone(s) related to the detected signals. Decoding sequence linker 706 may utilize the fixed and predetermined rule to link together signal(s) from successive peer discovery intervals. Further, decoding sequence linker 706 may leverage knowledge of the function employed by an encoding sequence linker of a disparate wireless terminal to identify a sequence of signals from differing peer discovery intervals that correspond to one another. Moreover, identifier discerner 708 may evaluate the sequence of signals to determine the identifier encoded

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upon such signals. For instance, a list of identified disparate wireless terminals may be updated according to the analysis effectuated by identifier discerner 708.

[0072] By leveraging a reversible function, system 700 enables identifying disparate wireless terminals in a peer-to-peer network whether or not wireless terminal 202 has prior knowledge of identifiers related to the disparate wireless terminals (and similarly wireless terminal 202 may be identified by disparate wireless terminal(s)). Such recognition of wireless terminal(s) located within range may enhance coordination of traffic transmission and management of interference among multiple peer-to-peer connections.

[0073] According to an illustration, the identifier of wireless terminal 202 (*e.g.*, WT ID retained in memory 216 of wireless terminal 202) may be discoverable from signals transmitted by signal generator 210 of wireless terminal 202. Likewise, unique identifiers respectively corresponding to disparate wireless terminals in the peer-to-peer network may be similarly discoverable (*e.g.*, by peer analyzer 212 of wireless terminal 202). Further, based upon the determined identifier(s), peer analyzers (*e.g.*, peer analyzer 212) may recognize another wireless terminal as a peer. For example, the signal formats transmitted in successive peer discovery intervals may be linked with each other with a fixed and predetermined rule (*e.g.*, by encoding sequence linkers of wireless terminals), which is applicable across the peer-to-peer network. During a particular peer discovery interval, multiple wireless terminals may transmit their signature signals. However, a signature signal in one peer discovery interval may not uniquely identify a transmitting wireless terminal (*e.g.*, wireless terminal 202, disparate wireless terminal(s)). Thus, the transmitting wireless terminal may form a sequence of signature signals transmitted by that single transmitting wireless terminal over successive peer discovery intervals in order to recover the identifier of the transmitting wireless terminal. Moreover, the fixed and predetermined rule helps a receiving wireless terminal (*e.g.*, wireless terminal 202, disparate wireless terminal(s)) form one sequence of the signature signals so as to construct the identifier of the transmitting wireless terminal.

[0074] Substantially any fixed and predetermined rule may be employed when using beacon signals. Pursuant to an example, the signature signals from one transmitting wireless terminal may have the same position of the selected OFDM symbol in successive intervals. The transmitting wireless terminal may choose to skip a

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subset of the time intervals for transmission so that it can monitor those time intervals and check whether other transmitting wireless terminals are sending signature signals in those time intervals. In another example, the signature signals from one transmitting wireless terminal have the same position of the selected tone in successive time intervals. The positions of the selected symbols may be a function of the identifier of the transmitting wireless terminal. In yet another example, in two successive time intervals, the signature signals from one transmitting wireless terminal may be sent at tone y_1 of selected symbol x_1 and at tone y_2 of selected symbol x_2 , respectively; according to this example, the rule may be that $y_2=x_1$ or $x_2=y_1$. It is understood that the above equation may be defined in a modulo sense, where the modulus is a predetermined constant. In general, the linking function represents a constraint that x_1, y_1, x_2, y_2 have to satisfy, that is $g(x_1, y_1, x_2, y_2)=0$.

[0075] With reference to **Fig. 8**, illustrated is an example graphical depiction of an evaluation of a linked sequence of peer discovery signals generated with a reversible function. Time-frequency resource 800 represents a signal (*e.g.*, beacon) generated and/or obtained during a first peer discovery interval, T_i , and time-frequency resource 802 represents a signal generated and/or obtained during a second peer discovery interval, T_{i+1} . Moreover, the first peer discovery interval, T_i , may be the peer discovery interval proceeding the second peer discovery interval, T_{i+1} . The time-frequency resources 800-802 may be similar to time-frequency resource 400 of **Fig. 4**. Further, it is to be appreciated, however, that the claimed subject matter is not limited to these examples.

[0076] According to the depicted example, the reversible function may provide information related to the identifier based upon the selected symbol (*e.g.*, x axis). Further, information utilized to link signals from successive peer discovery intervals may be provided by the selected tone (*e.g.*, y axis). For example, the reversible function may provide that $y_{i+1}=x_i$. By way of illustration, a signal may be transmitted during the first peer discovery interval, T_i , with a coordinate pair (x_i, y_i) . The selected symbol, x_i , may provide information associated with a part of the identifier, while the remainder may be included in subsequent signal(s) that may be linked in a sequence. To determine the signal within the next peer discovery interval, T_{i+1} , that is included in the sequence, the signal with a selected tone coordinate, y_{i+1} , that is equal to x_i is identified. Further, although not shown, during a following peer discovery interval, T_{i+2} , $y_{i+2}=x_{i+1}$, and so

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forth. Although one signal is illustrated during each peer discovery interval, it is contemplated that any number of signals may be transmitted and/or received during each such interval. Additionally, it is to be appreciated that any disparate manner of linking beacon signals between differing peer discovery intervals is intended to fall within the scope of the hereto appended claims. Further, signals from any number of successive peer discovery intervals may be linked to communicate an identifier (*e.g.*, 2, 3, 4, ...).

[0077] Referring to **Figs. 9-12**, methodologies relating to performing peer discovery within a peer-to-peer network are illustrated. While, for purposes of simplicity of explanation, the methodologies are shown and described as a series of acts, it is to be understood and appreciated that the methodologies are not limited by the order of acts, as some acts may, in accordance with one or more embodiments, occur in different orders and/or concurrently with other acts from that shown and described herein. For example, those skilled in the art will understand and appreciate that a methodology could alternatively be represented as a series of interrelated states or events, such as in a state diagram. Moreover, not all illustrated acts may be required to implement a methodology in accordance with one or more embodiments.

[0078] Turning to **Fig. 9**, illustrated is a methodology 900 that facilitates identifying a wireless terminal (*e.g.*, disparate wireless terminal) in a peer-to-peer network that employs a reversible function for encoding peer discovery signals. At 902, a sequence of signals (*e.g.*, first signals) may be received across a series of peer discovery intervals, wherein the signals may be generated by a disparate wireless terminal using a predetermined hash function to which wireless terminals in a peer-to-peer network abide. The hash function may have constrained the disparate wireless terminal that generated and transmitted the sequence of signals (*e.g.*, the disparate wireless terminal from which the sequence of signals may be obtained). Further, the signals may have been generated based on an identifier (*e.g.*, of the transmitting wireless terminal) and a time counter variable (*e.g.*, synchronized time variable associated with each peer discovery interval). For example, the hash function may be a linear function, a non-linear function, and so forth. At 904, an identifier may be derived from the sequence of signals (*e.g.*, first signals) across the series of peer discovery intervals. The hash function may be reversible; thus, the identifier corresponding to the disparate wireless terminal that generated and transmitted the sequence of signals may

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be determined by a receive wireless terminal from the received signal. For example, the identifier may be obtained over R peer discovery intervals, where R may be any integer (e.g., 3, less than 3, less than 20, ...).

[0079] Pursuant to another example, timing associated with the peer discovery intervals may be synchronized. In particular, a signal (e.g., second signal) may be received from a signal source, wherein the signal source may be a base station, an access node, or a satellite. The second signal, for instance, may be broadcast over the peer-to-peer network. Further, timing information may be derived from the second signal. Thus, peers within the peer-to-peer network may identify substantially similar timing information since the peers evaluate a substantially similar signal (e.g., the second signal). Moreover, a time position of the peer discovery intervals in the series may be determined from the derived timing information.

[0080] Moreover, a time counter variable may be leveraged in connection with deriving the identifier from the received sequence of signal. For instance, a third signal may be received from the signal source. It is contemplated that the third signal may be the second signal and/or may be a signal distinct from the second signal. Additionally, a time counter variable may be derived from the third signal. The value of the time counter variable, for example, may vary between successive peer discovery intervals based on a predetermined function. Moreover, the time counter variable may be used to derive the identifier.

[0081] It is to be appreciated that each of the peer discovery intervals may include a plurality of symbols and each symbol may include a plurality of tones. Further, each of the signals (e.g., first signals) may include one or a plurality of beacon signals. For example, a beacon signal may include one tone in one symbol period. Further, the received power of the tone of the beacon signal may be at least 5 dB higher than an average per-tone power of other tones in the same symbol period.

[0082] Signals in differing peer discovery intervals may be linked according to a predetermined linking constraint function. For example, it may be determined whether at least one beacon signal is present in each peer discovery interval of the series. An index of the symbol and an index of the tone of each beacon signal may be estimated. Further, a predetermined linking constraint function may be applied to determine whether a first beacon signal in one peer discovery interval and a second beacon signal in a different peer discovery interval in the series are associated with the same identifier.

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Accordingly, the first beacon signal and the second beacon signal may be used to derive the identifier if the first beacon signal and the second beacon signal are determined to be associated with the same identifier. For example, the predetermined linking function may be a constraint function that symbol indices and tone indices of the first beacon signal and the second beacon signal have to satisfy. By way of further illustration, the constraint function may be such that the symbol index of the first beacon signal is equal to at least one of the tone index or the symbol index of the second beacon signal in a modulo sense and the modulus is a predetermined constant.

[0083] According to another example, it is contemplated that the identifier may be determined based at least in part upon a stored list of known identifiers. For example, the derived identifier may be compared with the list of known identifiers to determine whether the derived identifier matches any of the known identifiers. Moreover, a corresponding wireless terminal or user may be determined to be present in a vicinity if the derived identifier matches one known identifier.

[0084] According to another example, a disparate sequence of signals (*e.g.*, fourth signals) may be generated based upon the hash function; the hash function may consider a disparate identifier (*e.g.*, second identifier, associated with a wireless terminal generating the disparate sequence or a user using such wireless terminal) and/or a time counter variable. Pursuant to this example, the disparate sequence of signals may be transmitted over a series of peer discovery intervals (*e.g.*, that may be similar or different from the series across which the received sequence was obtained) to enable determination of the disparate identifier by disparate wireless terminal(s) to which the signals may be communicated.

[0085] Now referring to **Fig. 10**, illustrated is a methodology 1000 that facilitates decoding a sequence of signals obtained from a peer in a peer-to-peer environment. At 1002, a first signal may be detected during a first peer discovery interval. For example, the signal may be a beacon signal. Further, for instance, the signal may be a beacon signal; accordingly, a tone on a symbol (*e.g.*, OFDM symbol) may be positioned within the first peer discovery interval. The tone may be a high energy tone (*e.g.*, the received power is high). At 1004, a second signal may be detected during a second peer discovery interval. It is contemplated that any number of disparate signals may also be detected during the first and/or second peer discovery interval. At 1006, the first signal may be linked with the second signal based upon a function by

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which peers in a peer-to-peer environment are constrained. For instance, the function may be a fixed and predetermined rule utilized to encode and decode peer discovery signals communicated in the peer-to-peer environment. It is to be appreciated that substantially any such function (*e.g.*, reversible) is intended to fall within the scope of the claimed subject matter. Moreover, more than two signals from differing peer discovery intervals may be linked to yield a sequence of signals that correspond to a transmitting peer. According to another example, each of the signals may provide information associated with how to link that signal with a next signal. At 1008, a identifier of a peer may be determined from the linked signals. Pursuant to an example, each of the signals may provide information associated with a portion of the identifier. By way of further illustration, a data capacity associated with each of the signals may be smaller than the size of the identifier (*e.g.*, each signal may provide 10 bits of information while the identifier may be 32 bits or greater).

[0086] Moreover, the function (*e.g.*, reversible function) may be employed to encode and transmit signal(s) during peer discovery interval(s). Further, the function may enable providing linking related information and/or information pertaining to a identifier of a wireless terminal that encodes and transmits the signal(s). According to an illustration, a wireless terminal may encode and send signals to peer(s) that include information related to an identifier of the wireless terminal and how to link the signals; the wireless terminal may also receive and decode signals from peer(s) based on linking information from the received signals to determine identifier(s) of such peer(s).

[0087] With reference to **Fig. 11**, illustrated is a methodology 1100 that facilitates identifying a disparate wireless terminal in a peer-to-peer network. At 1102, a signal (*e.g.*, first signal) may be received in a peer discovery interval; the signal may be generated by a disparate wireless terminal using a predetermined hash function. The predetermined hash function may be irreversible; however, it is to be appreciated that a reversible function may be employed. The signal, for example, may be a beacon signal. Further, since the signal may be yielded by employing the irreversible function, an identifier associated with the disparate wireless terminal utilized to generate the signal may be unable to be directly calculated. Moreover, the signal may be analyzed to determine a coordinate pair that includes a selected symbol and a selected tone. At 1104, an expected signal may be generated utilizing at least one known identifier from a stored list based on the predetermined hash function. For example, the predetermined

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hash function employed to yield the generated expected signal may be substantially similar to the predetermined hash function employed by the disparate wireless terminal to generate the signal. Pursuant to an illustration, the predetermined hash function may consider a list of known identifiers (*e.g.*, buddy list) and/or a time associated with a peer discovery interval (*e.g.*, time counter variable). The known identifiers may be pre-stored in the memory of the wireless terminal. At 1106, the received signal may be compared with the generated expected signal to determine a presence of the disparate wireless terminal in a vicinity. The disparate wireless terminal may correspond to the known identifier used to generate the expected signal. For example, a plurality of expected signals may be generated, and one of the expected signals that matches the received signal may be recognized. Further, the peer corresponding to the matching expected signal may be determined to be the source of the signal (*e.g.*, the disparate wireless terminal) with a degree of probability. Moreover, if such peer is repeatedly matched to received signals during distinct peer discovery intervals, a higher probability may be allocated to the peer. Additionally, an energy level associated with the received signal may impact the probability; thus, a high energy level of the received signal may correspond to a higher probability as compared to a low energy level of the received signal. Pursuant to a further example, a disparate signal may be generated utilizing the predetermined hash function, and such disparate signal may be transmitted over the peer-to-peer network for a similar comparison at differing peers.

[0088] Pursuant to another example, timing associated with the peer discovery intervals may be synchronized. In particular, a signal (*e.g.*, second signal) may be received from a signal source, wherein the signal source may be a base station, an access node, or a satellite. The second signal, for instance, may be broadcast over the peer-to-peer network. Further, timing information may be derived from the second signal. Thus, peers within the peer-to-peer network may identify substantially similar timing information since the peers evaluate a substantially similar signal (*e.g.*, the second signal). Moreover, a time position of the peer discovery intervals in a series may be determined from the derived timing information.

[0089] Moreover, a time counter variable may be leveraged in connection with deriving the identifier from the received sequence of signal. For instance, a third signal may be received from the signal source. It is contemplated that the third signal may be the second signal and/or may be a signal distinct from the second signal. Additionally,

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a time counter variable may be derived from the third signal. The value of the time counter variable, for example, may vary between successive peer discovery intervals based on a predetermined function. Moreover, the time counter variable may be used to generate the expected signal.

[0090] It is to be appreciated that each of the peer discovery intervals may include a plurality of symbols and each symbol may include a plurality of tones. Further, each of the signals (*e.g.*, first signal) may include one or a plurality of beacon signals. For example, a beacon signal may include one tone in one symbol period. Further, the received power of the tone of the beacon signal may be at least 5 dB higher than an average per-tone power of other tones in the same symbol period.

[0091] The known identifier(s) retained in memory may be utilized to generate expected signal(s). For example, a determination may be made as to whether at least one beacon signal is present in the peer discovery interval. Further, an index of the symbol and an index of the tone of the received beacon may be estimated. Thus, generating the expected signal may further include calculating the index of the symbol and the index of the tone of the expected signal (*e.g.* expected beacon signal) based on the predetermined hash function using at least one of the known identifiers and the time counter variable. Moreover, a value (*e.g.*, greater than zero) may be assigned to a probability that the disparate wireless terminal corresponding to the known identifier used to generate the expected signal is present in the vicinity.

[0092] Moreover, the probability may be adjusted. For example, a signal (*e.g.*, fourth signal) may be received during another peer discovery interval (*e.g.*, second peer discovery interval), wherein the fourth signal may be generated by the disparate wireless terminal using the predetermined hash function. Further, first and second peer discovery intervals may be distinct from one another. An expected signal may be generated using the known identifier based on the predetermined hash function. Moreover, the received fourth signal may be compared with the generated expected signal. Thereafter, the value of the probability that a wireless terminal corresponding to the known identifier is present in the vicinity may be increased if the comparison result indicates that the received fourth signal is substantially similar to the generated expected signal and if the probability is less than 1. Additionally, the value of the probability that the wireless terminal corresponding to the known identifier is present in the vicinity

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may be decreased if the comparison indicates that the received fourth signal is different from the generated expected signal.

[0093] By way of further example, an energy level of the received first signal may be evaluated. A value of a probability may be determined based upon the energy level.

[0094] Now turning to **Fig. 12**, illustrated is a methodology 1200 that facilitates analyzing signals obtained during a peer discovery interval in a peer-to-peer network. At 1202, a plurality of signals may be detected during a peer discovery interval. For instance, the plurality of signals may be peer discovery signals transmitted by peer(s) (*e.g.*, known or unknown) and/or noise. At 1204, expected signals may be derived based upon known identifiers retained in memory and a time counter variable associated with the peer discovery interval using a predetermined hash function (*e.g.*, irreversible function). For example, a list of known identifiers corresponding to known peers (*e.g.*, buddy peers) may be retained in memory. Pursuant to an illustration, expected tone-expected symbol pairs may be determined. At 1206, the plurality of detected signals may be compared with the expected signals. At 1208, a first known peer is determined to be within a peer-to-peer network when one of the detected signals matches one of the expected signals. At 1210, a second known peer is determined to be outside of the peer-to-peer network when the detected signals fail to match the expected signal corresponding to the second known peer. At 1212, one or more of the detected signals may be discarded if such detected signals do not match the expected signals corresponding to any of the known identifiers.

[0095] It will be appreciated that, in accordance with one or more aspects described herein, inferences can be made regarding discovering and identifying peers in a peer-to-peer environment. 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

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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.

[0096] According to an example, one or more methods presented above can include making inferences pertaining to identifying sources of peer discovery signals in a peer-to-peer network. In accordance with another example, an inference may be made related to estimating a probability of a peer being located within proximity based upon a number of detected signals that match an expected signal format and/or energy levels associated with detected signals. It will be appreciated that the foregoing examples are illustrative in nature and are not intended to limit the number of inferences that can be made or the manner in which such inferences are made in conjunction with the various embodiments and/or methods described herein.

[0097] **Fig. 13** depicts an example communication system 1300 implemented in accordance with various aspects including multiple cells: cell I 1302, cell M 1304. Note that neighboring cells 1302, 1304 overlap slightly, as indicated by cell boundary region 1368, thereby creating potential for signal interference between signals transmitted by base stations in neighboring cells. Each cell 1302, 1304 of system 1300 includes three sectors. Cells which have not be subdivided into multiple sectors ($N=1$), cells with two sectors ($N=2$) and cells with more than 3 sectors ($N>3$) are also possible in accordance with various aspects. Cell 1302 includes a first sector, sector I 1310, a second sector, sector II 1312, and a third sector, sector III 1314. Each sector 1310, 1312, 1314 has two sector boundary regions; each boundary region is shared between two adjacent sectors.

[0098] Sector boundary regions provide potential for signal interference between signals transmitted by base stations in neighboring sectors. Line 1316 represents a sector boundary region between sector I 1310 and sector II 1312; line 1318 represents a sector boundary region between sector II 1312 and sector III 1314; line 1320 represents a sector boundary region between sector III 1314 and sector I 1310. Similarly, cell M 1304 includes a first sector, sector I 1322, a second sector, sector II 1324, and a third sector, sector III 1326. Line 1328 represents a sector boundary region between sector I 1322 and sector II 1324; line 1330 represents a sector boundary region between sector II 1324 and sector III 1326; line 1332 represents a boundary region between sector III 1326 and sector I 1322. Cell I 1302 includes a base station (BS), base station I 1306, and a plurality of end nodes (ENs) (e.g., wireless terminals) in each sector 1310, 1312, 1314. Sector I 1310 includes EN(1) 1336 and EN(X) 1338 coupled

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to BS 1306 *via* wireless links 1340, 1342, respectively; sector II 1312 includes EN(1') 1344 and EN(X') 1346 coupled to BS 1306 *via* wireless links 1348, 1350, respectively; sector III 1314 includes EN(1'') 1352 and EN(X'') 1354 coupled to BS 1306 *via* wireless links 1356, 1358, respectively. Similarly, cell M 1304 includes base station M 1308, and a plurality of end nodes (ENs) in each sector 1322, 1324, 1326. Sector I 1322 includes EN(1) 1336' and EN(X) 1338' coupled to BS M 1308 *via* wireless links 1340', 1342', respectively; sector II 1324 includes EN(1') 1344' and EN(X') 1346' coupled to BS M 1308 *via* wireless links 1348', 1350', respectively; sector 3 1326 includes EN(1'') 1352' and EN(X'') 1354' coupled to BS 1308 *via* wireless links 1356', 1358', respectively.

[0099] System 1300 also includes a network node 1360 which is coupled to BS I 1306 and BS M 1308 *via* network links 1362, 1364, respectively. Network node 1360 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 1366. Network links 1362, 1364, 1366 may be, *e.g.*, fiber optic cables. Each end node, *e.g.*, EN(1) 1336 may be a wireless terminal including a transmitter as well as a receiver. The wireless terminals, *e.g.*, EN(1) 1336 may move through system 1300 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) 1336, may communicate with peer nodes, *e.g.*, other WT's in system 1300 or outside system 1300 *via* a base station, *e.g.*, BS 1306, and/or network node 1360. WT's, *e.g.*, EN(1) 1336 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.

[00100] Local area peer-to-peer communication may also be supported by communication system 1300. For example, a common spectrum may be utilized for both local area peer-to-peer communication as well as communication *via* the wide area

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network (e.g., cellular infrastructure network). Wireless terminals may communicate with other peers *via* a local area peer-to-peer network such as peer-to-peer networks 1370, 1372, and 1374. Although three peer-to-peer networks 1370-1374 are depicted, it is to be appreciated that any number, size, shape, *etc.* of peer-to-peer networks may be supported. For instance, each peer-to-peer network 1370-1374 may support transfer of signals directly between wireless terminals. Further, each peer-to-peer network 1370-1374 may include wireless terminals within a similar geographic area (e.g., within range of one another). For example, EN(1) 1336 may communicate with EN(X) 1338 by way of the local area peer-to-peer network 1370. However, it is to be appreciated that wireless terminals need not be associated with the same sector and/or cell to be included in a common peer-to-peer network. Further, peer-to-peer networks may overlap (e.g., EN(X') 1346 may leverage peer-to-peer networks 1372 and 1374). Additionally, a wireless terminal may not be supported by a peer-to-peer network. Wireless terminals may employ the wide area network and/or the peer-to-peer network where such networks overlap (e.g., concurrently or serially). Moreover, wireless terminals may seamlessly switch or concurrently leverage such networks. Accordingly, wireless terminals whether transmitting and/or receiving may selectively employ one or more of the networks to optimize communications.

[00101] Fig. 14 illustrates an example base station 1400 in accordance with various aspects. Base station 1400 implements tone subset allocation sequences, with different tone subset allocation sequences generated for respective different sector types of the cell. Base station 1400 may be used as any one of base stations 1306, 1308 of the system 1300 of Fig. 13. The base station 1400 includes a receiver 1402, a transmitter 1404, a processor 1406, e.g., CPU, an input/output interface 1408 and memory 1410 coupled together by a bus 1409 over which various elements 1402, 1404, 1406, 1408, and 1410 may interchange data and information.

[00102] Sectorized antenna 1403 coupled to receiver 1402 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 1405 coupled to transmitter 1404 is used for transmitting data and other signals, e.g., control signals, pilot signal, beacon signals, *etc.* to wireless terminals 1500 (see Fig. 15) within each sector of the base station's cell. In various aspects, base station 1400 may employ multiple receivers 1402 and multiple transmitters 1404, e.g., an individual receiver 1402

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for each sector and an individual transmitter 1404 for each sector. Processor 1406, may be, *e.g.*, a general purpose central processing unit (CPU). Processor 1406 controls operation of base station 1400 under direction of one or more routines 1418 stored in memory 1410 and implements the methods. I/O interface 1408 provides a connection to other network nodes, coupling the BS 1400 to other base stations, access routers, AAA server nodes, *etc.*, other networks, and the Internet. Memory 1410 includes routines 1418 and data/information 1420.

[00103] Data/information 1420 includes data 1436, tone subset allocation sequence information 1438 including downlink strip-symbol time information 1440 and downlink tone information 1442, and wireless terminal (WT) data/info 1444 including a plurality of sets of WT information: WT 1 info 1446 and WT N info 1460. Each set of WT info, *e.g.*, WT 1 info 1446 includes data 1448, terminal ID 1450, sector ID 1452, uplink channel information 1454, downlink channel information 1456, and mode information 1458.

[00104] Routines 1418 include communications routines 1422 and base station control routines 1424. Base station control routines 1424 includes a scheduler module 1426 and signaling routines 1428 including a tone subset allocation routine 1430 for strip-symbol periods, other downlink tone allocation hopping routine 1432 for the rest of symbol periods, *e.g.*, non strip-symbol periods, and a beacon routine 1434.

[00105] Data 1436 includes data to be transmitted that will be sent to encoder 1414 of transmitter 1404 for encoding prior to transmission to WTs, and received data from WTs that has been processed through decoder 1412 of receiver 1402 following reception. Downlink strip-symbol time information 1440 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 1442 includes information including a carrier frequency assigned to the base station 1400, 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.

[00106] Data 1448 may include data that WT1 1500 has received from a peer node, data that WT 1 1500 desires to be transmitted to a peer node, and downlink

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channel quality report feedback information. Terminal ID 1450 is a base station 1400 assigned ID that identifies WT 1 1500. Sector ID 1452 includes information identifying the sector in which WT1 1500 is operating. Sector ID 1452 can be used, for example, to determine the sector type. Uplink channel information 1454 includes information identifying channel segments that have been allocated by scheduler 1426 for WT1 1500 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 1500 includes one or more logical tones, each logical tone following an uplink hopping sequence. Downlink channel information 1456 includes information identifying channel segments that have been allocated by scheduler 1426 to carry data and/or information to WT1 1500, *e.g.*, downlink traffic channel segments for user data. Each downlink channel assigned to WT1 1500 includes one or more logical tones, each following a downlink hopping sequence. Mode information 1458 includes information identifying the state of operation of WT1 1500, *e.g.* sleep, hold, on.

[00107] Communications routines 1422 control the base station 1400 to perform various communications operations and implement various communications protocols. Base station control routines 1424 are used to control the base station 1400 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.

[00108] Signaling routine 1428 controls the operation of receiver 1402 with its decoder 1412 and transmitter 1404 with its encoder 1414. The signaling routine 1428 is responsible for controlling the generation of transmitted data 1436 and control information. Tone subset allocation routine 1430 constructs the tone subset to be used in a strip-symbol period using the method of the aspect and using data/information 1420 including downlink strip-symbol time info 1440 and sector ID 1452. The downlink tone subset allocation sequences will be different for each sector type in a cell and different for adjacent cells. The WTs 1500 receive the signals in the strip-symbol periods in accordance with the downlink tone subset allocation sequences; the base station 1400 uses the same downlink tone subset allocation sequences in order to generate the transmitted signals. Other downlink tone allocation hopping routine 1432 constructs downlink tone hopping sequences, using information including downlink tone

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information 1442, and downlink channel information 1456, 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 1434 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.

[00109] Fig. 15 illustrates an example wireless terminal (*e.g.*, end node, mobile device, ...) 1500 which can be used as any one of the wireless terminals (*e.g.*, end nodes, mobile devices, ...), *e.g.*, EN(1) 1336, of the system 1300 shown in Fig. 13. Wireless terminal 1500 implements the tone subset allocation sequences. Wireless terminal 1500 includes a receiver 1502 including a decoder 1512, a transmitter 1504 including an encoder 1514, a processor 1506, and memory 1508 which are coupled together by a bus 1510 over which the various elements 1502, 1504, 1506, 1508 can interchange data and information. An antenna 1503 used for receiving signals from a base station 1400 (and/or a disparate wireless terminal) is coupled to receiver 1502. An antenna 1505 used for transmitting signals, *e.g.*, to base station 1400 (and/or a disparate wireless terminal) is coupled to transmitter 1504.

[00110] The processor 1506 (*e.g.*, a CPU) controls operation of wireless terminal 1500 and implements methods by executing routines 1520 and using data/information 1522 in memory 1508.

[00111] Data/information 1522 includes user data 1534, user information 1536, tone subset allocation sequence information 1550, and an identifier 1556. User data 1534 may include data, intended for a peer node, which will be routed to encoder 1514 for encoding prior to transmission by transmitter 1504 to base station 1400, and data received from the base station 1400 which has been processed by the decoder 1512 in receiver 1502. User information 1536 includes uplink channel information 1538, downlink channel information 1540, terminal ID information 1542, base station ID information 1544, sector ID information 1546, and mode information 1548. Uplink channel information 1538 includes information identifying uplink channels segments that have been assigned by base station 1400 for wireless terminal 1500 to use when transmitting to the base station 1400. Uplink channels may include uplink traffic channels, dedicated uplink control channels, *e.g.*, request channels, power control

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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 1540 includes information identifying downlink channel segments that have been assigned by base station 1400 to WT 1500 for use when BS 1400 is transmitting data/information to WT 1500. 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.

[00112] User info 1536 also includes terminal ID information 1542, which is a base station 1400 assigned identification, base station ID information 1544 which identifies the specific base station 1400 that WT has established communications with, and sector ID info 1546 which identifies the specific sector of the cell where WT 1500 is presently located. Base station ID 1544 provides a cell slope value and sector ID info 1546 provides a sector index type; the cell slope value and sector index type may be used to derive tone hopping sequences. Mode information 1548 also included in user info 1536 identifies whether the WT 1500 is in sleep mode, hold mode, or on mode.

[00113] Tone subset allocation sequence information 1550 includes downlink strip-symbol time information 1552 and downlink tone information 1554. Downlink strip-symbol time information 1552 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 1554 includes information including a carrier frequency assigned to the base station 1400, 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.

[00114] Routines 1520 include communications routines 1524, wireless terminal control routines 1526, synchronization routines 1528, signal generation/broadcast routines 1530, and detection routines 1532. Communications routines 1524 control the various communications protocols used by WT 1500. For example, communications routines 1524 may enable communicating *via* a wide area network (*e.g.*, with base

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station 1400) and/or a local area peer-to-peer network (*e.g.*, directly with disparate wireless terminal(s)). By way of further example, communications routines 1524 may enable receiving a broadcast signal (*e.g.*, from base station 1400). Wireless terminal control routines 1526 control basic wireless terminal 1500 functionality including the control of the receiver 1502 and transmitter 1504. Synchronization routines 1528 control synchronizing wireless terminal 1500 to a received signal (*e.g.*, from base station 1400). Peers within a peer-to-peer network may also be synchronized to the signal. For example, the received signal may be a Beacon, a PN (pseudo random) sequence signal, a pilot signal, *etc.* Further, the signal may be periodically obtained and a protocol (*e.g.*, associated with synchronization routines 1528) also known to peers may be utilized to identify intervals corresponding to distinct functions (*e.g.*, peer discovery, paging, traffic). Signal generation/broadcast routines 1530 control creating a message for transmission during an identified peer discovery interval. A symbol and/or tone associated with the message may be selected based upon a protocol (*e.g.*, associated with signal generation/broadcast routines 1530). Moreover, signal generation/broadcast routines 1530 may control sending the message to peers within the peer-to-peer network. Signal generation/broadcast routines 1530 may utilize a reversible function or an irreversible function to transfer peer discovery signals based upon identifier 1556. Detection routines 1532 control detection and identification of peers based upon messages received during an identified peer discovery interval. Detection routines 1532 may utilize a similar function (*e.g.*, reversible, irreversible) as compared to signal generation/broadcast routines 1530 to determine an identity of a peer. Further, detection routines 1532 may identify peers based at least in part upon information retained in a buddy peer list (*e.g.*, that may be included in data/information 1522 of memory 1508 when employing an irreversible function).

[00115] With reference to **Fig. 16**, illustrated is a system 1600 that enables utilizing a reversible function in connection with peer discovery signals in a peer-to-peer network. For example, system 1600 may reside at least partially within a wireless terminal. It is to be appreciated that system 1600 is represented as including functional blocks, which may be functional blocks that represent functions implemented by a processor, software, or combination thereof (*e.g.*, firmware). System 1600 includes a logical grouping 1602 of electrical components that can act in conjunction. For instance, logical grouping 1602 may include an electrical component for receiving a

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sequence of signals across a series of peer discovery intervals, the signals being generated by a peer using a predetermined hash function to which peers in a peer-to-peer network abide 1604. For example, the predetermined hash function may be a reversible function that may enable generating the sequence of signals based upon the identifier and/or a value of a time counter variable (*e.g.*, associated with a time of a peer discovery interval). Further, logical grouping 1602 may comprise an electrical component for deriving an identifier from the sequence of signals across the series of peer discovery intervals 1606. Pursuant to an example, each of the signals may include information pertaining to linking that signal with other signals in the sequence and/or information related to a portion of the identifier. Moreover, a disparate sequence of signals may be generated and/or transmitted across peer discovery intervals to peers. Additionally, system 1600 may include a memory 1608 that retains instructions for executing functions associated with electrical components 1604 and 1606. While shown as being external to memory 1608, it is to be understood that one or more of electrical components 1604 and 1606 may exist within memory 1608.

[00116] With reference to **Fig. 17**, illustrated is a system 1700 that enables utilizing an irreversible function in connection with encoding and/or decoding peer discovery signals in a peer-to-peer network. System 1700 may reside at least partially within a wireless terminal, for instance. It is to be appreciated that system 1700 is represented as including functional blocks, which may be functional blocks that represent functions implemented by a processor, software, or combination thereof (*e.g.*, firmware). System 1700 includes a logical grouping 1702 of electrical components that can act in conjunction. For instance, logical grouping 1702 may include an electrical component for receiving a signal in a peer discovery interval, the signal being generated by a peer using a predetermined hash function 1704. For example, the predetermined hash function may be an irreversible function that may be commonly known and employed in the peer-to-peer network. Further, logical grouping 1702 may comprise an electrical component for generating an expected signal utilizing at least one known identifier from a stored list based upon the predetermined hash function 1706. Moreover, logical grouping 1702 may include an electrical component for comparing the received signal with the generated signal to determine a presence of the peer in a vicinity 1708. For example, Additionally, system 1700 may include a memory 1710 that retains instructions for executing functions associated with electrical components 1704,

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1706, and 1708. While shown as being external to memory 1710, it is to be understood that one or more of electrical components 1704, 1706, and 1708 may exist within memory 1710.

[00117] It is to be understood that the embodiments described herein may be implemented in hardware, software, firmware, middleware, microcode, or any combination thereof. For a hardware implementation, the processing units may 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.

[00118] When the embodiments are implemented in software, firmware, middleware or microcode, program code or code segments, they may be stored in a machine-readable medium, such as a storage component. A code segment may 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 may 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.* may be passed, forwarded, or transmitted using any suitable means including memory sharing, message passing, token passing, network transmission, *etc.*

[00119] For a software implementation, the techniques described herein may be implemented with modules (*e.g.*, procedures, functions, and so on) that perform the functions described herein. The software codes may be stored in memory units and executed by processors. The memory unit may 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.

[00120] 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

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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.

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CLAIMS

1. A method that facilitates operating a wireless terminal in a peer-to-peer network, comprising:

receiving a sequence of first signals across a series of peer discovery intervals, wherein the first signals are generated by a disparate wireless terminal using a predetermined hash function to which wireless terminals in the peer-to-peer network abide; and

deriving an identifier from the sequence of first signals across the series of peer discovery intervals.

2. The method of claim 1, wherein the predetermined hash function is a reversible function.

3. The method of claim 1, further comprising:

receiving a second signal from a signal source, wherein the signal source includes one of a base station, an access node, or a satellite;

deriving timing information from the second signal; and

determining time positions of the peer discovery intervals in the series from the derived timing information.

4. The method of claim 3, further comprising:

receiving a third signal from the signal source;

deriving a time counter variable from the third signal, wherein a value of the time counter variable varies between two successive peer discovery intervals based on a predetermined function; and

using the time counter variable to derive the identifier.

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5. The method of claim 4, wherein each of the peer discovery intervals includes a plurality of symbols and each of the plurality of symbols includes a plurality of tones and the first signals include one or a plurality of beacon signals wherein a beacon signal includes one tone in one symbol period and a received power of the one tone is at least 5 dB higher than an average per-tone power of other tones in the same symbol period.
6. The method of claim 5, further comprising
determining at least one beacon signal is present in each peer discovery interval of the series;
estimating an index of the symbol and an index of the tone of the beacon signals;
applying a predetermined linking constraint function to determine whether a first beacon signal in one peer discovery interval and a second beacon signal in a different peer discovery interval in the series are associated with the same identifier; and
using the first beacon signal and the second beacon signal to derive the identifier if the first beacon signal and the second beacon signal are determined to be associated with the same identifier.
7. The method of claim 6, wherein the predetermined linking constraint function is a constraint function that symbol indices and tone indices of the first beacon signal and the second beacon signal have to satisfy.
8. The method of claim 7, wherein the constraint function is such that the symbol index of the first beacon signal is equal to at least one of the tone index or the symbol index of the second beacon signal in a modulo sense and a modulus is a predetermined constant.

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9. The method of claim 4, further comprising:
generating a disparate sequence of fourth signals based upon the predetermined hash function to encode a second identifier of the wireless terminal or a user using the wireless terminal; and
transmitting the disparate sequence of fourth signals over a second series of peer discovery intervals to enable other wireless terminals to decipher the encoded, second identifier.
10. The method of claim 9, further comprising generating each signal of the sequence of fourth signals based upon the time counter variable associated with corresponding peer discovery intervals.
11. The method of claim 1, further comprising:
linking the signals to form the sequence; and
determining the identifier from the linked signals.
12. The method of claim 1, further comprising:
storing a list of known identifiers;
comparing the derived identifier with the list to determine whether the derived identifier matches any of the known identifiers; and
determining that a corresponding wireless terminal or user is present in a vicinity if the derived identifier matches one known identifier.
13. A wireless communications apparatus, comprising:
a memory that retains instructions related to detecting a sequence of first signals during a series of peer discovery intervals, wherein the first signals are generated by a peer using a predetermined hash function that constrains peers in a peer-to-peer environment, and deriving an identifier from the sequence of first signals across the series of peer discovery intervals; and
a processor, coupled to the memory, configured to execute the instructions retained in the memory.

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14. The wireless communications apparatus of claim 13, wherein the predetermined hash function is a reversible function.

15. The wireless communications apparatus of claim 13, wherein the memory further retains instructions for deriving timing information from a second signal obtained from one or more of a base station, an access node or a satellite, and determining time positions of the peer discovery intervals in the series from the derived timing information.

16. The wireless communications apparatus of claim 15, wherein the memory further retains instructions for deriving a time counter variable that varies between two successive peer discovery intervals from a third signal received from the one or more of the base station, the access node or the satellite, and using the time counter variable to derive the identifier.

17. The wireless communications apparatus of claim 16, wherein each of the peer discovery intervals includes a plurality of symbols and each of the plurality of symbols includes a plurality of tones and the first signals include one or a plurality of beacon signals wherein a beacon signal includes one tone in one symbol period and a received power of the one tone is at least 5 dB higher than an average per-tone power of other tones in the same symbol period.

18. The wireless communications apparatus of claim 17, wherein the memory further retains instructions for estimating a symbol index and a tone index of received beacon signals, determining whether a first beacon signal in one peer discovery interval and a second beacon signal in a second peer discovery interval in the series are associated with the same identifier by applying a predetermined linking constraint function, and employing the first beacon signal and the second beacon signal to derive the identifier when the first beacon signal and the second beacon signal are determined to be associated with the same identifier.

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19. The wireless communications apparatus of claim 18, wherein the predetermined linking constraint function provides constraints for symbol indices and tone indices of the first beacon signal and the second beacon signal.

20. The wireless communications apparatus of claim 19, wherein the predetermined linking constraint function constrains the symbol index of the first beacon signal to be equal to one or more of the tone index or the symbol index of the second beacon signal in a modulo sense and a modulus is a predetermined constant.

21. The wireless communications apparatus of claim 16, wherein the memory further retains instructions for encoding a disparate sequence of fourth signals with a second identifier of a wireless terminal or a user of the wireless terminal by employing the predetermined hash function, and sending the disparate sequence of fourth signals over a second series of peer discovery intervals to enable peers to evaluate the encoded, second identifier.

22. The wireless communications apparatus of claim 21, wherein the memory further retains instructions for encoding each signal of the disparate sequence of fourth signals based upon the time counter variable associated with corresponding peer discovery intervals.

23. The wireless communications apparatus of claim 21, wherein the memory further retains instructions for linking the first signals to form the sequence, and determining the identifier from the linked first signals.

24. The wireless communications apparatus of claim 21, wherein the memory further retains instructions for comparing the derived identifier with a stored list of known identifiers to determine whether the derived identifier matches any of the known identifiers, and determining that a corresponding wireless terminal or user is present in a vicinity if the derived identifier matches one known identifier.

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25. A wireless communications apparatus that enables utilizing a reversible function in connection with peer discovery signals in a peer-to-peer network, comprising:

means for receiving a sequence of signals across a series of peer discovery intervals, the signals being generated by a disparate wireless terminal using a predetermined reversible function to which wireless terminals in a peer-to-peer network abide; and

means for deriving an identifier from the sequence of signals across the series of peer discovery intervals.

26. The wireless communications apparatus of claim 25, further comprising means for determining time positions of the peer discovery intervals in the series from timing information received from a base station, an access node, and/or a satellite.

27. The wireless communications apparatus of claim 26, further comprising means for deriving a time counter variable that changes between two successive peer discovery intervals, the time counter variable being utilized to derive the identifier.

28. The wireless communications apparatus of claim 27, wherein each of the peer discovery intervals includes a plurality of symbols and each of the plurality of symbols includes a plurality of tones and the signals include one or a plurality of beacon signals wherein a beacon signal includes one tone in one symbol period and a received power of the one tone is at least 5 dB higher than an average per-tone power of other tones in the same symbol period.

29. The wireless communications apparatus of claim 28, further comprising:
means for determining whether a first beacon signal in one peer discovery interval and a second beacon signal in a second peer discovery interval are associated with the same identifier by applying a predetermined linking constraint function; and
means for deriving the identifier based upon the first beacon signal and the second beacon signal when associated with the same identifier.

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30. The wireless communications apparatus of claim 27, further comprising:
means for generating a disparate sequence of signals with the time counter variable and a disparate identifier of a wireless terminal or a user of the wireless terminal based upon the predetermined reversible function; and
means for broadcasting the disparate sequence of signals over the peer-to-peer network.
31. The wireless communications apparatus of claim 25, further comprising:
means for determining whether the derived identifier matches a known identifier from a retained list of known identifiers; and
means for identifying a corresponding peer or user as being present in a vicinity if the derived identifier matches one known identifier.
32. A machine-readable medium having stored thereon machine-executable instructions for:
receiving a sequence of first signals across a series of peer discovery intervals, wherein the first signals are generated by a disparate wireless terminal using a predetermined hash function to which wireless terminals in the peer-to-peer network abide; and
deriving an identifier from the sequence of first signals across the series of peer discovery intervals.
33. The machine-readable medium of claim 32, wherein the predetermined hash function is a reversible function.
34. The machine-readable medium of claim 32, the machine-executable instructions further comprise determining time positions of the peer discovery intervals in the series from timing information derived from a second signal, wherein the second signal is received from one or more of a base station, an access node, or a satellite.

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35. The machine-readable medium of claim 34, the machine-executable instructions further comprise identifying a time counter variable to be utilized for deriving the identifier, wherein the time counter variable varies between two successive peer discovery intervals based upon a predetermined function.

36. The machine-readable medium of claim 35, wherein each of the peer discovery intervals includes a plurality of symbols and each of the plurality of symbols includes a plurality of tones and the first signals include one or a plurality of beacon signals wherein a beacon signal includes one tone in one symbol period and a received power of the one tone is at least 5 dB higher than an average per-tone power of other tones in the same symbol period.

37. The machine-readable medium of claim 36, the machine-executable instructions further comprise:

estimating a symbol index and a tone index of the beacon signals;

applying a predetermined linking constraint function to determine whether a first beacon signal in one peer discovery interval and a second beacon signal in a differing peer discovery interval in the series are associated with the same identifier; and

utilizing the first beacon signal and the second beacon signal to derive the identifier when the first beacon signal and the second beacon signal are determined to be associated with the same identifier.

38. The machine-readable medium of claim 35, the machine-executable instructions further comprise:

generating a disparate sequence of transmission signals based upon the predetermined hash function to encode a second identifier of the wireless terminal or a user using the wireless terminal; and

sending the disparate sequence over a second series of peer discovery intervals to enable other wireless terminals to decipher the encoded, second identifier.

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39. In a wireless communication system, an apparatus comprising:
a processor configured to:

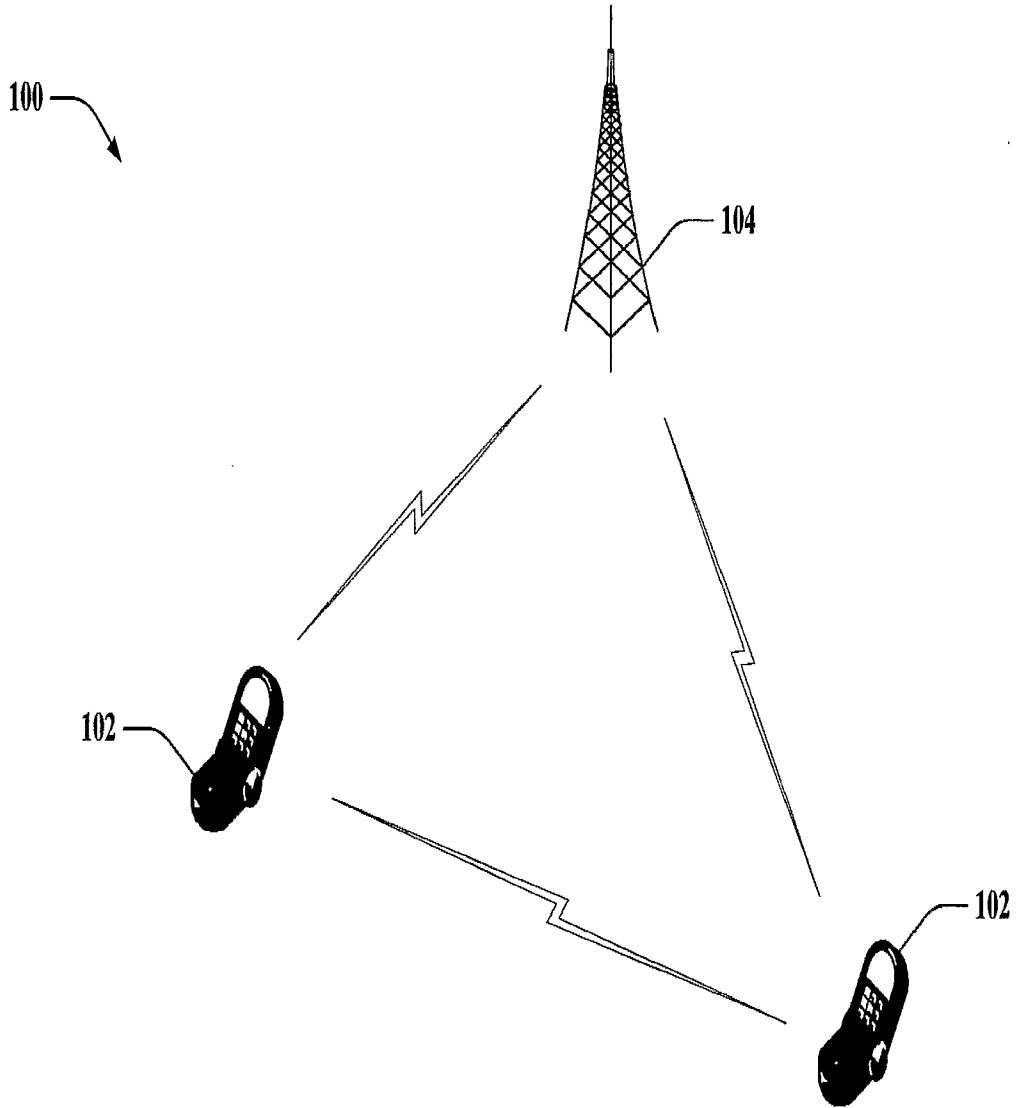
receive a sequence of signals across a series of peer discovery intervals,
wherein the signals are generated by a disparate wireless terminal using a
predetermined hash function to which wireless terminals in the peer-to-peer
network abide; and

derive an identifier from the sequence of signals across the series of peer
discovery intervals.

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FIG. 1

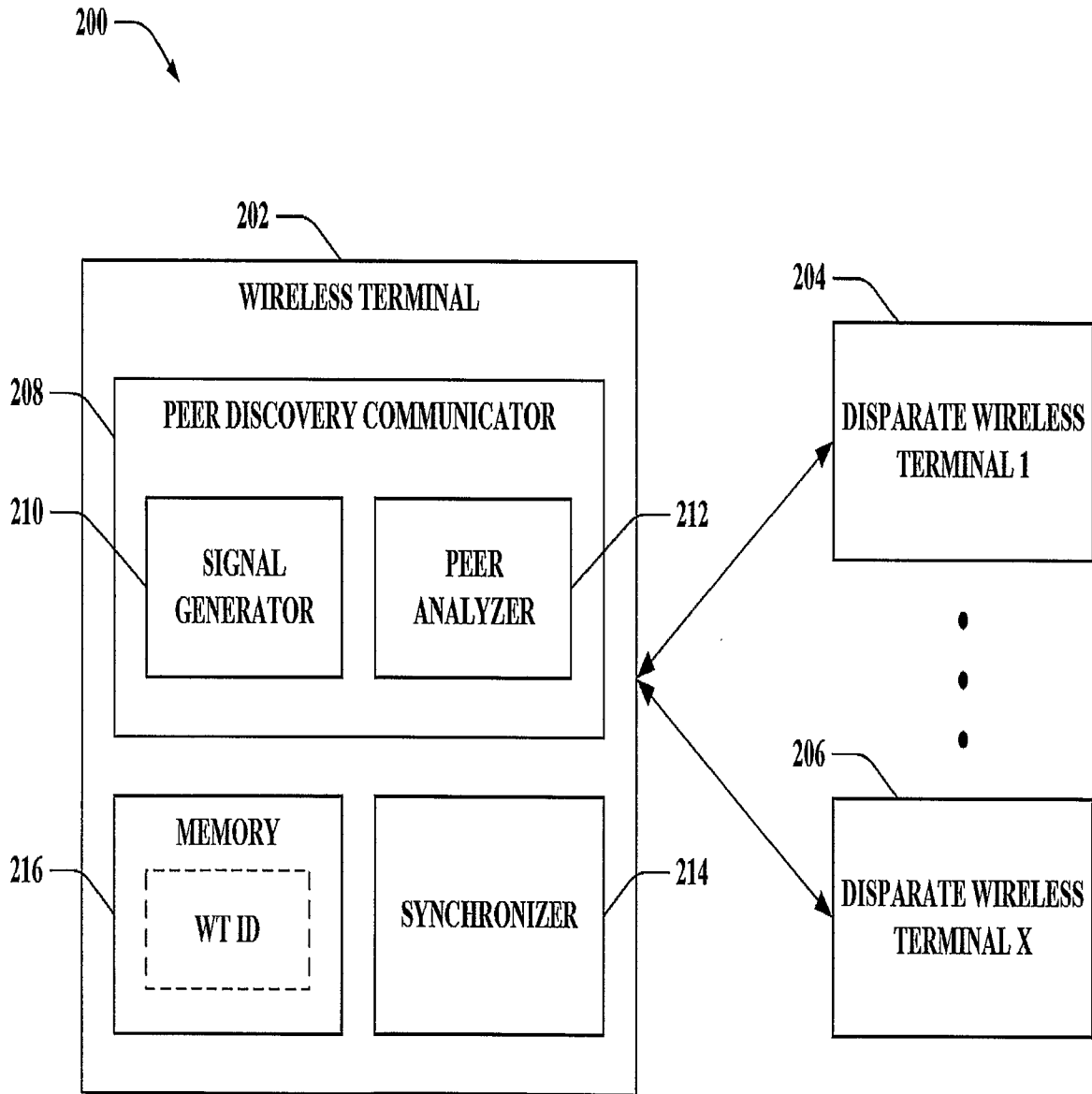


FIG. 2

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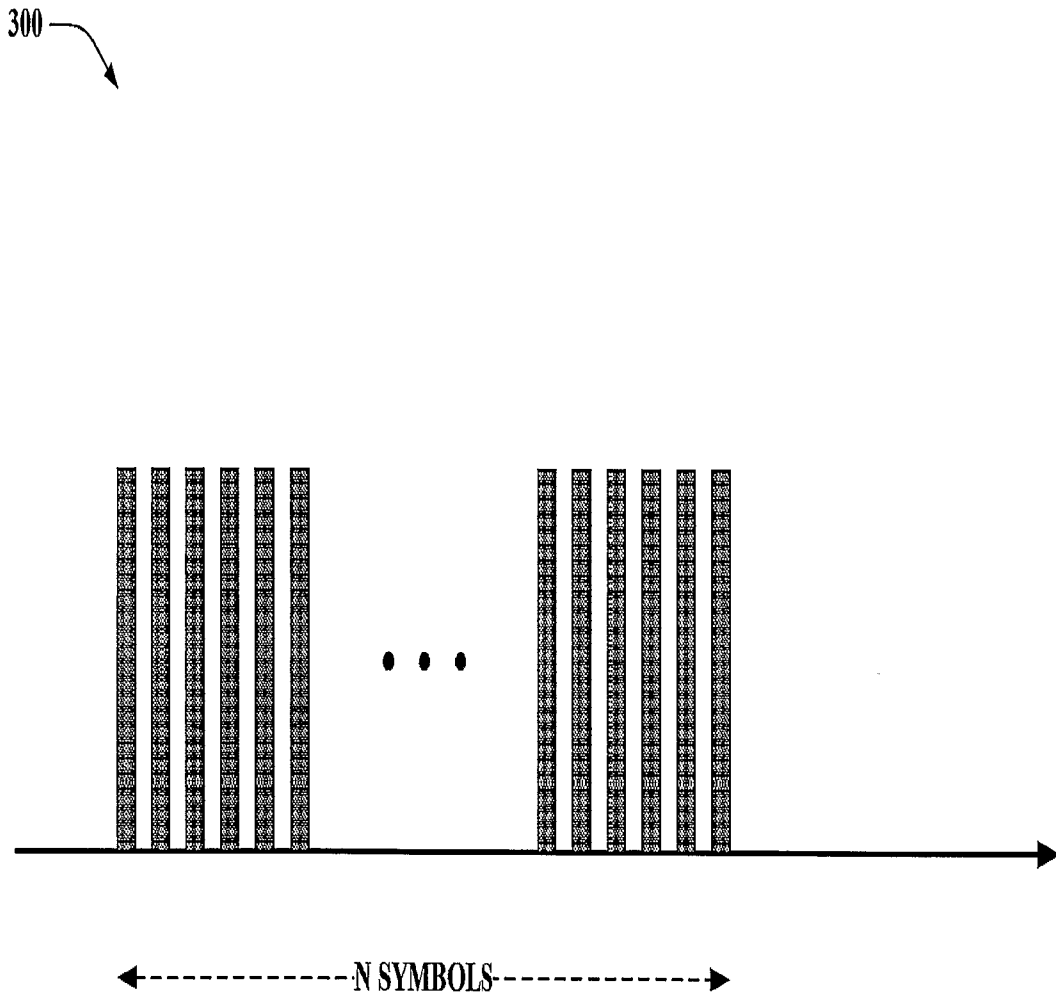
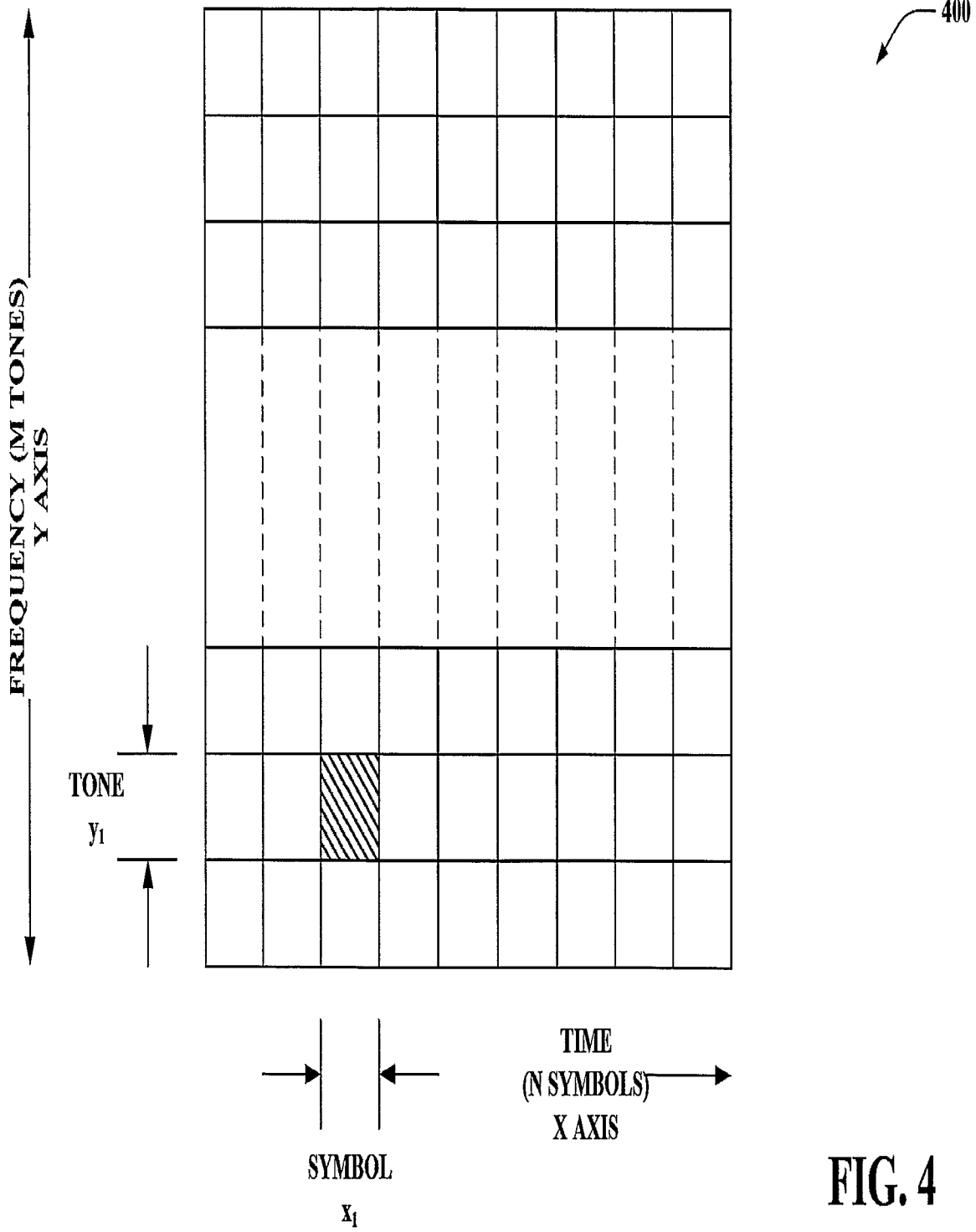


FIG. 3

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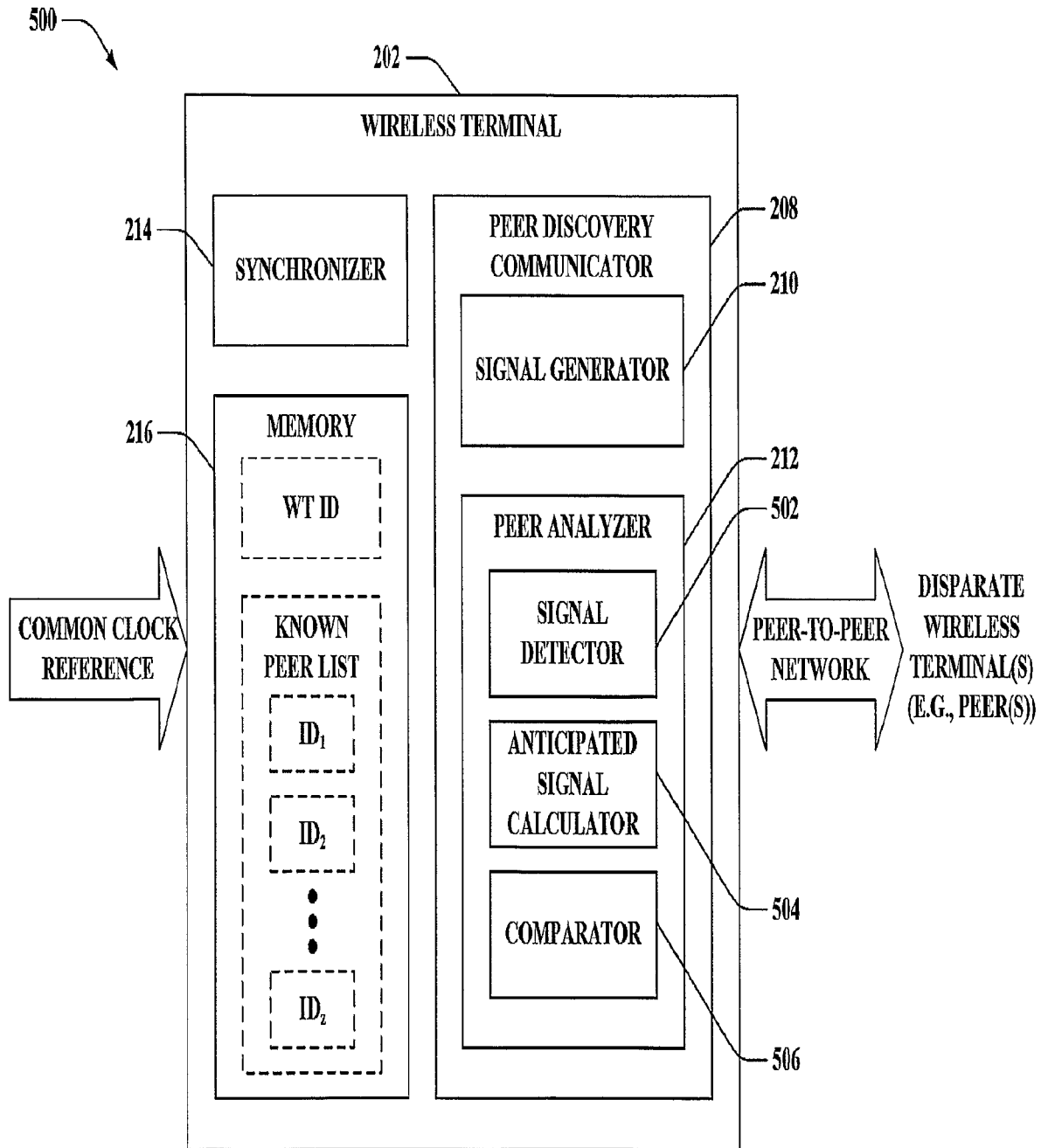
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FIG. 4

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FIG. 5

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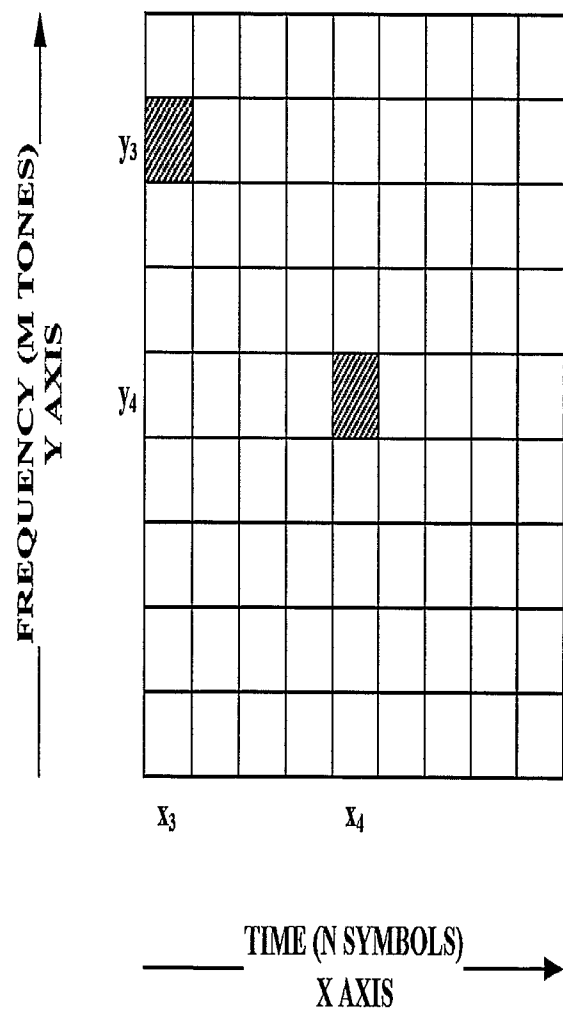
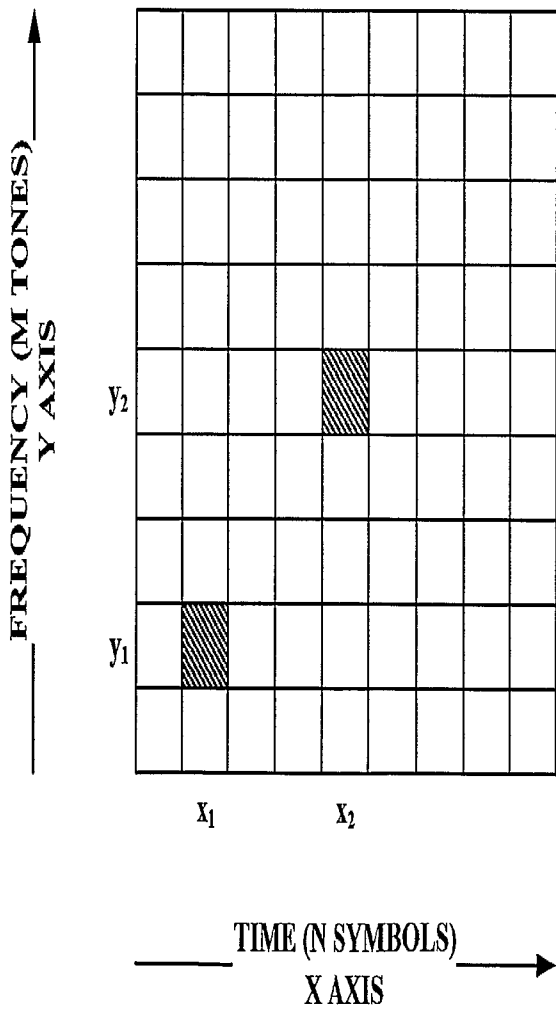
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DETECTED SIGNALS

ANTICIPATED BUDDY SIGNALS



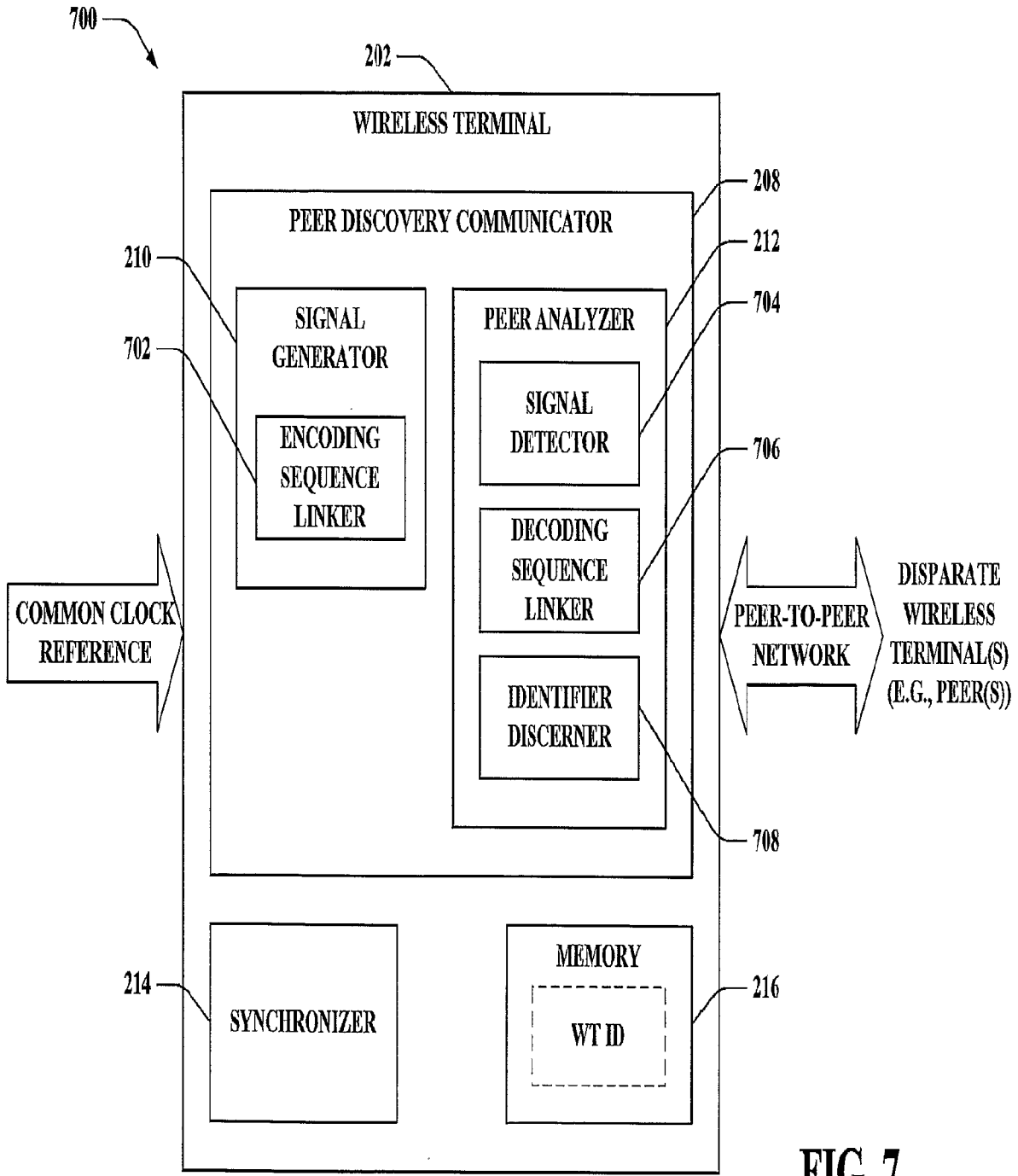
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FIG. 6

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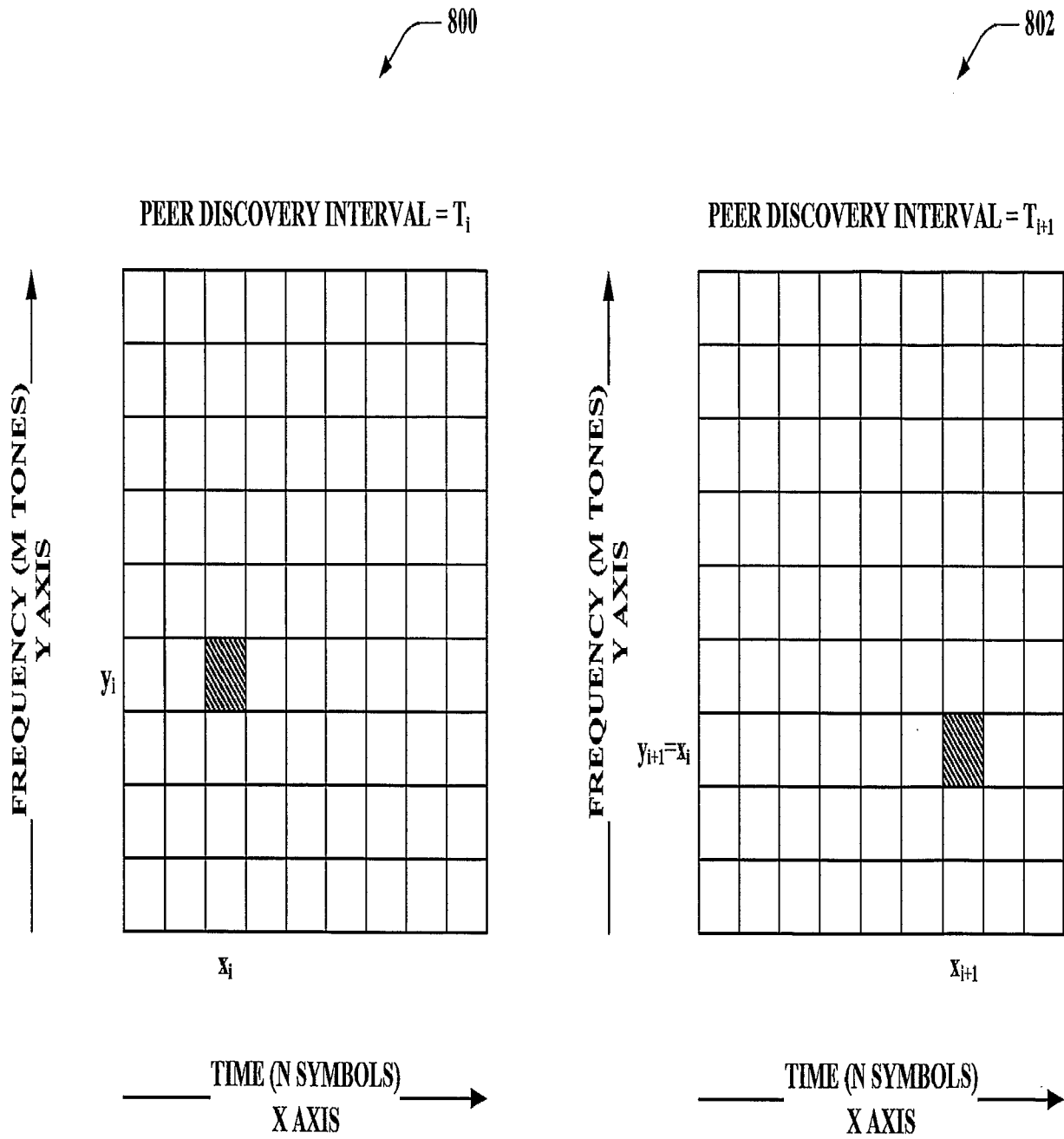
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FIG. 7

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FIG. 8

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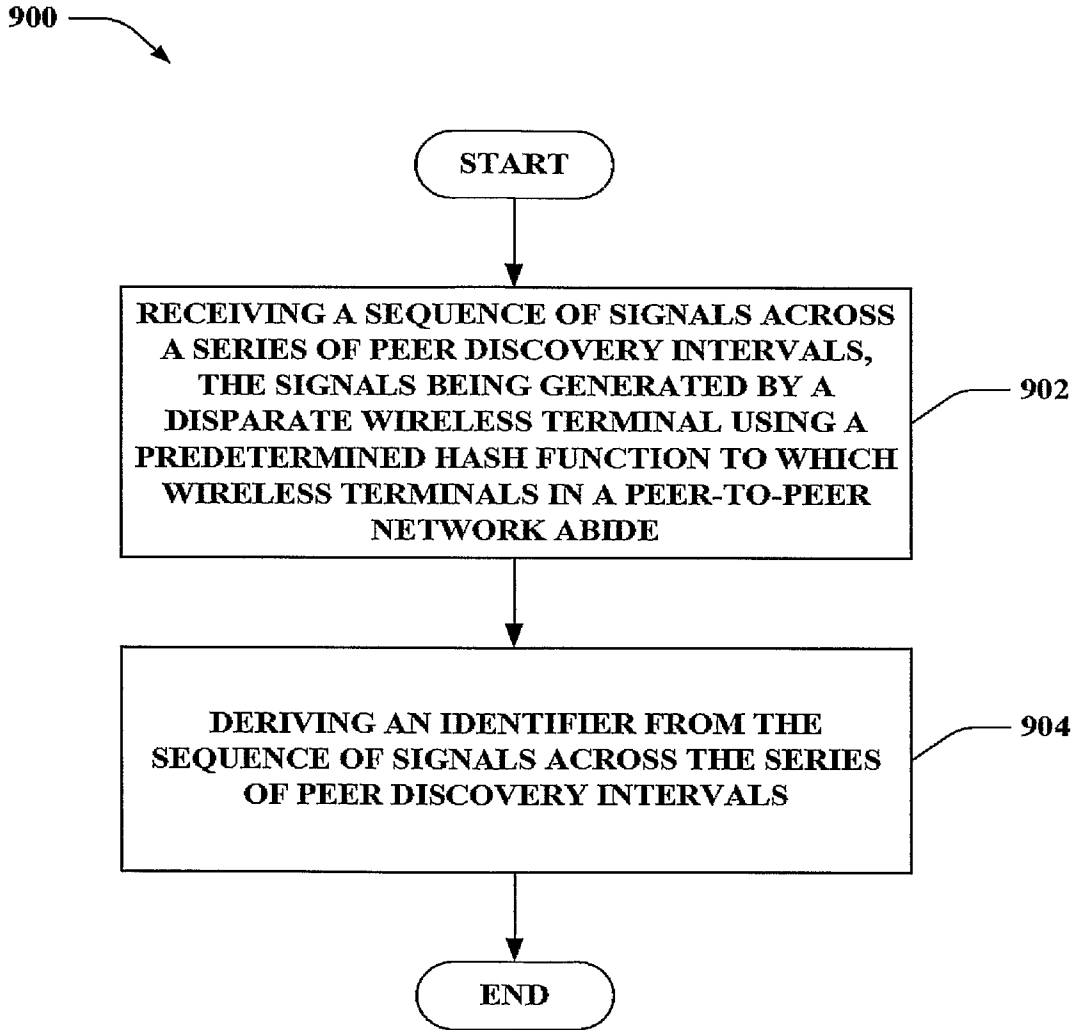


FIG. 9

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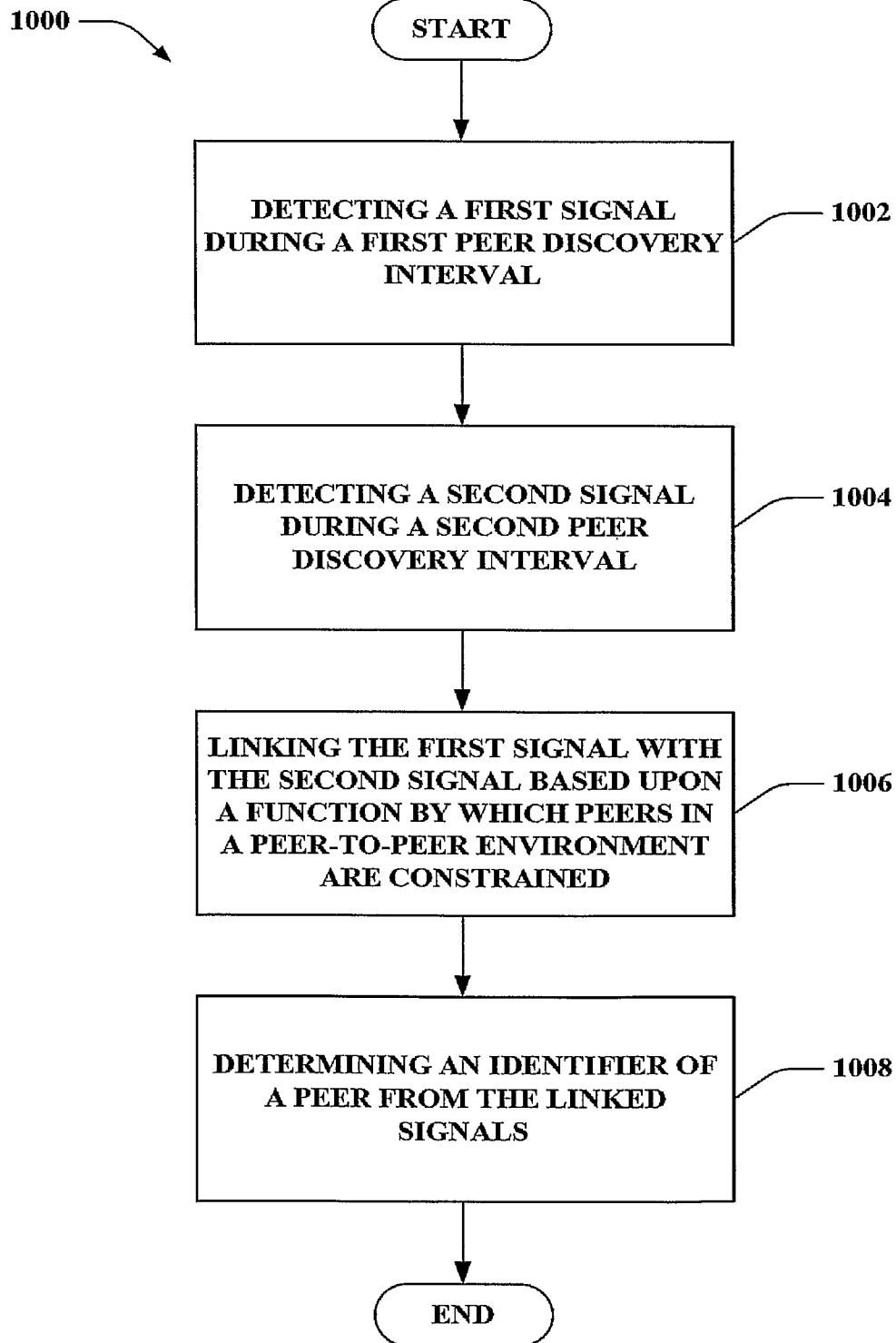


FIG. 10

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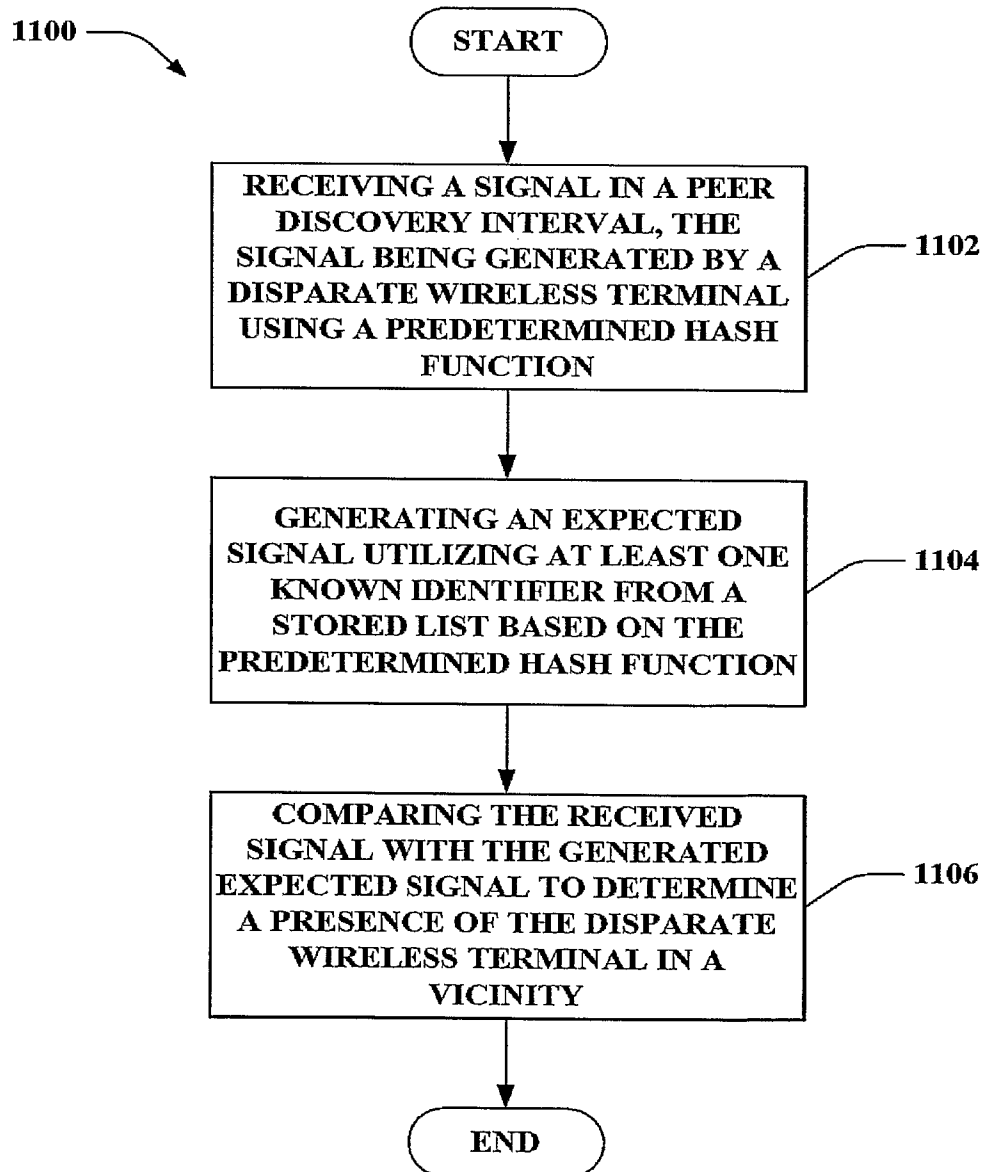


FIG. 11

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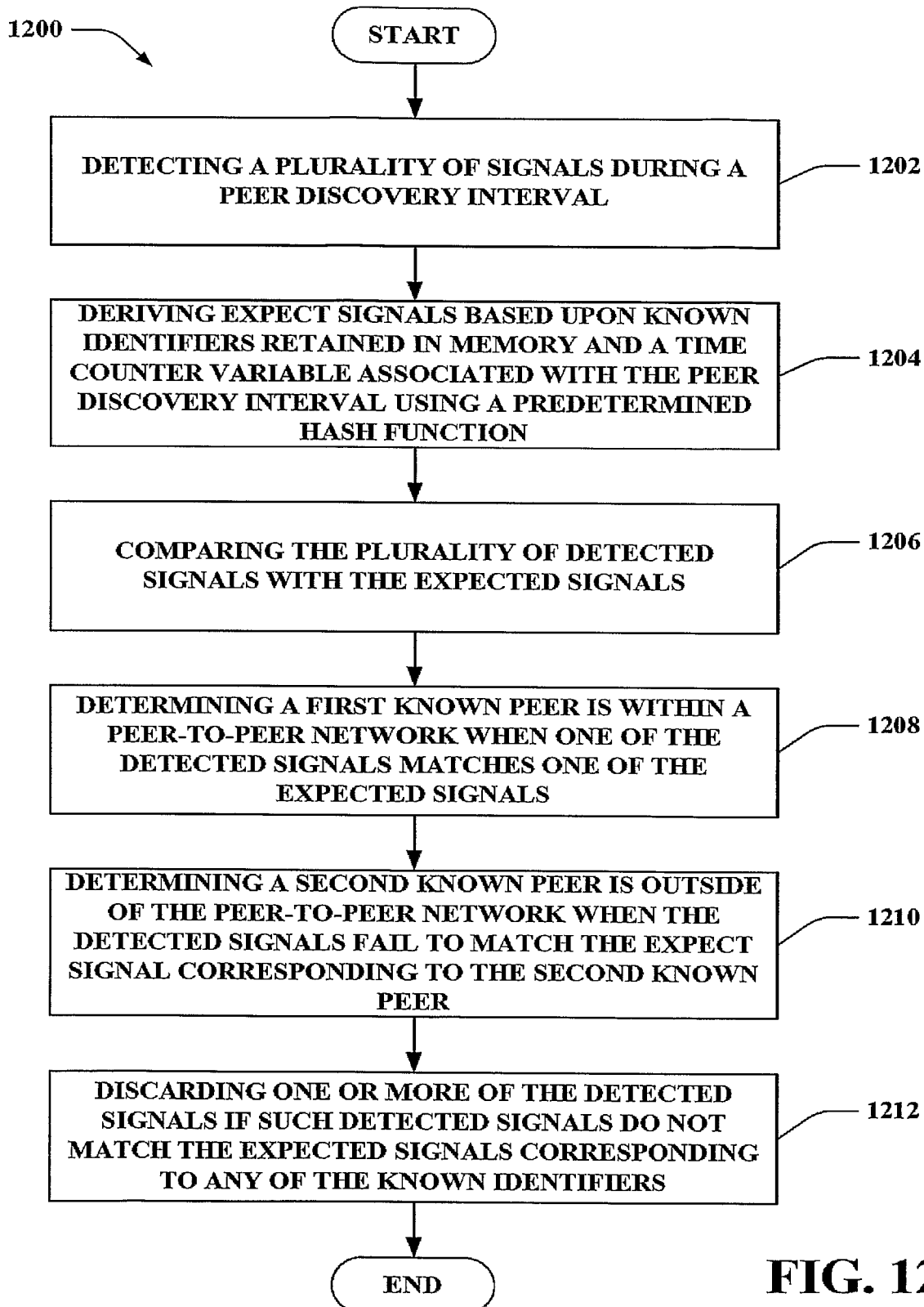


FIG. 12

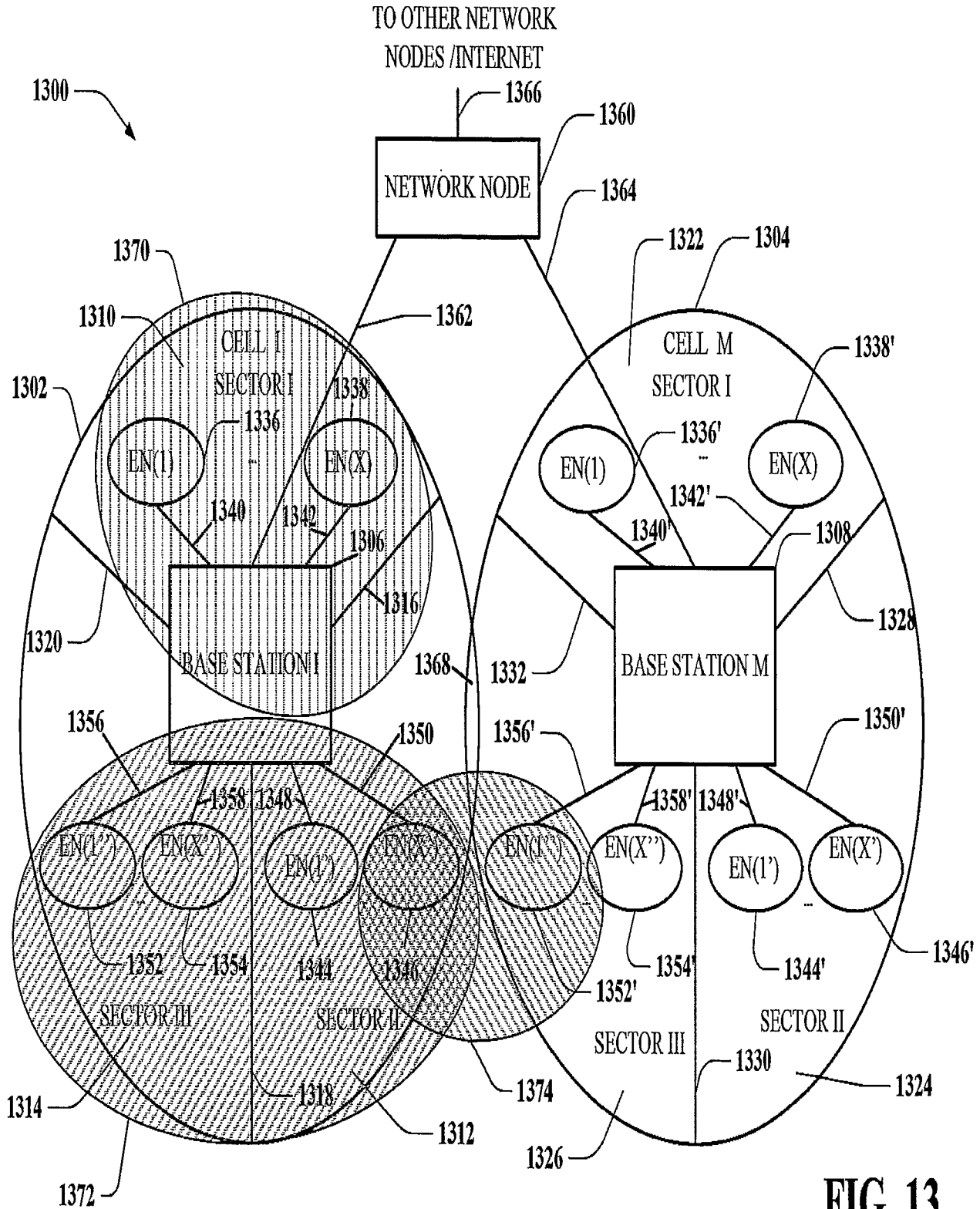


FIG. 13

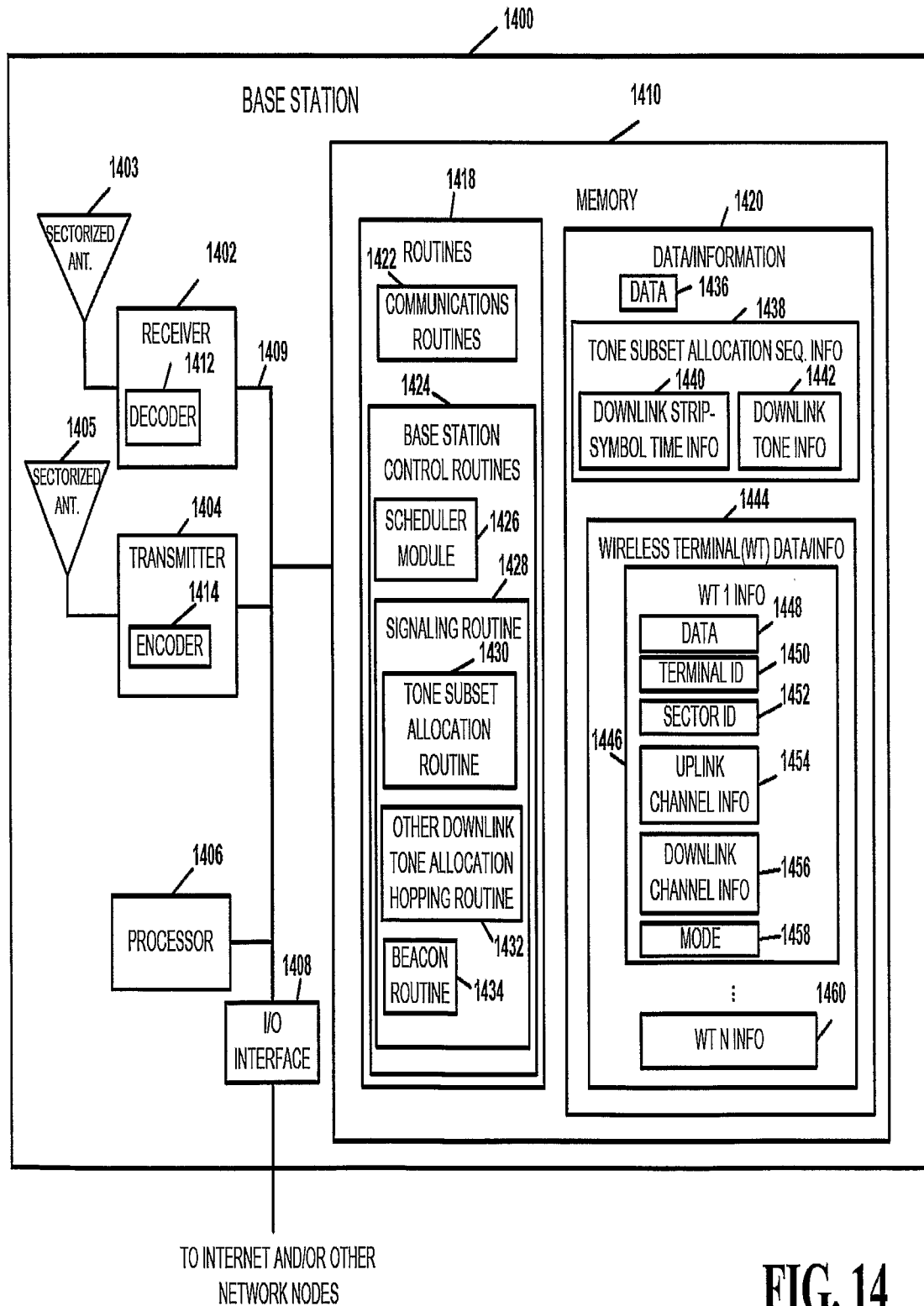


FIG. 14

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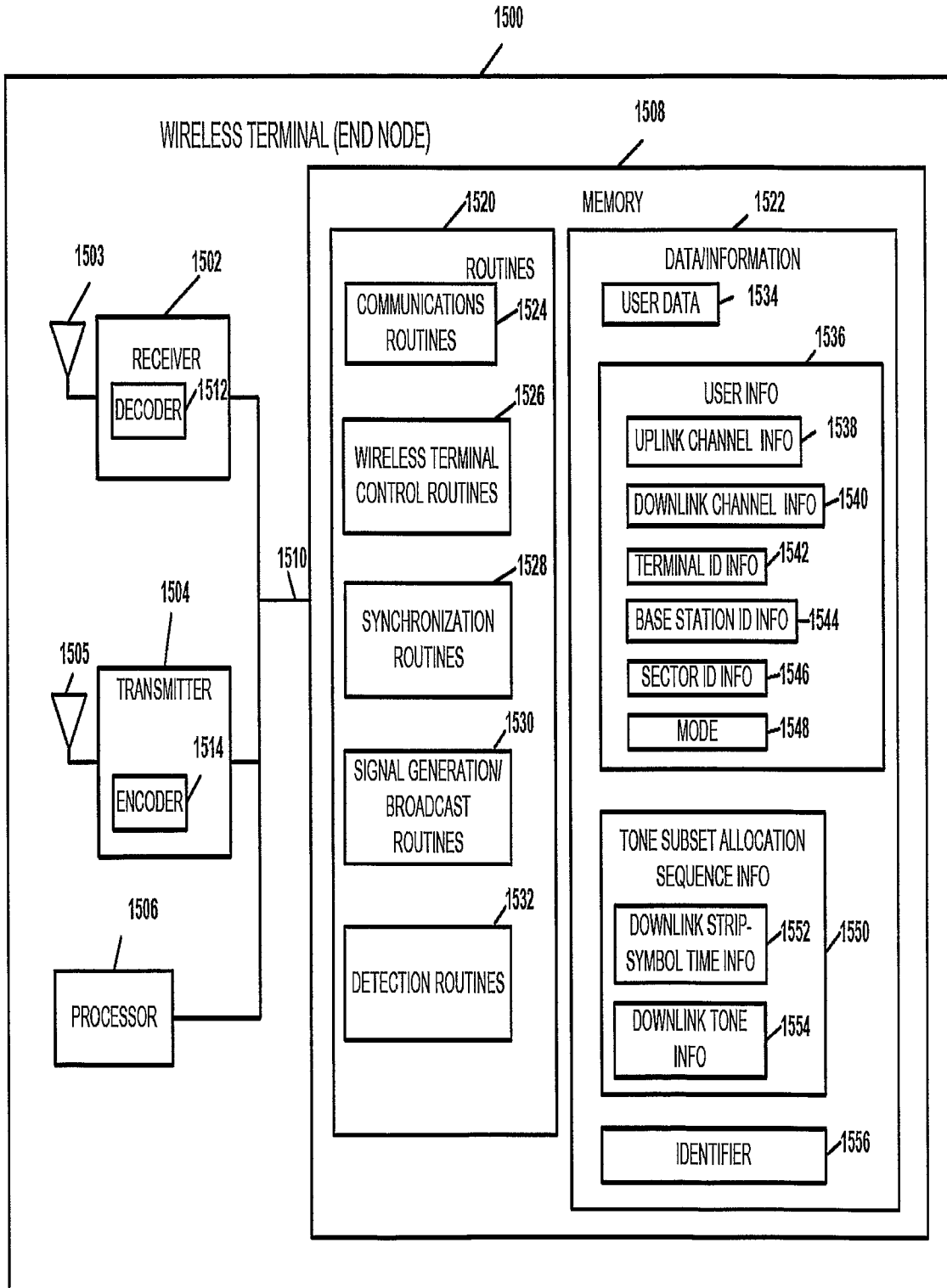
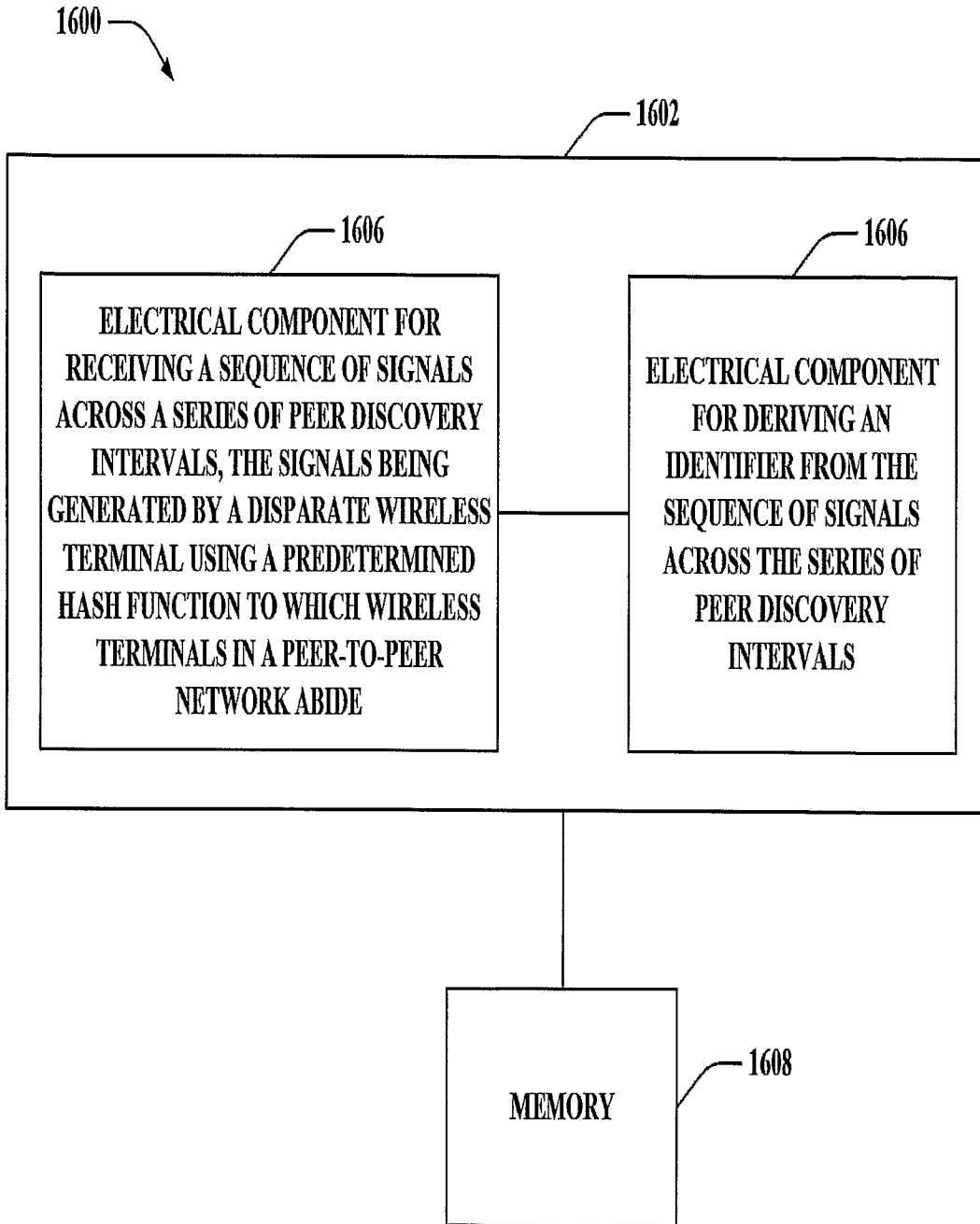


FIG. 15

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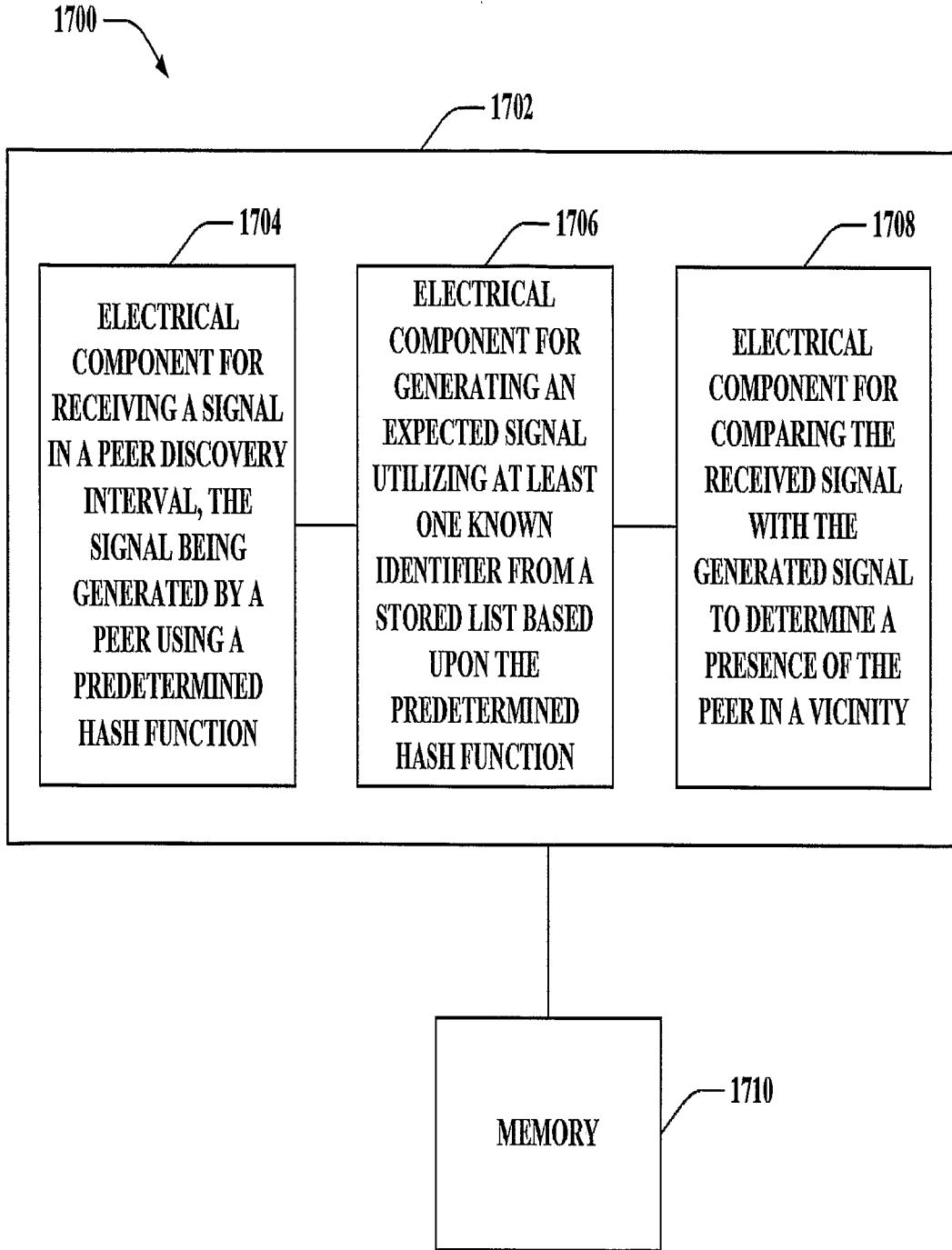
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FIG. 16

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FIG. 17

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER INV. H04L12/28		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) H04L H04Q		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/177639 A1 (REUNAMAKI JUKKA [FI] ET AL) 11 August 2005 (2005-08-11) paragraphs [0008] - [0010], [0029] - [0050] -----	1-5, 12-17, 25-28, 31-36, 39
A	US 2004/259529 A1 (SUZUKI HIDEYUKI [JP]) 23 December 2004 (2004-12-23) abstract paragraphs [0043] - [0052]; claim 1 -----	1-39
A	US 2004/204850 A1 (MACNEILLE PERRY ROBINSON [US] ET AL) 14 October 2004 (2004-10-14) abstract paragraphs [0014], [0014]; claims 1,5 ----- -/--	1-39
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents : *A* document defining the general state of the art which is not considered to be of particular relevance *E* earlier document but published on or after the international filing date *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *O* document referring to an oral disclosure, use, exhibition or other means *P* document published prior to the international filing date but later than the priority date claimed *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. *&* document member of the same patent family		
Date of the actual completion of the international search 11 May 2007		Date of mailing of the international search report 06/06/2007
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016		Authorized officer Falò, Luca

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2007/060347

G(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>EP 0 848 567 A1 (HEWLETT PACKARD CO [US] AGILENT TECHNOLOGIES INC [US]) 17 June 1998 (1998-06-17) abstract column 2, line 35 - column 3, line 35 column 8, lines 4-20 -----</p>	1-39

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2007/060347

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005177639 A1	11-08-2005	NONE	
US 2004259529 A1	23-12-2004	JP 2004241865 A	26-08-2004
US 2004204850 A1	14-10-2004	NONE	
EP 0848567 A1	17-06-1998	US 6088587 A	11-07-2000