

PN CODE BASED ADDRESSING METHODS AND APPARATUS FOR AIRLINK COMMUNICATIONS

RELATED APPLICATIONS

[0001] The present application claims the benefit of U.S. Provisional Patent Application S.N. 60/812,011 filed on June 7, 2006, titled "A METHOD AND APPARATUS FOR L2TP TUNNELING" and the benefit of U.S. Provisional Patent Application S.N. 60/812,012 filed on June 7, 2006 titled "A METHOD AND APPARATUS FOR ADDRESSING MULTIPLE ACCESS POINTS" each of which is hereby expressly incorporated by reference.

FIELD

[0002] The present invention is directed to methods and apparatus for communications, and more particularly to methods and apparatus related to routing of packets.

BACKGROUND

[0003] Wireless communications systems often include a plurality of access points (APs) and/or other network elements in addition to access terminals, e.g., mobile or other end node devices. In many cases access terminals normally communicate with access points via wireless communications links while other elements in the network, e.g., APs, generally communicate via non-air links, e.g., fiber, cable or wire links. In the case of an airlink, bandwidth is a valuable constrained resource. Accordingly, it is desirable that communication over the airlink be performed in an efficient manner without excessive overhead.

[0004] Communications links between access points and/or other network devices are often less constrained from a bandwidth perspective than are air links between access terminals and access points. Accordingly, more overhead in terms of address length and/or other information may be acceptable over backhaul links than over an airlink.

[0005] While IP addresses have been used successfully in networks for many years, they tend to include a fair number of bits. For communications over airlinks, it

would be desirable if shorter addresses could be used over the airlink. However, it would be desirable that any changes to addresses used over the airlink not preclude the use of IP addresses over other links, e.g., backhaul links..

SUMMARY

[0006] Methods and apparatus for communicating between an access terminal (AT) and an Access Point (AP) are described. For communications over the air link, between an AP and an AT a Pilot PN code based address is used as an AP identifier, e.g., address. The pilot PN code is an pilot identifier that is used to distinguish the pilot channel or channels transmitted by different access points or sectors. When the pilot channel uses a Pseudorandom Noise (PN) type of generation scheme, this identifier is typically called a PilotPN. In this application, the term “PN Code” refers to a generic pilot identifier and a PN Code address refers to an address based on a PN Code.

[0007] Other examples of pilot generation include Gold sequence, Beacon based pilots etc. and in such cases a PN Code address refers to an address based on an identifier communicated by the type of pilots being used.

[0008] The PN code based address may be based on Pilot PN code based signals received from an AP. Thus, the PN based AP address may be determined from pilot signals received from an AP. The PN based AP address may be a shortened version of a PN code corresponding to an AP, a full PN code corresponding to an AP, or a value which can be derived in a known manner from a PN code corresponding to an AP. By using a PN code based value as an address for an AP, an AT can identify an AP in an airlink communication without having to use an IP address corresponding to the AP. In addition, PN based addressing has the advantage of using information readily available to an AT since this information can be obtained or derived from signals normally transmitted to an AT for other reasons. Thus, an AT can identify a local or remote AP to a serving AP with which the AT has an active connection without having to go through an IP address discovery process or other addressing update process. Furthermore, because the PN code based identifier being used for communications over an airlink can be shorter than a full IP address of an AP, efficient use of the airlink can be achieved.

[0009] The PN coded based address used to identify an AP can be used by the serving AP for downlink transmission and/or by an AT for uplink transmission. In the case of downlink transmissions, the serving AP indicates the source of the payload being transmitted, e.g., a remote AP or the local serving AP, by including the PN code based address corresponding to the sending device. For example, when a packet payload corresponding to a remote AP, communicated to the serving AP via a Layer 2 tunnel, the serving AP determines the PN code based address used to identify the remote AP from the remote AP's IP address. This may be done using a look-up table maintained by the serving AP which includes IP device address information and corresponding PN code identifier information. The look-up table allows a serving AP to map between device IP and PN code addresses thereby allowing an IP address to be determined from the PN code identifier or the PN code identifier to be determined from an IP address. In some embodiments the actual PN code addresses used over the airlink are stored in the look-up table. However, the stored PN code information may be a value, e.g., the PN code of an AP, from which the PN code address for airlink communications can be derived, e.g., in a known manner, e.g., by truncation and/or through use of a predetermined formula. In some embodiments, the look-up table may be maintained based on address and PN code information transmitted via backhaul communications links connecting various network devices, such information may be sent as part of routing update information, initial AP device configuration information and/or through other techniques. For example, in some embodiments, APs are initially provisioned with information on the PN codes used by neighboring, e.g., physically adjacent, APs and their corresponding IP addresses.

[0010] In the case of uplink signals, an AT uses the PN code based address to identify the destination device to which a transmitted payload, e.g., the payload of a MAC (Media Access Control) packet, is to be communicated. The destination device identified by the PN code address may be a remote AP or the currently serving AP to which the packet is communicated over an airlink. Upon receiving a packet from an AT, the serving AP determines if the packet corresponds to a remote AP and, if so, in some embodiments then determines the corresponding long, e.g., IP (Internet Protocol) address, of the destination AP from the PN code identifier received over the airlink. The received packet payload is then forwarded to the destination AP using the

determined IP address as the destination address of the packet being sent. The packet may, and in various embodiments is, communicated to the destination AP identified by the determined IP address via a Layer 2 tunnel used for communicating packets between the remote AP and the serving AP.

[0011] In this manner, an AT can communicate over the airlink using fewer bits to identify a destination device than would be required if a long address, e.g., the full IP address of the destination device, was used for communications over an airlink between a serving AP and an AT.

[0012] An exemplary method of communicating information to an access terminal comprises: generating a packet, said packet including a PN code address identifying an access point and information to be communicated to said access terminal; and transmitting said generated packet over an airlink to said access terminal. An exemplary method of operating an access point to communicate information to a remote access point comprises: receiving a packet from an access terminal, said packet including a PN code address and information to be communicated to a remote device; determining a long address corresponding to said PN code address to be used for communicating a packet to said remote device, said long address including more bits than said PN code address; and sending said information to be communicated, with the long address, to said remote device. An exemplary access point for communicating information to an access terminal, comprises: a network interface for receiving a packet from a remote device via a network connection, said packet including a long address and information to be communicated; a long address to PN code address mapping module for determining a PN code address corresponding to said long address, said PN code address for use over a wireless communications link, said PN code address including fewer bits than said long address; a downlink packet generation module for generating a packet including said PN code address and said information to be communicated; and a wireless transmitter for transmitting, over said wireless communications link, downlink packets.

[0013] An exemplary method of operating an access terminal to communicate information comprises: receiving a signal from a device; generating a PN code address from said received signal; and generating a packet including said PN code address, said packet being directed to said device. An exemplary method of operating an access

terminal to receive information from a remote device through an access point comprises: receiving from said access point a packet including a PN code address corresponding to said remote device and information from said remote device; and identifying the remote device which provided the information from said PN code address and stored information relating the received PN code addresses to an access point. An exemplary access terminal for communicating information to a remote device through an access point comprises: a packet generation module for generating a packet including an PN code address corresponding to said remote device and information to be communicated to said remote device; and a wireless transmitter for transmitting the generated packet over the air to said access point.

[0014] While various embodiments have been discussed in the summary above, it should be appreciated that not necessarily all embodiments include the same features and some of the features described above are not necessary but can be desirable in some embodiments. Numerous additional features, embodiments and benefits are discussed in the detailed description which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Figure 1 illustrates a multiple access wireless communication system according to one embodiment.

[0016] Figure 2 is a block diagram of an exemplary communication system.

[0017] Figure 3 illustrates an exemplary network including a distributed access network (AN) architecture and an access terminal (AT).

[0018] Figure 4 illustrates an exemplary network including a centralized AN architecture and an AT.

[0019] Figure 5 is a flowchart of an exemplary method of operating an access point to communicate information to an access terminal in accordance with various embodiments.

[0020] Figure 6 is a flowchart of an exemplary method of operating an access point to communicate with a remote access point.

[0021] Figure 7 is a drawing of an exemplary access point in accordance with various embodiments.

[0022] Figure 8 is a flowchart of an exemplary method of operating an access terminal to communicate information in accordance with various embodiments.

[0023] Figure 9 is a flowchart of an exemplary method of operating an access terminal to receive information from a remote device through an access point.

[0024] Figure 10 is a drawing of an exemplary access terminal in accordance with various embodiments.

DETAILED DESCRIPTION

[0025] Wireless communication systems are widely deployed to provide various types of communication content such as voice, data, and so on. These systems may be multiple-access systems capable of supporting communication with multiple users by sharing the available system resources (e.g., bandwidth and transmit power). Examples of such multiple-access systems include World Interoperability for Microwave Access (WiMAX), infrared protocols such as Infrared Data Association (IrDA), short-range wireless protocols/technologies, Bluetooth® technology, ZigBee® protocol, ultra wide band (UWB) protocol, home radio frequency (HomeRF), shared wireless access protocol (SWAP), wideband technology such as a wireless Ethernet compatibility alliance (WECA), wireless fidelity alliance (Wi-Fi Alliance), 802.11 network technology, public switched telephone network technology, public heterogeneous communications network technology such as the Internet, private wireless communications network, land mobile radio network, code division multiple access (CDMA), wideband code division multiple access (WCDMA), universal mobile telecommunications system (UMTS), advanced mobile phone service (AMPS), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal frequency division multiple access (OFDMA), global system for mobile communications (GSM), single carrier (1X) radio transmission technology (RTT), evolution data only (EV-DO) technology, general packet radio service (GPRS), enhanced data GSM environment (EDGE), high speed downlink data packet access

(HSPDA), analog and digital satellite systems, and any other technologies/protocols that may be used in at least one of a wireless communications network and a data communications network.

[0026] Generally, a wireless multiple-access communication system can simultaneously support communication for multiple wireless terminals. Each terminal communicates with one or more base stations via transmissions on the forward and reverse links. The forward link (or downlink) refers to the communication link from the base stations to the terminals, and the reverse link (or uplink) refers to the communication link from the terminals to the base stations. This communication link may be established via a single-in-single-out, multiple-in-single-out or a multiple-in-multiple-out (MIMO) system.

[0027] Referring to Fig. 1, a multiple access wireless communication system according to one embodiment is illustrated. An access point 100 (AP) includes multiple antenna groups, one including 104 and 106, another including 108 and 110, and an additional including 112 and 114. In Fig. 1, only two antennas are shown for each antenna group, however, more or fewer antennas may be utilized for each antenna group. Access terminal 116 (AT) is in communication with antennas 112 and 114, where antennas 112 and 114 transmit information to access terminal 116 over forward link 120 and receive information from access terminal 116 over reverse link 118. Access terminal 122 is in communication with antennas 106 and 108, where antennas 106 and 108 transmit information to access terminal 122 over forward link 126 and receive information from access terminal 122 over reverse link 124. In a FDD system, communication links 118, 120, 124 and 126 may use different frequencies for communication. For example, forward link 120 may use a different frequency than that used by reverse link 118.

[0028] Each group of antennas and/or the area in which they are designed to communicate is often referred to as a sector of the access point. In the embodiment, antenna groups each are designed to communicate to access terminals in a sector of the areas covered by access point 100.

[0029] In communication over forward links 120 and 126, the transmitting antennas of access point 100 utilize beamforming in order to improve the signal-to-

noise ratio of forward links for the different access terminals 116 and 122. Also, an access point using beamforming to transmit to access terminals scattered randomly through its coverage causes less interference to access terminals in neighboring cells than an access point transmitting through a single antenna to all its access terminals.

[0030] An access point may be a fixed station used for communicating with the terminals and may also be referred to as an access node, a Node B, a base station or some other terminology. An access terminal may also be called an access device, user equipment (UE), a wireless communication device, terminal, wireless terminal, mobile terminal, mobile node, end node or some other terminology.

[0031] FIG. 2 is a block diagram of an embodiment of an exemplary access point 210 and an exemplary access terminal 250 in a MIMO system 200. At the access point 210, traffic data for a number of data streams is provided from a data source 212 to a transmit (TX) data processor 214.

[0032] In an embodiment, each data stream is transmitted over a respective transmit antenna. TX data processor 214 formats, codes, and interleaves the traffic data for each data stream based on a particular coding scheme selected for that data stream to provide coded data.

[0033] The coded data for each data stream may be multiplexed with pilot data using OFDM techniques. The pilot data is typically a known data pattern that is processed in a known manner and may be used at the receiver system to estimate the channel response. The multiplexed pilot and coded data for each data stream is then modulated (i.e., symbol mapped) based on a particular modulation scheme (e.g., BPSK, QSPK, M-PSK, or M-QAM) selected for that data stream to provide modulation symbols. The data rate, coding, and modulation for each data stream may be determined by instructions performed by processor 230.

[0034] The modulation symbols for each of the data streams are then provided to a TX MIMO processor 220, which may further process the modulation symbols (e.g., for OFDM). TX MIMO processor 220 then provides N_T modulation symbol streams to N_T transmitters (TMTR) 222a through 222t. In certain embodiments, TX MIMO processor 220 applies beamforming weights to the symbols of the data streams and to the antenna from which the symbol is being transmitted.

[0035] Each transmitter (222a, ..., 222t) receives and processes a respective symbol stream to provide one or more analog signals, and further conditions (e.g., amplifies, filters, and upconverts) the analog signals to provide a modulated signal suitable for transmission over the MIMO channel. N_T modulated signals from transmitters 222a through 222t are then transmitted from N_T antennas 224a through 224t, respectively.

[0036] At access terminal 250, the transmitted modulated signals are received by N_R antennas 252a through 252r and the received signal from each antenna 252 is provided to a respective receiver (RCVR) 254a through 254r. Each receiver (254a, ..., 254r) conditions (e.g., filters, amplifies, and downconverts) a respective received signal, digitizes the conditioned signal to provide samples, and further processes the samples to provide a corresponding "received" symbol stream.

[0037] An RX data processor 260 then receives and processes the N_R received symbol streams from N_R receivers (254a, ..., 254r) based on a particular receiver processing technique to provide N_T "detected" symbol streams. The RX data processor 260 then demodulates, deinterleaves, and decodes each detected symbol stream to recover the traffic data for the data stream. The processing by RX data processor 260 is complementary to that performed by TX MIMO processor 220 and TX data processor 214 at transmitter system 210.

[0038] A processor 270 periodically determines which pre-coding matrix to use (discussed below). Processor 270 formulates a reverse link message comprising a matrix index portion and a rank value portion.

[0039] The reverse link message may comprise various types of information regarding the communication link and/or the received data stream. The reverse link message is then processed by a TX data processor 238, which also receives traffic data for a number of data streams from a data source 236, modulated by a modulator 280, conditioned by transmitters 254a through 254r, and transmitted, via antennas (252a, 252r), respectively, back to access point 210.

[0040] At access point 210, the modulated signals from access terminal 250 are received by antennas 224, conditioned by receivers 222, demodulated by a demodulator 240, and processed by a RX data processor 242 to extract the reverse link message

transmitted by the receiver system 250. Processor 230 then determines which pre-coding matrix to use for determining the beamforming weights, then processes the extracted message.

[0041] Memory 232 includes routines and data/information. Processors 230, 220 and/or 242 execute the routines and uses the data/information in memory 232 to control the operation of the access point 210 and implement methods. Memory 272 includes routines and data/information. Processors 270, 260, and/or 238 execute the routines and uses the data/information in memory 272 to control the operation of the access terminal 250 and implement methods.

[0042] In an aspect, SimpleRAN is designed to significantly simplify the communications protocols between the backhaul access network elements in a wireless radio access network, while providing fast handoff to accommodate the demands of low latency applications, such as VOIP, in fast changing radio conditions.

[0043] In an aspect, the network comprises access terminals (AT) and an access network (AN).

[0044] The AN supports both a centralized and distributed deployment. The network architectures for the centralized and distributed deployments are shown in Fig. 3 and Fig. 4 respectively.

[0045] Figure 3 illustrates an exemplary network 300 including a distributed AN 302 and an AT 303.

[0046] In the distributed architecture shown in Fig. 3, the AN 302 comprises access points (AP) and home agents (HA). AN 302 includes a plurality of access points (APa 304, APb 306, APc 308) and home agent 310. In addition, AN 302 includes an IP cloud 312. The APs (304, 306, 308) are coupled to the IP cloud via links (314, 316, 318), respectively. The IP cloud 312 is coupled to the HA 310 via link 320.

An AP includes a:

Network function (NF):

- One per AP, and multiple NFs can serve a single AT.

- A single NF is the IP layer attachment point (IAP) for each AT, i.e., the NF to which the HA forwards packets sent to the AT. In the example of Figure 4, NF 336 is the current IAP for AT 303, as shown by the line 322 in Fig. 4.
- The IAP may change (L3 handoff) to optimize routing of packets over the backhaul to the AT.
- The IAP also performs the function of the session master for the AT. (In some embodiments, only the session master can perform session configuration, or change the session state.)
- The NF acts as the controller for each of the TFs in the AP and performs functions like allocating, managing and tearing down resources for an AT at the TF.

Transceiver functions (TF) or sector:

- Multiple per AP, and multiple TFs can serve a single AT.
- Provides the air interface attachment for the AT.
- Can be different for the forward and reverse links.
- Changes (L2 handoff) based on radio conditions.

[0047] In AN 302 APa 304 includes NF 324, TF 326 and TF 328. In AN 302 APb 306 includes NF 330, TF 332 and TF 334. In AN 302 APc 308 includes NF 336, TF 338 and TF 340.

An AT includes a:

Interface I_x presented to the mobile node (MN) for each NF in the active set.

Mobile node (MN) to support IP layer mobility at the access terminal.

APs communicate using a tunneling protocol defined over IP. The tunnel is an IP-in-IP tunnel for the data plane and an L2TP tunnel for the control plane.

[0048] Exemplary AT 303 includes a plurality of Interfaces (I_a 342, I_b 344, I_c 346) and MN 348. AT 303 can be, and sometimes is, coupled to AP_a 304 via

wireless link 350. AT 303 can be, and sometimes is, coupled to AP_b 306 via wireless link 352. AT 303, can be, and sometimes is, coupled to AP_c 308 via wireless link 354.

[0049] Figure 4 illustrates an exemplary network 400 including a distributed AN 402 and an AT 403.

[0050] In a centralized architecture shown in Fig. 4, the NF is no longer logically associated with a single TF, so the AN comprises network functions, access points and home agents. Exemplary AN 402 includes a plurality of NFs (404, 406, 408), a plurality of APs (AP_a 410, AP_b 412, AP_c 414), HA 416 and IP cloud 418. NF 404 is coupled to IP cloud 418 via link 420. NF 406 is coupled to IP cloud 418 via link 422. NF 408 is coupled to IP cloud 418 via link 424. IP cloud 418 is coupled to HA 416 via link 426. NF 404 is coupled to (AP_a 410, AP_b 412, AP_c 414) via links (428, 430, 432), respectively. NF 406 is coupled to (AP_a 410, AP_b 412, AP_c 414) via links (434, 436, 438), respectively. NF 408 is coupled to (AP_a 410, AP_b 412, AP_c 414) via links (440, 442, 444), respectively.

[0051] AP_a 410 includes TF 462 and TF 464. AP_b 412 includes TF 466 and TF 468. AP_c 414 includes TF 470 and TF 472.

[0052] Since an NF acts as the controller for a TF, and many NFs can be logically associated with a single TF, the NF controller for an AT, i.e., the NF communicating with an AT as a part of the active set, performs the functions of allocating, managing and tearing down resources for the TF at that AT. Therefore, multiple NFs may control resources at a single TF, although these resources are managed independently. In the example of Figure 4, NF 408 is acting as an IAP for AT 403, as shown by the line 460.

[0053] The rest of the logical functions performed are the same as for the distributed architecture.

[0054] Exemplary AT 403 includes a plurality of Interfaces (I_a 446, I_b 448, I_c 450) and MN 452. AT 403 can be, and sometimes is, coupled to AP_a 410 via wireless link 454. AT 403 can be, and sometimes is, coupled to AP_b 412 via wireless link 456. AT 403 can be, and sometimes is, coupled to AP_c 414 via wireless link 458.

[0055] In systems like DO and 802.20, an AT obtains service from an AP by making an access attempt on an access channel of a particular sector (TF). The NF associated with the TF receiving the access attempt contacts the IAP that is the session master for the AT and retrieves a copy of the AT's session. (The AT indicates the identity of the IAP by including a UATI in the access payload. The UATI may be used as an IP address to directly address the IAP, or may be used to look up the address of the IAP.) On a successful access attempt, the AT is assigned air interface resources such as a MAC ID and data channels to communicate with that sector.

[0056] Additionally, the AT may send a report indicating the other sectors it can hear and their signal strengths. The TF receives the report and forwards it to a network based controller in the NF which in turn provides the AT with an active set. For DO and 802.20 as they are implemented today, there is exactly one NF that the AT can communicate with (except during an NF handoff when there are temporarily two). Each of the TFs in communication with the AT will forward the received data and signaling to this single NF. This NF also acts as a network-based controller for the AT and is responsible for negotiating and managing the allocation and tear down of resources for the AT to use with the sectors in the active set.

[0057] The active set is therefore the set of sectors in which the AT is assigned air interface resources. The AT will continue to send periodic reports and the network based controller may add or remove sectors from the active set as the AT moves around in the network.

[0058] NFs in the active set will also fetch a local copy of the session for the AT when they join the active set. The session is needed to communicate properly with the AT.

[0059] For a CDMA air link with soft handoff, on the uplink each of the sectors in the active set may try to decode an AT's transmission. On the downlink, each of the sectors in the active set may transmit to the AT simultaneously, and the AT combines the received transmissions to decode the packet.

[0060] For an OFDMA system, or a system without soft handoff, a function of the active set is to allow the AT to switch quickly between sectors in the active set and maintain service without having to make a new access attempt. An access attempt is

generally much slower than a switch between members of the active set, since the active set member already has the session and the air interface resources assigned to the AT. Therefore, an active set is useful to do handoff without affecting the QoS service of active applications.

[0061] When, an AT and the session master in the IAP negotiate attributes, or alternatively the state of the connection changes, the new values for the attributes or the new state need to be distributed to each of the sectors in the active set in a timely manner to ensure optimal service from each sector. In some cases, for example if the type of headers changes, or security keys change, an AT may not be able to communicate at all with a sector until these changes are propagated to that sector. Thus every member of the active set should be updated when the session changes. Some changes may be less critical to synchronize than others.

[0062] There are three main types of state or context found in the network for an AT that has an active connection:

[0063] Data state is the state in the network on the data path between the AT and the IAP or an NF during a connection. Data state includes things such as header compressor state or RLP flow states which are very dynamic and difficult to transfer.

[0064] Session state is the state in the network on the control path between the AT and the IAP that is preserved when a connection is closed. Session state includes the value of the attributes that are negotiated between the AT and the IAP. These attributes affect the characteristics of the connection and the service received by the AT. For example, an AT may negotiate the QoS configuration for a new application and supply new filter and flow specifications to the network indicating the QoS service requirements for the application. As another example the AT may negotiate the size and type of the headers used in communication with the AN. The negotiation of a new set of attributes is defined as a session change.

[0065] Connection state is the state in the network on the control path between the AT and the IAP or an NF that is not preserved when a connection closes and the AT is idle. Connection state may include such information as power control loop values, soft handoff timing, and active set information.

[0066] In an IAP or L3 handoff the three types of state may need to be transferred between the old IAP and the new IAP. If only an idle AT can make an L3 handoff, then only the session state needs to be transferred. To support L3 handoff for an active AT, the data and connection state may also need to be transferred.

[0067] Systems like DO and 802.20, make L3 handoff of the data state simple by defining multiple routes (or data stacks), where the data state for each route is local to that route, i.e., the routes each have independent data state. By associating each IAP with a different route, the data state does not need to be transferred in a handoff. A further, even better step, is to associate each NF with a different route in which case L3 handoff is completely transparent to the data state, except for possible packet reordering.

[0068] Since the data state has multiple routes, the next logical step to support L3 handoff for an active AT is to move the control of the connection state from the IAP and make it local to each NF in the active set. This is done by defining multiple control routes (or control stacks) and defining the air interface so that the control stacks are independent and local to each NF. This may require that some of the negotiating and managing the allocation and tear down of resources of the connection state is transferred to the AT since there is no longer a single NF to manage all the members of the active set. It may also make some additional requirements on the air interface design to avoid a tight coupling between TFs – since different TFs may not share the same NF – in the active set. For instance, to operate in an optimal way, it is preferable to eliminate all tight synchronization between TFs that do not have the same NF, such as power control loops, soft handoff, etc.

[0069] Pushing the data and connection state down to the NFs eliminates the need to transfer this state on a L3 handoff, and also should make the NF-to-NF interface simpler.

[0070] The system therefore defines multiple independent data and control stacks (called interfaces in Fig. 3 and Fig. 4), in the AT to communicate with different NFs as needed, as well as the addressing mechanisms for the AT and TFs to logically distinguish between these stacks.

[0071] Fundamentally, some session state (QoS profile, security keys, attribute values, etc.) cannot be made local to an NF (or IAP) because it is too expensive to negotiate every time there is a NF (or a L3) handoff. Also the session state is relatively static and easy to transfer. What is needed are mechanisms to manage and update the session state as it changes and during IAP handoff where the session master moves.

[0072] Optimizing the session state transfer for L3 handoff is a useful feature for every system regardless of the network architecture since it simplifies network interfaces and should also improve the seamlessness of handoff.

Control vs. awareness of handoff

[0073] A separate but related issue is the AT control of L3 handoff. Today, in systems like DO and 802.20, the AT is aware of the L3 handoff since it allocates and tears down local stacks, but it has no control of when L3 handoff occurs. This is called network-based mobility management. The question is whether to make AT the handoff controller, i.e., to use AT based mobility management?

[0074] To support fault tolerance and load balancing, the network needs either to be able to make the handoff or have a mechanism to signal to the AT to do a handoff. Thus if AT based mobility management is used, the network still needs a mechanism to indicate when it should occur.

[0075] AT based mobility management has some obvious advantages, such as allowing for a single mechanism for inter and intra technology, or global and local mobility. It also simplifies the network interfaces further by not requiring the network elements to determine when to do handoff.

[0076] The primary reason systems like DO and 802.20 use network based mobility is that AT based mobility is not optimized to work fast enough to support voice. A secondary reason is the tunneling overhead introduced by terminating the mobile IP tunnels (for MIPv6) in the AT. The mobility latency can be solved by forwarding data using tunnels between the current and previous forward link serving sector, as well as possibly using multicasting, where the data is sent to multiple NFs in the active set simultaneously.

L2 and L3 handoff

In SimpleRAN, there are two types of handoff. For example, Layer 2 or L2 handoff refers to changing of the forward link or reverse link serving sector (TF) and L3 handoff refers to changing of the IAP. L2 handoff should be as fast as possible in response to changing radio conditions. Systems like DO and 802.20 use PHY layer signaling to make L2 handoff fast.

[0077] L2 handoff is transfer of the serving sector TF for the forward (FL) or reverse (RL) links. A handoff occurs when the AT selects a new serving sector in the active set based on the RF conditions seen at the AT for that sector. The AT performs filtered measurements on the RF conditions for the forward and reverse links for all sectors in the active set. For instance, in 802.20 for the forward link the AT can measure the SINR on the acquisition pilots, the common pilot channel (if present), and the pilots on the shared signaling channel, to select its desired FL serving sector. For the reverse link, the AT estimates the CQI erasure rate for each sector in the active set based on the up/down power control commands to the AT from the sector.

[0078] L2 handoff is initiated when the AT requests a different FL or RL serving sector via a reverse link control channel. Dedicated resources are assigned at a TF when it is included in the active set for an AT. The TF is already configured to support the AT before the handoff request. The target serving sector detects the handoff request and completes the handoff with the assignment of traffic resources to the AT. The forward link TF handoff requires a round trip of messaging between the source TF or IAP and target TF in order to receive data for the target TF to transmit. For reverse link TF handoff, the target TF may immediately assign resources to the AT.

[0079] L3 handoff is the transfer of the IAP. L3 handoff involves a HA binding update with the new IAP and requires a session transfer to the new IAP for the control-plane. L3 handoff is asynchronous to L2 handoff in the system so that L2 handoff is not limited by MIPv6 handoff signaling speed.

[0080] L3 handoff is supported over the air in the system by defining an independent route to each NF. Each flow provides multiple routes for transmission and reception of higher layer packets. The route indicates which NF processed the packet. For example, one NF may be associated at the TF and over the air as Route A, while

another NF may be associated with Route B. A serving TF can simultaneously send packets to an AT from both Route A and Route B, i.e., from both NFs, using a separate and independent sequence space for each.

[0081] There are two key ideas in the system design to ensure the QoS treatment for a mobile and its traffic is retained over each handoff mode: Decoupling of L2 and L3 handoff.

[0082] Reserving air interface resources and fetching the session at the target NF or TF before the handoff occurs to minimize the data flow interruption during the handoff. This is done by adding the target TF and NF to the active set.

[0083] The system is designed to separate L2 and L3 handoff in order to allow the system to support EF traffic during high rates of L2 handoff. L3 handoff requires a binding update, which is limited to a rate of 2 to 3 per second. In order to allow a faster L2 handoff rate of 20 to 30 Hz, L2 and L3 handoff are designed to be independent and asynchronous.

[0084] For L2 handoff, the active set management allows all the TFs in the active set to be configured and dedicated resources assigned in order to be ready to serve the AT in the event of an L2 handoff.

[0085] Consider a Mobile Wireless Communication System with multiple access points (AP) that provide service to access terminals (AT). Many systems have an active set, which is a set of APs that have assigned resources to the AT. At a given point in time, an AT may be within range of radio communication with one of the APs, or for the purpose of battery power optimization and radio interference reduction, may communicate only with one carefully selected AP (serving AP). The problem considered here is the delivery of messages and data between the various APs in the system, such that the serving AP can deliver messages to and from the AT.

APs can exchange data over an L2TP (layer two tunneling protocol) tunnel. If AP1 has to send a message or data to the AT, while AP2 is the serving AP, then AP1 first uses the L2TP tunnel to deliver the packet to AP2, and AP2 delivers this packet to the AT using a mechanism including the use of an identifier bit, e.g., a reprocess bit.

Similarly, if the AT has to send a message or data to AP1, while AP2 is serving, it sends the message to AP2 with a remote bit set, and AP2 sends this packet to AP1 via the L2TP tunnel.

The L2TP header includes the following fields

1. UserID: This is the address of the user to which the L2TP packet is addressed
2. ForwardOrReverse: This field identifies if the AT is the destination or the source of the packet.
3. FlowID: In one design, this field may be present only in forward link packets (packets destined to the AT), and it identifies the flow that the serving AP should use to deliver the packet to the AT
4. SecurityField: In one design, this field may be present only in reverse link packets (packets originated at the AT). The SecurityField may include an IsSecure bit, a KeyIndex field (to identify the keys used for security operation) and a CryptoSync field.

In an aspect, forward Link L2TP Packets are communicated. Here we describe the process used by an AP to send and receive a forward link L2TP packet.

An AP sends a forward link L2TP packet when it has data or a message to send to the AT. The AP forms the appropriate header and sends the L2TP packet to the serving AP (or if it does not know the identity of the serving AP, possibly by routing the packet through a central node – the IAP).

When an AP receives a forward link L2TP packet, it does the following steps

1. If the AP is not serving for the given UserID (in the L2TP header), it forwards the packet to the current serving AP (possibly by routing the packet through a central node – the IAP)
2. If the AP is serving for the given UserID, it delivers the packet to the AT using the RLP flow and associated QoS attributes for the given FlowID (in the L2TP header).

[0086] In an aspect, reverse Link L2TP Packets are communicated. Here we describe the process used by an AP to send and receive a reverse link L2TP packet.

An AP sends a reverse link L2TP packet when it receives a packet from the AT, and the remote bit is set for that packet. The first step for the AP sending the L2TP packet is address determination.

[0087] Address Determination: If the remote bit for the packet is set, the packet also includes an address field to identify which AP this packet should be delivered to (target AP). The receiving AP maps the address field to the IP address of the AP. This mapping may be established by

1. An AT assisted method wherein messages describing a mapping are sent from the AT to the AP, and the mapping information is then used by the AP to map between the address used over the airlink and the IP address.
2. A network assisted method whereby mapping information provided by a central entity or by the target AP is used.
3. A PilotPN based method. In this case the address field may simply be equal to the PilotPN (or some upper bits of the PilotPN) of the AP corresponding to the address. The receiving AP knows the PilotPN and IP addresses of all neighboring APs as part of the network configuration (which itself may be network assisted) and uses this information to map between the PN based address and corresponding IP address.
4. An IAP address method where a special address type is used by the AT to identify the AP which is the Internet attachment point for the AT. Each AP in an active set of APs corresponding to an AT knows the IP address of the IAP for the particular AT and can map between the IAP address and IP address of the AT's IAP..

[0088] After address determination, the AP sending the L2TP packet may also insert security related fields if needed, and as determined by the security design.

When an AP receives a reverse link L2TP packet, it does the following steps

1. If the AP is not serving the given UserID indicated in a received packet (in the L2TP tunnel), it ignores the packet

2. If the AP is serving the given UserID of the received packet, it processes the packet as if the packet were received from its own MAC layer. The processing of the packet may depend on the SecurityField received in the L2TP tunnel.

[0089] Figure 5 is a flowchart 500 of an exemplary method of operating an access point to communicate information to an access terminal in accordance with various embodiments. Operation starts in step 502 where the access point is powered on and initialized. The access point performing the method of flowchart 500 is, e.g., a serving access point which has an active airlink with the access terminal. Thus the access point is a serving access point from the perspective of the access terminal. Steps 504 and/or 506 are performed in some embodiments, but are omitted in other embodiments. Flow will be described as if both steps 504 and 506 are included; however, it is to be understood that operation flow can bypass an omitted step.

[0090] Operation proceeds from start step 502 to step 504. In step 504 the access point, e.g., the serving access point, receives a packet from a remote access point, said received packet including an IP address corresponding to the remote access point and information to be communicated to the access terminal. Then, in step 506 the access point, e.g., the serving access point, retrieves from an IP address to PN code mapping information database, PN code address information corresponding to said IP address of the remote access point. Operation proceeds from step 506 to step 508.

[0091] In step 508 the access point, e.g., the serving access point, generates a packet, said packet including a PN code address identifying an access point, e.g., said remote access point, and information to be communicated. Step 508 includes sub-step 510, in which the access point performing the method of flowchart 500, e.g., the serving access point, determines the PN code address from another address, e.g., an IP address, corresponding to said access point, e.g., said remote access point, said another address including more bits than said PN code address. In some embodiments, sub-step 510 includes sub-step 512. In sub-step 512, the access point performing the method of flowchart 500, e.g., the serving access point, determines the PN code address corresponding to the remote access point from the retrieved PN code address information corresponding to said IP address of said remote access point. Then, in step 512, the access point, e.g., the serving access point, transmits the generated packet over an airlink.

[0092] In some embodiments, the PN code address information includes the PN code address corresponding to the remote access point, and the step of performing an address determination operation includes using the retrieved PN code address as said PN code address in the transmitted packet. In some other embodiments, the retrieved PN code address information includes a value from which the PN code address corresponding to said remote access point can be derived by a predetermined function, and determining the PN code address corresponding to the remote device includes using said predetermined function to generate said PN code address from the value included in the retrieved PN code address information. In some embodiments, the determined PN code address is a portion of a Pilot PN code used by said remote access point and generating a packet includes including in said generated packet the information included in said received packet.

[0093] Figure 6 is a flowchart 600 of an exemplary method of operating an access point to communicate with a remote access point. Operation starts in step 602, where the access point is powered on and initialized and proceeds to step 604. In step 604, the access point receives information indicating PN codes used by other access points in the system. Then, in step 606 the access point stores PN code information corresponding to other nodes in the system with corresponding long addresses corresponding to the other nodes. Operation proceeds from step 606 to step 608.

[0094] In step 608, the access point, e.g., a serving access point from the perspective of an access terminal, receives a packet from the access terminal, said packet including a PN code address and information to be communicated to a remote device. Operation proceeds from step 608 to step 610. In step 610, the access terminal determines a long address corresponding to the said PN code address to be used for communicating a packet to said remote device, said long address including more bits than said PN code address. Step 610 includes sub-step 612 in which the access point retrieves, from an IP address to PN code address mapping information database, an IP address corresponding to a PN code address. Operation proceeds from step 610 to step 614. In step 614 the access point sends the information to be communicated with the long address to said remote device. In some embodiments, sending the information to be communicated, with the long address, to said remote device includes sending the received information to said remote access point using the determined IP address as a

destination identifier in a header used for routing said packet to said remote access point through a Layer 2 tunnel.

[0095] In some embodiments, the stored PN code information includes a value which can be determined in a predetermined known manner from a PN code address. In some embodiments, the stored PN code information includes the PN code address corresponding to the IP address of the remote access point.

[0096] Figure 7 is a drawing of an exemplary access point 700 in accordance with various embodiments. The access point 700 communicates information, via a wireless link, with an access terminal for which it is acting as a serving access point. Exemplary access point 700 includes a wireless receiver module 702, a wireless transmitter module 704, a processor 706, a network interface module 708 and memory 710 coupled together via a bus 712 over which the various elements may interchange data and information. Memory 710 includes routines 718 and data/information 720. The processor 706, e.g., a CPU, executes the routines 718 and uses the data/information 720 in memory 710 to control the operation of the access point and implement methods, e.g., a method in accordance with flowchart 500 of Figure 5 and/or flowchart 600 of Figure 6.

[0097] Wireless receiver module 702, e.g., an OFDM and/or CDMA receiver, is coupled to receiver antenna 714 via which the access point receives uplink signals from access terminals. Wireless receiver module 702 receives a packet from an access terminal, said received packet including a PN code address and information to be communicated to a remote device, e.g., a remote access point.

[0098] Wireless transmitter module 704, e.g., an OFDM and/or CDMA transmitter, is coupled to transmit antenna 716 via which the access point transmits downlink signals to access terminals. Wireless transmitter module 704 transmits, over a wireless communications link, downlink packets, e.g., a generated downlink packet from module 724 including a PN code address as part of a header and a packet payload portion including information to be communicated.

[0099] In some embodiments multiple antennas and/or multiple antenna elements are used for reception. In some embodiments multiple antenna and/or multiple antenna elements are used for transmission. In some embodiments at least some of the

same antennas or antenna elements are used for both transmission and reception. In some embodiments, the access point uses MIMO techniques.

[00100] Network interface module 708 couples the access point 700 to other network nodes, e.g., other access points, AAA nodes, home agent nodes, etc., and/or the Internet via network link 709. In various embodiments, inter-AP tunnels, e.g. Layer 2 Tunneling Protocol tunnels, are established over the backhaul network through network interface module 708 and the tunnel path includes network link 709. Network interface module 708 receives a packet from a remote device, e.g., a remote access point, via a network connection, e.g., link 709, said packet including a long address and information to be communicated.

[00101] Routines 718 includes a long address to PN code address mapping module 722, a downlink packet generation module 724, a database updating module 726, a PN code address to long address mapping module 728, and a tunneled packet generation module 730. Data/information 720 includes an address information database 732 and access terminal state information 742. Address information database 732, which is accessible to the long address to PN code address mapping module 722, includes stored information associating long addresses with corresponding PN code address information. Address information database 732 includes a plurality of sets of information corresponding to different access points in the communications system (access point 1 information 733, ... , access point n information 735). Access point 1 information 733 includes long address 1 734 and corresponding PN code address information 1 736. Access point n information 735 includes long address n 738 and corresponding PN code address information n 740. In some embodiments the long addresses (734, 738) are IP addresses. In various embodiments, a PN code address is based on a pilot PN code used by an access point having the long address corresponding to the PN code address. In various embodiments, the long address is an address used for routing packets between access points, e.g., between a remote access point and a serving access point, through a layer 2 tunnel, e.g., a layer 2 tunneling protocol tunnel, and the PN code information includes a PN code used for communicating packets over an airlink. Access terminal state information includes state information corresponding to a plurality of access terminals, e.g., access terminals having an active wireless link with

the access point 700 (access terminal 1 state information 744, ..., access terminal N state information 746).

[00102] Long address to PN code address mapping module 722 determines a PN code address corresponding to a long address, said PN code address for use over a wireless communications link, said PN code address including fewer bits than said long address. Downlink packet generation module 724 generates a packet including said PN code address and said information to be communicated.

[00103] PN code address to long address mapping module 728 determines a long address corresponding to a PN code address to be used for communicating information to a remote device, e.g., a remote access point, said long address including more bits than said PN code address. Tunneled packet generation module 730 generates a packet to be sent to a remote device, e.g., a remote access point, said tunneled packet generation module 730 generating a packet including: i) a long address determined from a PN code address included in a received packet and ii) information to be communicated which was included in the received packet that included the short address used to determine the long address.

[00104] Figure 8 is a flowchart 800 of an exemplary method of operating an access terminal to communicate information in accordance with various embodiments. Operation starts in step 802 where the access terminal is powered on and initialized and proceeds to step 804. In step 804, the access terminal receives a signal from a device, e.g., a pilot signal from a remote access point. Then, in step 806, the access terminal generates a PN code address from the received signal. In various embodiments step 806 includes sub step 808 in which the access terminal uses a predetermined function to generate the PN code address from a pilot PN code determined from the received pilot signal. In some such embodiments, the predetermined function uses a full PN pilot code as the PN code address of the remote device. In some other embodiments, the predetermined function uses a portion of a pilot PN code as the code address of the remote device, said portion being less than the full pilot PN code.

[00105] Operation proceeds from step 806 to step 810. In step 810 the access terminal stores in an airlink to IP address information database, information mapping between an IP address corresponding to said device, e.g., said remote access point, and said PN code address generated in step 806.

[00106] Operation proceeds from step 810 to step 812, in which the access terminal determines if the access terminal has a non-PN based airlink address for said device, e.g., said remote access point. In various embodiments, step 812 includes sub-step 814 in which the access terminal checks to determine if said access terminal has one of i) a predetermined reserved address; ii) an address supplied by the access terminal to the first access point to be used for communications over an airlink to said first access point for packets directed to said remote access point; and iii) a network supplied address to be used for packets communicated over an airlink to said remote access point.

[00107] Operation proceeds from step 812 to step 816. In step 816, flow is directed as a function of whether or not one or more non-PN based airlink addresses were found for the device, e.g., for the remote access point. If a non-PN based address was not found in step 812, then operation proceeds from step 816 to step 818; otherwise operation proceeds from step 816 to step 820.

[00108] Returning to step 818, in step 818, the access terminal generates a packet including said PN code address, said packet being directed to said device, e.g., to said remote access point. Operation proceeds from step 818 to step 822.

[00109] Returning to step 820, in step 820, the access terminal generates a packet including a non-PN based airlink address, said packet being directed to said device, e.g., to said remote access point. Operation proceeds from step 820 to step 822.

[00110] In step 822, the access terminal transmits said generated packet to a first communications device, e.g., a first access point, over a wireless communications link. The transmitted packet is directed to said remote device, e.g., to said remote access point. The first access point is coupled to the device, e.g., the remote access point, via a backhaul network providing a communications link.

[00111] Figure 9 is a flowchart 900 of an exemplary method of operating an access terminal to receive information from a remote device through an access point. Operation starts in step 902 where the access terminal is powered on and initialized and proceeds to step 904. In step 904, the access terminal receives a pilot signal from a remote device. Then, in step 906 the access terminal generates a pilot code address from said received pilot signal. Step 906 includes sub-step 908 in which the access terminal uses a predetermined function to generate the pilot code address from a pilot

PN code determined from the received pilot signal. In some embodiments, the predetermined function uses the full pilot PN code as the PN code address of the remote device. In some other embodiments, the predetermined function uses a portion of the pilot PN code as the PN code address of the remote device, said portion being less than the full pilot PN code. Operation proceeds from step 906 to step 910.

[00112] In step 910, the access terminal stores the pilot address generated from the received pilot signal in a database of information used for mapping between PN code addresses and long addresses. In various embodiments, storing the pilot address generated from the received pilot signal in a database of information includes storing said pilot code address with a long address corresponding to said remote device. In some such embodiments, the long address is an IP address corresponding to the remote device.

[00113] Operation proceeds from step 910 to step 912. In step 912, the access terminal receives from said access point a packet including a PN code address corresponding to said remote device and information from said remote device. Then, in step 914, the access terminal identifies the remote device which provided the information from said PN code address and stored information relating the received PN code address to an access point.

[00114] In one exemplary embodiment, the remote device is a remote access point and the remote device previously served as the access terminal's active network point of attachment, and the access point serves as the access terminal's current active network point of attachment.

[00115] Figure 10 is a drawing of an exemplary access terminal 1000 in accordance with various embodiments. Exemplary access terminal 1000 can, and sometimes does, communicate information to a remote device through an access point. Exemplary access terminal 1000 includes a wireless receiver module 1002, a wireless transmitter module 1004, a processor 1006, user I/O devices 1008 and memory 1010 coupled together via a bus 1012 over which the various elements may interchange data and information. Memory 1010 includes routines 1018 and data/information 1020. The processor 1006, e.g., a CPU, executes the routines 1018 and uses the data/information 1020 in memory 1010 to control the operation of the access terminal and implement methods, e.g., the methods of flowchart 800 of Figure 8 and flowchart 900 of Figure 9.

[00116] Wireless receiver module 1002, e.g., a CDMA or OFDM receiver, is coupled to receive antenna 1014 via which the access terminal 1000 receives downlink signals from access points. Wireless receiver module 1002 receives a packet communicated over the air to said access terminal which includes a PN code address identifying the source of information included in the received packet, e.g., received packet 1058.

[00117] Wireless transmitter module 1004, e.g., a CDMA or OFDM transmitter, is coupled to transmit antenna 1016 via which the access terminal 1000 transmits uplink signals to access points. Wireless transmitter module 1004 transmits a generated packet, e.g., generated packet 1052, over the air to an access point.

[00118] In some embodiments, the same antenna is used for transmission and reception. In some embodiments multiple antennas and/or multiple antenna elements are used for reception. In some embodiments multiple antenna and/or multiple antenna elements are used for transmission. In some embodiments at least some of the same antennas or antenna elements are used for both transmission and reception. In some embodiments, the access terminal uses MIMO techniques.

[00119] User I/O device 1008 include, e.g., microphone, keyboard, keypad, switches, camera, speaker, display, etc. User I/O devices 1008 allow a user of access terminal 1000 to input data/information, access output data/information, and control at least some functions of the access terminal 1000, e.g., initiate a communications session with a peer node, e.g., another access terminal.

[00120] Routines 1018 include a PN code address determination module 1022, a packet generation module 1024, a received packet source identification module 1026, and an address database updating module 1031. In some embodiments, routines 1018 include a non-PN based address availability module 1027, and an address type decision module 1029. Data/information 1020 includes a received pilot signal 1028, a corresponding PN code of the received pilot signal 1030 and a corresponding determined PN code address 1032. Data/information 1020 also includes an address information database 1034 which includes address mapping information corresponding to a plurality of access points (access point 1 information 1036, ..., access point n information 1038). Address information database 1034 is, e.g., an airlink to IP address

information database. Access point 1 information 1036 includes long address 1 1040 and corresponding PN code address 1 1042. Access point n information 1038 includes long address n 1044 and corresponding PN code address n 1046. Database 1034 stores PN code addresses determined from the received pilot signal. In some embodiments, the stored PN code addresses (1042, ..., 1046) are the PN codes of the pilot signal from which the PN code address was determined. For example, in some embodiments, PN code of pilot signal 1030 is the same as determined PN code address 1032. In some embodiments, a stored PN code address is derived from the PN code of the pilot signal from which the PN code address is determined according to a predetermined function. For example, determined PN code address 1032 is derived from PN code of pilot signal 1030 and the two values may be and sometimes are different.

[00121] In some embodiments the address information database 1034 may, and sometimes does, include one or more alternative non-PN based alternative addresses corresponding to a long address. For example, access point n information 1038, in some embodiments, includes non-PN code based alternative address n 1047 which also corresponds to long address n 1044. A non-PN code based address such as non-PN code based alternative address n 1047 is, e.g., one of a predetermined reserved address, an address supplied by access terminal 1000 to a first access point to be used for communications over an airlink with said first access point for packets directed to a remote access point, and a network supplied address to be used for packets communicated over an airlink to said remote access point.

[00122] Data/information 1020 also includes access terminal state information 1048, e.g., information including a list of access points with which the access terminal has a current active link. Data information 1020 also includes a destination address 1050 and a corresponding generated packet 1052. The destination address is, e.g., a long address such as an IP address corresponding to an AP. The generated packet 1052 includes a PN code address 1054, e.g., the corresponding PN code address to destination address 1050, and payload information 1056. Data/information 1020 also includes a received packet 1058 and a corresponding identified source address 1064. Received packet 1058 includes a PN code address 1060 and payload information 1062. The identified source address 1064 is the long address matching the PN code address 1060.

[00123] Packet generation module 1024 generates a packet, e.g., generated packet 1052, including an PN code address and information to be communicated to a remote device. In some embodiments, packet generation module 1024, at times, generates a packet including a non-PN code based address and information to be communicated to a remote device. In some such embodiments, packet generation module 1024 includes a PN code based packet generation sub-module and a non-PN code based packet generation sub-module.

[00124] PN code address determination module 1022 determines, e.g., generates, a PN code address from a pilot signal, said PN code address corresponding to an access point from which the pilot signal was received. For example, corresponding to one access point, PN code address determination module 1022 determines PN code address 1032 from received pilot signal 1028. In some embodiments, determining, e.g., generating a PN code address includes using a predetermined function to generate the PN code address from a pilot PN code determined from a received pilot signal. In some such embodiments, the predetermined function uses a full pilot PN code as the PN code address of the remote device from which the pilot signal was received. In some other embodiments, the predetermined function uses a portion of a pilot PN code as the PN code address of the remote device, said portion being less than the full pilot PN code.

[00125] Received packet source identification module 1026 identifies a source of a received packet using the address information database 1034. For example, received packet source identification module 1026 processes received packet 1058, examines the PN code address, and determines from the address information database 1034 the source of the information, e.g., the long address, associated with the PN code address 1060. Identified source address 1064 is an output of received packet source identification module 1026 and is one of the long addresses (1040, ..., 1044) in the database 1034.

[00126] Address database updating module 1031 updates and maintains address information database 1034, e.g., storing in address information database 1034 information mapping between an IP address corresponding to a remote device and a PN code address. For example, determined PN code address 1032 is stored in address information database 1034 and associated with its access point and corresponding long address.

[00127] Non-PN based address availability module 1027 determines if access terminal 1000 has a non-PN code based airlink address for a remote access point. In some embodiments, the packet generation module 1024 uses the PN code address to generate a packet when the availability module 1027 determines that a non-PN code based address is not available for a remote access point; otherwise the packet generation module 1024 uses one of the available non-PN code based addresses. Address type decision module 1029 determines which type of address to use. In some embodiments, the address type decision module 1029 decides whether to use a PN based address or a non-PN based address. In some embodiments, the address type decision module 1029 decides which type of non-PN based address to use when a plurality of non-PN based alternative addresses are available. In some embodiments, different types of alternative addresses are associated with different portions of a communications system, different devices and/or different priority levels.

[00128] In various embodiments, nodes described herein are implemented using one or more modules to perform the steps corresponding to one or more methods of the aspect, for example, signal processing, message generation and/or transmission steps. Thus, in some embodiments various features are implemented using modules. Such modules may be implemented using software, hardware or a combination of software and hardware. Many of the above described methods or method steps can be implemented using machine executable instructions, such as software, included in a machine readable medium such as a memory device, e.g., RAM, floppy disk, compact disc, DVD, etc. to control a machine, e.g., general purpose computer with or without additional hardware, to implement all or portions of the above described methods, e.g., in one or more nodes. Accordingly, among other things, the aspect is directed to a machine-readable medium including machine executable instructions for causing a machine, e.g., processor and associated hardware, to perform one or more of the steps of the above-described method(s).

[00129] In various embodiments nodes described herein are implemented using one or more modules to perform the steps corresponding to one or more methods, for example, signal processing, message generation and/or transmission steps. Some exemplary steps include transmitting a connection request, receiving a connection response, updating a set of information indicating an access point with which an access

terminal has an active connection, forwarding a connection request, forwarding a connection response, determining resource assignment, requesting resources, updating resources, etc. In some embodiments various features are implemented using modules. Such modules may be implemented using software, hardware or a combination of software and hardware. Many of the above described methods or method steps can be implemented using machine executable instructions, such as software, included in a machine readable medium such as a memory device, e.g., RAM, floppy disk, compact disc, DVD, etc. to control a machine, e.g., general purpose computer with or without additional hardware, to implement all or portions of the above described methods, e.g., in one or more nodes. Accordingly, among other things, various embodiments are directed to a machine-readable medium including machine executable instructions for causing a machine, e.g., processor and associated hardware, to perform one or more of the steps of the above-described method(s).

[00130] In some embodiments, the processor or processors, e.g., CPUs, of one or more devices, e.g., communications devices such as access terminals and/or access points, are configured to perform the steps of the methods described as being performed by the communications device. The configuration of the processor may be achieved by using one or more modules, e.g., software modules, to control processor configuration and/or by including hardware in the processor, e.g., hardware modules, to perform the recited steps and/or control processor configuration. Accordingly, some but not all embodiments are directed to a device, e.g., communications device, with a processor which includes a module corresponding to each of the steps of the various described methods performed by the device in which the processor is included. In some but not all embodiments a device, e.g., communications device, includes a module corresponding to each of the steps of the various described methods performed by the device in which the processor is included. The modules may be implemented using software and/or hardware.

[00131] Numerous additional variations on the methods and apparatus described above will be apparent to those skilled in the art in view of the above descriptions. Such variations are to be considered within scope. The methods and apparatus of various embodiments may be, and in various embodiments are, used with CDMA, orthogonal frequency division multiplexing (OFDM), and/or various other types of

communications techniques which may be used to provide wireless communications links between access nodes and mobile nodes. In some embodiments the access nodes are implemented as base stations which establish communications links with mobile nodes using OFDM and/or CDMA. In various embodiments the mobile nodes are implemented as notebook computers, personal data assistants (PDAs), or other portable devices including receiver/transmitter circuits and logic and/or routines, for implementing the methods of various embodiments.

WHAT IS CLAIMED IS:

1. A method of communicating information to an access terminal, the method comprising:
 - generating a packet, said packet including a PN code address identifying an access point and information to be communicated to said access terminal; and
 - transmitting said generated packet over an airlink.
2. The method of claim 1, wherein generating said packet includes determining said PN code address from another address corresponding to said access point, said another address including more bits than said PN code address.
3. The method of claim 2, wherein said another address is an IP address.
4. The method of claim 2, wherein the identified access point is a remote access point, and wherein said method is performed by a serving access point which has an active airlink with said access terminal, the method further comprising, prior to generating said packet:
 - receiving a packet from said remote access point, said received packet including an IP address corresponding to said remote access point and information to be communicated to the access terminal; and
 - retrieving, from an IP address to PN code address mapping information database, PN code address information corresponding to said IP address of said remote access point.
5. The method of claim 4, wherein performing a PN code address determination operation further includes:
 - determining the PN code address corresponding to said remote access point from said retrieved PN code address information corresponding to said IP address of said remote access point.

6. The method of claim 5,
wherein said PN code address information includes the PN code address
corresponding to said remote access point; and
wherein said step of performing an address determination operation includes
using the retrieved PN code address as said PN code address included in the transmitted
packet.
7. The method of claim 5,
wherein said retrieved PN code address information includes a value from which
the PN code address corresponding to said remote access point can be derived by a
predetermined function; and
wherein determining the PN code address corresponding to the remote device
includes using said predetermined function to generate said PN code address from the
value included in the retrieved PN code address information.
8. The method of claim 7,
wherein the determined PN code address is a portion of a Pilot PN code used by
said remote access point; and
wherein generating a packet includes including in said generated packet the
information included in said received packet.
9. An apparatus comprising:
a processor for use in a wireless device, the processor configured to:
generate a packet, said packet including a PN code address identifying an
access point and information to be communicated to an access terminal; and
transmit said generated packet over an airlink.
10. The apparatus of claim 9, wherein said processor, in generating said packet, is
further configured to:
determine said PN code address from another address corresponding to said
access point, said another address including more bits than said PN code address.

11. The apparatus of claim 10, wherein said another address is an IP address.

12. The apparatus of claim 10, wherein the identified access point is a remote access point, and wherein said wireless device is a serving access point which has an active airlink with said access terminal, the processor is further configured to, prior to generating said packet:

receive a packet from said remote access point, said received packet including an IP address corresponding to said remote access point and information to be communicated to the access terminal; and

retrieve, from an IP address to PN code address mapping information database, PN code address information corresponding to said IP address of said remote access point.

13. The apparatus of claim 12, wherein said processor, in performing the PN code address determination operation, is further configured to:

perform a PN code address determination operation by determining the PN code address corresponding to said remote access point from said retrieved PN code address information corresponding to said IP address of said remote access point.

14. A computer readable medium embodying machine executable instructions for communicating information to an access terminal, the method comprising:

generating a packet, said packet including a PN code address identifying an access point and information to be communicated; and

transmitting said generated packet over an airlink.

15. The computer readable medium of claim 14, further embodying machine executable instructions for, while generating said packet, determining said PN code address from another address corresponding to said access point, said another address including more bits than said PN code address.

16. The computer readable medium of claim 15, wherein said another address is an IP address.

17. The computer readable medium of claim 15, wherein the identified access point is a remote access point, and wherein said method is performed by a serving access point which has an active airlink with said access terminal, further embodying machine executable instructions for, prior to generating said packet:

receiving a packet from said remote access point, said received packet including an IP address corresponding to said remote access point and information to be communicated to the access terminal; and

retrieving, from an IP address to PN code address mapping information database, PN code address information corresponding to said IP address of said remote access point.

18. The computer readable medium of claim 17, further embodying machine executable instructions for:

determining the PN code address corresponding to said remote access point from said retrieved PN code address information corresponding to said IP address of said remote access point.

19. A method of operating an access point to communicate information to a remote access point, the method comprising:

receiving a packet from an access terminal, said packet including a PN code address and information to be communicated to a remote device;

determining a long address corresponding to said PN code address to be used for communicating a packet to said remote device, said long address including more bits than said PN code address; and

sending said information to be communicated, with the long address, to said remote device.

20. The method of claim 19, wherein determining a long address corresponding to said PN code address includes:

retrieving, from an IP address to PN code address mapping information database, an IP address corresponding to a PN code address.

21. The method of claim 20, further comprising, prior to said step of determining a long address corresponding to said PN code address,

receiving information indicating PN codes used by other access points in said system; and

storing PN code information corresponding to other nodes in said system with corresponding long addresses corresponding to said other nodes.

22. The method of claim 21, wherein said stored PN code information includes a value which can be determined in a predetermined known manner from a PN code address.

23. The method of claim 21, wherein said stored PN code information includes the PN code address corresponding to the IP address of said remote access point.

24. The method of claim 21,

wherein sending said information to be communicated, with the long address, to said remote device includes sending the received information to said remote access point using the determined IP address as a destination identifier in a header used for routing said packet to said remote access point through a Layer 2 tunnel.

25. An apparatus comprising:

a processor configured to:

receive a packet from an access terminal, said packet including a PN code address and information to be communicated to a remote device;

determine a long address corresponding to said PN code address to be used for communicating a packet to said remote device, said long address including more bits than said PN code address; and

send said information to be communicated, with the long address, to said remote device.

26. The apparatus of claim 25, wherein the processor, in determining a long address corresponding to said PN code address, is further configured to:

retrieve, from an IP address to PN code address mapping information database, an IP address corresponding to a PN code address.

27. The apparatus of claim 26, wherein the processor is further configured to, prior to said step of determining a long address corresponding to said PN code address,

receive information indicating PN codes used by other access points in said system; and

store PN code information corresponding to other nodes in said system with corresponding long addresses corresponding to said other nodes.

28. The apparatus of claim 27, wherein said stored PN code information includes a value which can be determined in a predetermined known manner from a PN code address.

29. The apparatus of claim 27, wherein the processor, in sending said information to be communicated, with the long address, to said remote device, is further configured to:

send the received information to said remote access point using the determined IP address as a destination identifier in a header used for routing said packet to said remote access point through a Layer 2 tunnel.

30. A computer readable medium embodying machine executable instructions for operating an access point to communicate information to a remote access point, the method comprising:

receiving a packet from an access terminal, said packet including a PN code address and information to be communicated to a remote device;

determining a long address corresponding to said PN code address to be used for communicating a packet to said remote device, said long address including more bits than said PN code address; and

sending said information to be communicated, with the long address, to said remote device.

31. The computer readable medium of claim 30, further embodying machine executable instructions for, in determining a long address corresponding to said PN code address:

retrieving, from an IP address to PN code address mapping information database, an IP address corresponding to a PN code address.

32. The computer readable medium of claim 31, further embodying machine executable instructions for, prior to said step of determining a long address corresponding to said PN code address:

receiving information indicating PN codes used by other access points in said system; and

storing PN code information corresponding to other nodes in said system with corresponding long addresses corresponding to said other nodes.

33. The computer readable medium of claim 32, wherein said stored PN code information includes a value which can be determined in a predetermined known manner from a PN code address.

34. The computer readable medium of claim 33, further embodying machine executable instructions for, in sending said information to be communicated, with the long address, to said remote device:

sending the received information to said remote access point using the determined IP address as a destination identifier in a header used for routing said packet to said remote access point through a Layer 2 tunnel.

35. An access point for communicating information to an access terminal, comprising:

a network interface for receiving a packet from a remote device via a network connection, said packet including a long address and information to be communicated;

a long address to PN code address mapping module for determining a PN code address corresponding to said long address, said PN code address for use over a wireless communications link, said PN code address including fewer bits than said long address;

a downlink packet generation module for generating a packet including said PN code address and said information to be communicated; and

a wireless transmitter for transmitting, over said wireless communications link, downlink packets.

36. The access point of claim 35, further comprising:

an address information database, accessible to said long address to PN code address mapping module, including stored information associating long addresses with corresponding PN code address information.

37. The access point of claim 36, wherein said long address is an IP address.

38. The access point of claim 37, wherein said PN code address is based on a Pilot PN code used by an access point having the long address corresponding to said PN code address.

39. The access point of claim 38,

wherein said long address is an address used for routing packets between said remote device and said access point through a Layer 2 tunnel; and

wherein said PN code information includes a PN code address used for communicating packets over an airlink.

40. The access point of claim 39,

wherein said network interface is coupled to said remote device by a backhaul link, said remote device being a remote access point.

41. The access point of claim 35, further comprising:

a wireless receiver for receiving a packet from an access terminal, said packet including a PN code address and information to be communicated to the remote device;

a PN code address to long address mapping module for determining a long address corresponding to said PN code address to be used for communicating information to said remote device, said long address including more bits than said PN code address; and

a tunneled packet generation module for generating a packet to be sent to said remote device, said tunneled packet generation module generating a packet including: i) a long address determined from a PN code address included in a received packet and ii) information to be communicated which was included in the received packet that included the short address used to determine the long address.

42. An access point for communicating information to an access terminal, comprising:

network interface means for receiving a packet from a remote device via a network connection, said packet including a long address and information to be communicated;

means for determining a PN code address corresponding to said long address, said PN code address for use over a wireless communications link, said PN code address including fewer bits than said long address;

means for generating a packet including said PN code address and said information to be communicated; and

means for transmitting, over said wireless communications link, downlink packets.

43. The access point of claim 42, further comprising:

address information database means, accessible to said means for determining, including stored information associating long addresses with corresponding PN code address information.

44. The access point of claim 43, wherein said long address is an IP address.

45. The access point of claim 44, wherein said PN code address is based on a Pilot PN code used by an access point having the long address corresponding to said PN code address.
46. The access point of claim 45,
wherein said long address is an address used for routing packets between said remote device and said access point through a Layer 2 tunnel; and
wherein said PN code information includes a PN code address used for communicating packets over an airlink.
47. A method of operating an access terminal to communicate information, the method comprising:
receiving a signal from a device;
generating a PN code address from said received signal; and
generating a packet including said PN code address, said packet being directed to said device.
48. The method of claim 47, further comprising:
transmitting said packet to a first access point over a wireless communications link.
49. The method of claim 47,
wherein said signal is a pilot signal;
wherein said device is a remote access point; and
wherein said first access point is coupled to said remote access point by a communications link.
50. The method of claim 47, wherein said PN code address is used as a default when another airlink address is not available for said device.
51. The method of claim 49, further comprising:

prior to generating said packet, determining if said access terminal has a non-PN code based airlink address for said remote access point; and

using said PN code address to generate said packet when it is determined that a non-PN code based address is not available for said remote access point.

52. The method of claim 51, wherein determining if said access terminal has a non-PN code based airlink address for said remote access point includes checking to determine if said access terminal has one of i) a predetermined reserved address; ii) an address supplied by the access terminal to the first access point to be used for communications over an airlink to said first access point for packets directed to said remote access point; and iii) a network supplied address to be used for packets communicated over an airlink to said remote access point.

53. The method of claim 52, further comprising:
storing in an airlink to IP address information database, information mapping between an IP address corresponding to said remote device and said PN code address.

54. The method of claim 48,
wherein said received signal is a pilot signal; and
wherein generating a PN code address includes:
using a predetermined function to generate the PN code address
from a pilot PN code determined from the received pilot signal.

55. The method of claim 54, wherein said predetermined function uses a full pilot PN code as the PN code address of the remote device.

56. The method of claim 54, wherein said predetermined function uses a portion of a pilot PN code as the PN code address of the remote device, said portion being less than the full pilot PN code.

57. An apparatus comprising:
a processor configured to:
receive a signal from a device;
generate a PN code address from said received signal; and
generate a packet including said PN code address, said packet
being directed to said device.
58. The apparatus of claim 57, wherein said processor is further configured to:
transmit said packet to a first access point over a wireless
communications link.
59. The apparatus of claim 57,
wherein said signal is a pilot signal;
wherein said device is a remote access point; and
wherein said first access point is coupled to said remote access point by a
communications link.
60. The apparatus of claim 59, wherein said processor is further configured to:
prior to generating said packet, determine if an access terminal including said
apparatus has a non-PN code based airlink address for said remote access point; and
use said PN code address to generate said packet when it is determined that a
non-PN code based address is not available for said remote access point.
61. The apparatus of claim 58,
wherein said received signal is a pilot signal; and
wherein said access terminal processor is further configured to, in generating a
PN code address:
use a predetermined function to generate the PN code address
from a pilot PN code determined from the received pilot signal.
62. A computer readable medium embodying machine executable instructions for
operating an access terminal to communicate information, the method comprising:

receiving a signal from a device;
generating a PN code address from said received signal; and
generating a packet including said PN code address, said packet being directed to said device.

63. The computer readable medium of claim 62, further embodying machine executable instructions for:

transmitting said packet to a first access point over a wireless communications link.

64. The computer readable medium of claim 62,
wherein said signal is a pilot signal;
wherein said device is a remote access point; and
wherein said first access point is coupled to said remote access point by a communications link.

65. The computer readable medium of claim 64, further embodying machine executable instructions for:

prior to generating said packet, determining if said access terminal has a non-PN code based airlink address for said remote access point; and

using said PN code address to generate said packet when it is determined that a non-PN code based address is not available for said remote access point.

66. The computer readable medium of claim 63,
wherein said received signal is a pilot signal; and
further embodying machine executable instructions for, in generating a PN code address:

using a predetermined function to generate the PN code address from a pilot PN code determined from the received pilot signal.

67. A method of operating an access terminal to receive information from a remote device through an access point, the method comprising:

receiving from said access point a packet including a PN code address corresponding to said remote device and information from said remote device; and identifying the remote device which provided the information from said PN code address and stored information relating the received PN code address to an access point.

68. The method of claim 67, further comprising:

prior to identifying the remote device,

receiving a pilot signal from said remote device;

generating a PN code address from said received pilot signal; and

storing the PN code address generated from the received pilot signal in a database of information used for mapping between PN code addresses and long addresses.

69. The method of claim 68, wherein generating a PN code address includes:

using a predetermined function to generate the PN code address from a pilot PN code determined from the received pilot signal.

70. The method of claim 69, wherein said predetermined function uses the full pilot PN code as the PN code address of the remote device.

71. The method of claim 70, wherein said predetermined function uses a portion of the pilot PN code as the PN code address of the remote device, said portion being less than the full pilot PN code.

72. The method of claim 68, wherein storing said PN code address in a database of information includes storing said pilot code address with a long address corresponding to said remote device.

73. The method of claim 72, wherein said long address is an IP address corresponding to said remote device.

74. The method of claim 70, wherein said remote device is a remote access point; wherein said remote access point previously served as said access terminal's active network point of attachment; and wherein said access point serves as the access terminal's current active network point of attachment.

75. An apparatus comprising:
a processor configured to:
receive from an access point a packet including a PN code address corresponding to a remote device and information from said remote device; and
identify the remote device which provided the information from said PN code address and stored information relating the received PN code address to an access point.

76. The apparatus of claim 75, wherein the processor is further configured to:
prior to identifying the remote device,
receive a pilot signal from said remote device;
generate a PN code address from said received pilot signal; and
store the PN code address generated from the received pilot signal in a database of information used for mapping between PN code addresses and long addresses.

77. The apparatus of claim 76, wherein the processor, in generating a PN code address, is further configured to:
use a predetermined function to generate the PN code address from a pilot PN code determined from the received pilot signal.

78. The apparatus of claim 77, wherein said predetermined function uses the full pilot PN code as the PN code address of the remote device.

79. The apparatus of claim 76, wherein the processor, in storing said PN code address in a database of information, is further configured to:

store said pilot code address with a long address corresponding to said remote device.

80. A computer readable medium embodying machine executable instructions for operating an access terminal to receive information from a remote device through an access point, the method comprising:

receiving from said access point a packet including a PN code address corresponding to said remote device and information from said remote device; and
identifying the remote device which provided the information from said PN code address and stored information relating the received PN code address to an access point.

81. The method of claim 80, further embodying machine executable instructions for:
prior to identifying the remote device,

receiving a pilot signal from said remote device;
generating a PN code address from said received pilot signal; and
storing the PN code address generated from the received pilot signal in a database of information used for mapping between PN code addresses and long addresses.

82. The method of claim 81, further embodying machine executable instructions for, in generating a PN code address:

using a predetermined function to generate the PN code address from a pilot PN code determined from the received pilot signal.

83. The method of claim 82, wherein said predetermined function uses the full pilot PN code as the PN code address of the remote device.

84. The method of claim 81, further embodying machine executable instructions for, in storing said PN code address in a database of information:

storing said pilot code address with a long address corresponding to said remote device.

85. An access terminal for communicating information to a remote device through an access point, comprising:

a packet generation module for generating a packet including a PN code address corresponding to said remote device and information to be communicated to said remote device; and

a wireless transmitter for transmitting the generated packet over the air to said access point.

86. The access terminal of claim 85, further comprising:

a PN code address determination module for determining a PN code address from a pilot signal, said PN code address corresponding to an access point from which said pilot signal was received.

87. The access terminal of claim 86, further comprising:

a database including information for storing PN code addresses determined from pilot signals received by said access terminal.

88. The access terminal of claim 87, wherein said stored PN code addresses are the PN codes of the pilot signals from which the PN code addresses were determined.

89. The access terminal of claim 88, wherein said stored PN code addresses are derived from the PN codes of the pilot signal from which the PN code addresses were determined according to a predetermined function.

90. The access terminal of claim 86, further comprising:

a wireless receiver for receiving a packet communicated over the air to said access terminal which includes a PN code address identifying the source of information included in the received packet.

91. The access terminal of claim 90, further comprising:
an access point identification module for identifying from the PN code address which one of a plurality of access points from which pilot signals have been received was the source of the information included in the received packet.

92. An access terminal for communicating information to a remote device through an access point, comprising:

packet generation means for generating a packet including a PN code address corresponding to said remote device and information to be communicated to said remote device; and

means for transmitting the generated packet over the air to said access point.

93. The access terminal of claim 92, further comprising:

means for determining a PN code address from a pilot signal, said PN code address corresponding to an access point from which said pilot signal was received.

94. The access terminal of claim 93, further comprising:

database means for storing PN code addresses determined from pilot signals received by said access terminal.

95. The access terminal of claim 94, wherein said stored PN code addresses are the PN codes of the pilot signals from which the PN code addresses were determined.

96. The access terminal of claim 93, further comprising:

means for receiving a packet communicated over the air to said access terminal which includes a PN code address identifying the source of information included in the received packet.