A grant-free transmission mode may be used to communicate small traffic transmissions to reduce overhead and latency. The grant-free transmission mode may be used in downlink and uplink data channels of a wireless network. In the downlink channel, a base station transmits packets to a group of UEs in a search space without communicating any transmission code assignments to the UEs. The UEs receive the downlink packets using blind detection. In the uplink channel, UEs transmit packets in an access space using assigned access codes which are either independently derived by the UEs or otherwise communicated by the base station using a slow-signaling channel. Hence, the grant-free transmission mode allows mobile devices to make small traffic transmissions without waiting for uplink grant requests.
FIG. 4

400

410
ALLOCATE TIME-FREQUENCY RESOURCES OF A DOWNLINK DATA CHANNEL AS A SEARCH SPACE FOR A GROUP OF UEs

420
ASSIGN TRANSMISSION CODES TO THE UEs IN THE GROUP OF UEs

430
TRANSMIT PACKETS OVER THE TIME-FREQUENCY RESOURCES IN ACCORDANCE WITH THE TRANSMISSION CODE ASSIGNMENTS WITHOUT COMMUNICATING ANY TRANSMISSION CODE ASSIGNMENTS TO THE GROUP OF UEs

FIG. 5

500

510
IDENTIFY A SEARCH SPACE FOR A GROUP OF UEs

520
DETERMINING CANDIDATE TRANSMISSION CODES ASSOCIATED WITH THE SEARCH SPACE

530
RECEIVING A PACKET COMMUNICATED IN THE SEARCH SPACE USING BLIND DETECTION
FIG. 6

PRE-ASSIGNED RESOURCE FOR UE GROUP-1

PRE-ASSIGNED RESOURCE FOR UE GROUP-2

UE GROUP-1

UE GROUP-2

UEA1

UEA2

UEA3

UEA4

UEA5

UEA6

UEA7

UEA10

UEB1

UEB2

UEB3

UEB9

ALLOW SIGNATURE COLLISION
Fig. 7

1. Identifying an access space for a group of UEs
2. Identifying access codes associated with the access space
3. Transmit the packet in the access space using the assigned access codes without obtaining an uplink grant

Fig. 8

1. Identifying an access space for a group of UEs
2. Identifying access codes associated with the access space
3. Receive packets in the access space using blind detection
FIG. 9

FIG. 10
SYSTEM AND METHOD FOR SMALL TRAFFIC TRANSMISSIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/737,636 filed on Dec. 14, 2012, entitled “System and Method for Small Traffic Transmissions,” which is incorporated herein by reference as if reproduced in its entirety.

TECHNICAL FIELD

[0002] The present invention relates to a system and method for wireless communications, and, in particular embodiments, to a system and method for small traffic transmissions.

BACKGROUND

[0003] In third generation partnership (3GPP) long term evolution (LTE) networks, both downlink (DL) and uplink (UL) transmissions utilize scheduling-based access, meaning that network resources (e.g., time-frequency resources) are allocated for each transmission. The scheduling-based access typically comprises either dynamic scheduling or semi-static scheduling. In dynamic scheduling, the user equipment (UE) and base station (BS) will communicate grant based signaling for each transmission time interval (TTI). In semi-static scheduling, the UE and BS will communicate grant based signaling for blocks of TTIs. Dynamic scheduling may allow the UE and BS to achieve fast link adaptation, while semi-static signaling may produce less signaling overhead.

SUMMARY

[0004] Technical advantages are generally achieved, by embodiments of this disclosure which describe a system and method for small traffic transmissions.

[0005] In accordance with an embodiment, a method for communicating data is provided. In this example, the method includes allocating resources of a downlink channel as a search space for a group of mobile devices; assigning a first transmission code to a first mobile device; and transmitting a packet over the resources in accordance with the first transmission code without communicating transmission code assignments to the first mobile device. The first mobile device is configured to receive the packet using blind detection. An apparatus for performing this method is also provided.

[0006] In accordance with another embodiment, another method for communicating data is provided. In this example, the method includes identifying a search space for a group of mobile devices. The search space includes resources of a downlink channel. The method further includes determining a set of candidate transmission codes associated with the search space, and receiving a packet communicated in the search space using blind detection. The search space comprises resources of a downlink channel, and the packet is communicated in accordance with a first transmission code in the set of candidate transmission codes. An apparatus for performing this method is also provided.

[0007] In accordance with yet another embodiment, yet another method for communicating data is provided. In this example, the method includes identifying an access space for a group of mobile devices. The access space comprises resources of an uplink channel. The method further comprises determining a first transmission code in a set of transmission codes for a first mobile device in the group of mobile devices, and transmitting a packet over the resources of the uplink channel using the first transmission code without obtaining an uplink grant. An apparatus for performing this method is also provided.

[0008] In accordance with yet another embodiment, yet another method for communicating data is provided. In this example, the method includes identifying an access space for a group of mobile devices. The access space comprises resources of an uplink channel. The method further comprises identifying a set of transmission codes associated with access space, and receiving packets communicated over the resources of the uplink channel using blind detection. An apparatus for performing this method is also provided.

[0009] In accordance with yet another embodiment, a method for advertising grant-free communication mode capabilities is provided. In this example, the method includes communicating capability information between a mobile device and a base station. The capability information indicates a grant-free communication mode capability. The method further comprises communicating grant-free signaling parameters between the mobile device and the base station. The grant-free signaling parameters define a search space or an access space for the grant-free communication mode. An apparatus for performing this method is also provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] For a more complete understanding of the present disclosure, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

[0011] FIG. 1 illustrates a diagram of a wireless network for communicating data;

[0012] FIG. 2 illustrates a diagram of another wireless network for communicating data;

[0013] FIG. 3 illustrates a diagram of an embodiment downlink data channel for carrying grant free small packet transmissions;

[0014] FIG. 4 illustrates a flowchart of an embodiment method for communicating grant free small packet transmissions in a downlink data channel;

[0015] FIG. 5 illustrates a flowchart of an embodiment method for receiving grant free small packet transmissions in a downlink data channel;

[0016] FIG. 6 illustrates a diagram of an embodiment downlink data channel for carrying grant free small packet transmissions;

[0017] FIG. 7 illustrates a flowchart of an embodiment method for performing grant free small packet transmissions in an uplink data channel;

[0018] FIG. 8 illustrates a flowchart of an embodiment method for receiving grant free small packet transmissions over an uplink data channel;

[0019] FIG. 9 illustrates a block diagram of an embodiment processing system; and

[0020] FIG. 10 illustrates a block diagram of an embodiment communications device.

[0021] Corresponding numerals and symbols in the different figures generally refer to corresponding parts unless otherwise indicated. The figures are drawn to clearly illustrate the relevant aspects of the embodiments and are not necessarily drawn to scale.
DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0022] The making and using of embodiments of this disclosure are discussed in detail below. It should be appreciated, however, that the present invention provides many applicable inventive concepts that can be embodied in a wide variety of specific contexts. The specific embodiments discussed are merely illustrative of specific ways to make and use the invention, and do not limit the scope of the invention.

[0023] In both dynamic and semi-static scheduling, the grant based signaling is communicated via a physical uplink control channel (PUCCH) and/or physical downlink control channel (PDCCH). More specifically, downlink transmission parameters, e.g., modulation and coding scheme (MCS), channel resource allocation, multiple-input multiple output (MIMO) transmission mode, etc.) and uplink grant assignments are traditionally communicated through the PDCCH, while uplink grant requests are signaled through the PUCCH. Many future applications will rely on small packet transmissions, including for example, real time gaming, instant messaging, machine-to-machine (M2M) communications, status update messaging, etc. Communicating small packet transmissions using conventional scheduling-based transmission techniques may be relatively inefficient and/or undesirable. More specifically, dynamic scheduling may generate significant amounts of overhead compared to the small packet communication’s payload size, while semi-persistent scheduling may be unable to meet the QoS requirements for delay sensitive small traffic transmission. Accordingly, an alternative communication scheme for small packet transmissions is desired.

[0024] Aspects of this disclosure provide a grant-free transmission mode for small traffic transmissions in downlink and uplink data channels of a wireless network. In the downlink channel, a base station transmits packets to a group of UEs in a search space without communicating any transmission code assignments to the UEs. The UEs receive the downlink packets using blind detection. In the uplink channel, UEs transmit packets in an access space using assigned access codes which are either independently derived by the UEs or otherwise communicated by the base station using a slow-signaling channel. In any event, UEs can make small traffic transmissions without waiting for uplink grant requests. In this disclosure, grant-free transmissions refer to data transmissions that are performed without communicating grant-based signaling in a dynamic control channel, such as a PUCCH or PDCCH. Grant-free transmissions can include uplink or downlink transmissions, and should be interpreted as such unless otherwise specified.

[0025] FIG. 1 illustrates a network 100 for communicating data. The network 100 comprises an access point (AP) 110 having a coverage area 112, a plurality of user equipments (UEs) 120, and a backhaul network 130. The AP 110 may comprise any component capable of providing wireless access by, inter alia, establishing uplink (dashed line) and/or downlink (dotted line) connections with the UEs 120, such as a base station, an enhanced base station (eNB), a femtocell, and other wirelessly enabled devices. The UEs 120 may comprise any component capable of establishing a wireless connection with the AP 110. The backhaul network 130 may be any component or collection of components that allow data to be exchanged between the AP 110 and a remote end (not shown). In some embodiments, the network 100 may comprise various other wireless devices, such as relays, femtocells, etc.

[0026] FIG. 2 illustrates a wireless communications network 200 comprising a plurality of base stations (BS) providing voice and/or data wireless communication service to a plurality of mobile stations (MSs). The BSs may be referred to by other names such as access network (AN) elements, access points (APs), Node-Bs, eNBs, or any other network device configured to communicate with MSs in the wireless communications network 200. Each BS has a corresponding coverage area for communicating data, and coverage areas of adjacent BSs may overlap in order to accommodate handoffs. BSs may include schedulers for allocating radio resources.

[0027] FIG. 3 illustrates a downlink data channel 300 for carrying grant-free small packet transmissions. As shown, different groups of UEs are assigned different search spaces comprising time-frequency resources of the downlink data channel 300. Further, UEs within a given group are assigned individual transmission codes. Transmission codes may include various types of sequences, such as low density signatures, code division multiple access signatures, pseudo noise (PN) sequences, Zadoff-Chu sequences, Walsh-Hadamard codes, and others. In one embodiment, the transmission code can be obtained from the codewords defined in a codebook or metrics. In an embodiment, individual transmission codes are assigned exclusively to individual UEs to achieve unicast transmission. In another embodiment, an individual codeword is assigned to a multicast group of users to achieve multicast transmission. The search space for a group of UEs may be defined, for example, as a specific downlink channel resources (e.g., time, frequency, spatial etc.) over which transmissions for the group are communicated. The search space may be assigned by the network or derived from a UE connection signature. The arrival time of the packet may be unpredictable, so multiple detection trials may be used. In various embodiments, multiple transmission codes and/or search spaces can be allocated to a UE requiring more bandwidth.

[0028] FIG. 4 illustrates a method 400 for sending grant-free transmissions in a downlink data channel, as might be performed by a base station. As shown, the method 400 begins at step 410, where the base station allocates time frequency resources of a downlink data channel as a search space for a group of UEs. Thereafter, the method 400 proceeds to step 420, where the base station assigns candidate transmission codes to individual UEs in the group of UEs. Notably, while the transmission code assignments are known to the base station, the transmission code assignments are not communicated to UEs. Subsequently, the method 400 proceeds to step 430, where the base station transmits packets over the resources in accordance with the predefined codes. Notably, the packets are transmitted without communicating any transmission code assignments to the group of UEs.

[0029] FIG. 5 illustrates a method 500 for receiving grant-free transmissions in a downlink data channel, as might be performed by a mobile device. The mobile device may be a user equipment, a mobile station, or any other device configured to receive wireless transmissions from a base station. As shown, the method 500 begins with step 510, where the mobile device identifies a search space for a group of UEs to which the mobile device belongs. Thereafter, the method 500 proceeds to step 520, where the mobile station determines a set of candidate transmission codes associated with the search
space. The set of candidate transmission codes may be identified via a priori information, or in accordance with control information communicated by the base station (e.g., during initialization, via a slow-signaling channel, etc.). Subsequently, the method 500 proceeds to step 530, where the mobile station receives a packet communicated in the search space using blind detection. More specifically, the mobile station may perform blind detection by decoding packets communicated in the search space using corresponding transmission codes in the set of candidate transmission codes. The mobile station may then perform a cyclic redundancy check (CRC) on each decoded packet to verify which of the packets was destined for the mobile station. In an embodiment, the packet destined for the mobile station includes an identifier associated with the mobile station, e.g., a UE identifier, etc. In another embodiment, the CRC is masked by a mobile device connection ID associated with the mobile device. In embodiments, the mobile station may be able to decode other UEs’ packets if the mobile station has knowledge of the other UEs’ information. Examples of such information are other UEs’ IDs or a group ID. Embodiments of non-adaptive transmission include a predefined modulation level and/or a predefined possible coding level, and also a repetition pattern.

FIG. 6 illustrates a diagram of an uplink data channel 600 for carrying grant-free small packet transmissions. As shown, different groups of UEs are assigned different access spaces comprising time-frequency resources of the uplink data channel 600. Further, UEs within a given group are assigned individual access codes. The access codes may include various types of sequences, such as low density signatures, code division multiple access signatures, pseudo noise (PN) sequences, Zadoff-Chu sequences, Walsh-Hadamard codes, and others. In an embodiment, an individual access code is used by a single user to achieve contention-free access in the uplink channel. Alternatively, an individual access code is used by multiple users to perform transmissions over the access space in a contention manner. The access space and/or access code may be assigned by the network or derived from a prior information or information communicated over a slow-signaling channel. In an embodiment, the information used to derive the access code/spaces are predefined rules known by the network and UEs, e.g., UE connection signatures, UE IDs, etc. In various embodiments, more access space and/or access codes can be assigned to a UE that needs more bandwidth. The base station detects the UL packets by trying all possible access codes assigned to the predefined access space. The base station identifies the UE through CRC checking or header identification. Embodiments of non-adaptive transmission include a predefined modulation level, a predefined possible coding level, a repetition pattern, or combinations thereof.

FIG. 7 illustrates a method 700 for sending grant-free transmissions in an uplink data channel, as might be performed by a mobile station. As shown, the method 700 begins at step 710, the mobile station identifies an access space for a group of UEs. Thereafter, the method 700 proceeds to step 720, where the mobile station identifies assigned access codes associated with the predefined access space. In an embodiment, the mobile station independently derives the assigned access code in accordance with some pre-defined rules known at the base station and mobile stations. In another embodiment, the assigned access code is communicated by the base station via a slow-signaling channel. In yet another embodiment, the mobile station derives the assigned access code from an access code set in accordance with some pre-defined rules such that the base station only needs to announce a pre-defined access code set comprising all possible codes associated with the predefined access resources. Subsequently, the method 700 proceeds to step 730, where the mobile station transmits the packet in the access space using the selected access code. The packet is transmitted without obtaining an uplink grant.

FIG. 8 illustrates a method 800 for receiving grant-free transmissions in an uplink data channel, as might be performed by a base station. As shown, the method 800 begins with step 810, where the base station identifies an access space for a group of UEs to which the mobile device belongs. Thereafter, the method 800 proceeds to step 820, where the base station determines the transmission codes associated with the access space. Subsequently, the method 800 proceeds to step 830, where the base station receives a packet communicated in the access space using blind detection. More specifically, the base station may perform blind detection by decoding packets communicated in the access space using corresponding access codes in the set of candidate access codes. The base station may then perform a cyclic redundancy check (CRC) on each decoded packet and identify the mobile station. In an embodiment, the packet destined for the base station includes an identifier associated with the mobile station, e.g., a UE identifier, etc. In another embodiment, the CRC is masked by a mobile device connection ID associated with the mobile device.

Access codes may be defined differently in various embodiments. For example, the network may define orthogonal pseudo-orthogonal code sets or codebooks, such as low density signature (LDS), code division multiple access (CDMA), pseudo-random noise (PN) sequence, Zadoff-Chu (ZC) sequence, Walsh-Hadamard code, and other sparse multiple access codes. The code set or codebook may typically be known by both the base station and the mobile terminals. The mobile terminals may select one or multiple codes from the code set to transmit small packets.

A semi-static transmission mode configuration is signaled to the UE through the broadcast channel. The broadcast signaling may indicate whether a grant-free transmission mode is supported by the network, as well as traffic types or other parameters associated with the grant-free transmission mode. The network may support grant-free transmission mode in the downlink channel, the uplink channel, or both, and may indicate such capability via broadcast signaling (or otherwise). Additionally, the UE may advertise or otherwise indicate a grant-free transmission mode capability (or lack thereof) when accessing the network. For example, the UE may indicate whether the UE is capable of performing grant-free transmission over the uplink channel and/or receiving grant-free transmissions over the downlink channel. Modulation and Coding Scheme (MCS) settings can be updated through the broadcast channel or other slow-signaling channel. The search space and the access space for each UE may be determined by the network in accordance with the UE connection ID, geometry location, active traffic/service types, etc. In some cases, the broadcast signaling and access space can be signaled to the UEs through the broadcast channel. The search space and access space can be updated and signaled to the UEs through the slow-signaling channel. The maximum size of code set and the formation of the code set can also be updated and signaled to the UE through the slow signaling channel.
FIG. 9 is a block diagram of a processing system that may be used for implementing the devices and methods disclosed herein. Specific devices may utilize all of the components shown, or only a subset of the components, and levels of integration may vary from device to device. Furthermore, a device may contain multiple instances of a component, such as multiple processing units, processors, memories, transmitters, receivers, etc. The processing system may comprise a processing unit equipped with one or more input/output devices, such as a speaker, microphone, mouse, touchscreen, keypad, keyboard, printer, display, and the like. The processing unit may include a central processing unit (CPU), memory, a mass storage device, a video adapter, and an input/output (I/O) interface device such as a bus.

The bus may be one or more of any type of several bus architectures including a memory bus or memory controller, a peripheral bus, video bus, or the like. The CPU may comprise any type of electronic data processor. The memory may comprise any type of system memory such as static random access memory (SRAM), dynamic random access memory (DRAM), synchronous DRAM (SDRAM), read-only memory (ROM), a combination thereof, or the like. In an embodiment, the memory may include ROM for use at boot-up, and DRAM for program and data storage for use while executing programs.

The mass storage device may comprise any type of storage device configured to store data, programs, and other information and to make the data, programs, and other information accessible via the bus. The mass storage device may comprise, for example, one or more of a solid state drive, hard disk drive, a magnetic disk drive, an optical disk drive, or the like.

The video adapter and the I/O interface provide interfaces to couple external input and output devices to the processing unit. As illustrated, examples of input and output devices include the display coupled to the video adapter and the mouse/keyboards/printer coupled to the I/O interface. Other devices may be coupled to the processing unit, and additional or fewer interface cards may be utilized. For example, a serial interface such as Universal Serial Bus (USB) (not shown) may be used to provide an interface for a printer.

The processing unit also includes one or more network interfaces, which may comprise wired links, such as an Ethernet cable or the like, and/or wireless links to access nodes or different networks. The network interface allows the processing unit to communicate with remote units via the networks. For example, the network interface may provide wireless communication via one or more transmitters/transceivers or more receivers/receive antennas. In an embodiment, the processing unit is coupled to a local-area network or a wide-area network for data processing and communications with remote devices, such as other processing units, the Internet, remote storage facilities, or the like.

FIG. 10 illustrates a block diagram of an embodiment of a communications device 1000, which may be equivalent to one or more devices (e.g., UEs, NBs, etc.) discussed above. The communications device 1000 may include a processor 1004, a memory 1006, a cellular interface 1010, a supplemental interface 1012, and a backhaul interface 1014, which may (or may not) be arranged as shown in FIG. 10. The processor 1004 may be any component capable of performing computations and/or other processing related tasks, and the memory 1006 may be any component capable of storing programming and/or instructions for the processor 1004. The cellular interface 1010 may be any component or collection of components that allows the communications device 1000 to communicate using a cellular signal, and may be used to receive and/or transmit information over a cellular connection of a cellular network. The supplemental interface 1012 may be any component or collection of components that allows the communications device 1000 to communicate data or control information via a supplemental protocol. For instance, the supplemental interface 1012 may be a non-cellular wireless interface for communicating in accordance with a Wireless-Fidelity (Wi-Fi) or Bluetooth protocol. Alternatively, the supplemental interface 1012 may be a wireline interface. The backhaul interface 1014 may be optionally included in the communications device 1000, and may comprise any component or collection of components that allows the communications device 1000 to communicate with another device via a backhaul network.

Although the description has been described in detail, it should be understood that various changes, substitutions and alterations can be made without departing from the spirit and scope of this disclosure as defined by the appended claims. Moreover, the scope of the disclosure is not intended to be limited to the particular embodiments described herein, as one of ordinary skill in the art will readily appreciate from this disclosure that processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed, may perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

What is claimed is:

1. A method comprising: allocating, by a base station, resources of a downlink channel as a search space for a group of mobile devices; assigning a first transmission code to a first mobile device; and transmitting, by the base station, a packet over the resources in accordance with the first transmission code without communicating transmission code assignments to the first mobile device, wherein the first mobile device is configured to receive the packet using blind detection.

2. The method of claim 1, wherein the first transmission code comprises an orthogonal or quasi-orthogonal signature.

3. The method of claim 2, wherein the first transmission code comprises at least one of a low density signature, a code division multiple access (CDMA) signature, a pseudo noise (PN) sequence, a Zadoff-Chu sequence, and a Walsh-Hadamard code.

4. The method of claim 2, wherein the first transmission code comprises a sparse multiple access code.

5. The method of claim 1, wherein the packet includes at least some data that is not control information.

6. The method of claim 1, wherein transmitting the packet over the resources of the downlink channel comprises: transmitting the packet in accordance with multiple transmission codes.

7. The method of claim 1, wherein the search space comprises time-frequency resources of the downlink channel.

8. The method of claim 1, wherein the search space comprises spatial resources of the downlink channel.
9. A base station comprising:
   a processor; and
   a computer readable storage medium storing programming
   for execution by the processor, the programming includ-
   ing instructions to:
   allocate time-frequency resources as a search space for a
group of mobile devices;
   assign a first transmission code to a first mobile device;
   and
   transmit a first packet over the resources in accordance
with the first transmission code without communi-
tating any transmission code assignments to the first
mobile device, wherein the first mobile device is con-
figured to receive the first packet using blind detec-
tion.

10. A method comprising:
   identifying a search space for a group of mobile devices,
   the group of mobile device including at least a first
   mobile device, wherein the search space comprises
   resources of a downlink channel;
   determining a set of candidate transmission codes associ-
ated with the search space; and
   receiving, by the first mobile device, a packet communi-
cated in the search space using blind detection, wherein
   the packet is communicated in accordance with a first
   transmission code in the set of candidate transmission
codes.

11. The method of claim 10, wherein receiving the packet
   using blind detection comprises:
   receiving, by the first mobile device, the packet without
   knowing beforehand which transmission code in the set
   of candidate transmission codes was used to communi-
cate the packet.

12. The method of claim 10, wherein receiving the packet
   using blind detection comprises:
   decoding, by the first mobile device, a plurality of packets
   communicated in the search space using a correspond-
ing transmission code in the set of candidate transmis-
sion codes, wherein each packet is communicated in
   accordance with a different transmission code in the set
   of candidate transmission codes; and
   determining which of the decoded packets carries an iden-
tifier associated with the first mobile device.

13. The method of claim 10, wherein the search space
   comprises time-frequency resources of the downlink channel.

14. The method of claim 10, wherein the search space
   comprises spatial resources of the downlink channel.

15. A mobile device comprising:
   a processor; and
   a computer readable storage medium storing programming
   for execution by the processor, the programming includ-
   ing instructions to:
   identify a search space for a group of mobile devices
associated with the mobile device, the mobile device
   comprising resources of a downlink channel;
   determine a set of candidate transmission codes associ-
ated with the search space; and
   receive a packet communicated in the search space using
blind detection, wherein the packet is communicated
   in accordance with a first transmission code in the set
of candidate transmission codes.

16. A method comprising:
   identifying an access space for a group of mobile devices,
   the access space comprising resources of an uplink
channel, wherein the group of mobile devices comprise
at least a first mobile device;
   determining a first transmission code in a set of transmis-
sion codes for the first mobile device; and
   transmitting, by the first mobile device, a packet over the
   resources of the uplink channel using the first transmis-
sion code without obtaining an uplink grant.

17. The method of claim 16, wherein the first transmission
code comprises an orthogonal or quasi-orthogonal signature.

18. The method of claim 17, wherein the first transmission
code comprises at least one of a low density orthogonal,
a code
division multiple access (CDMA) signature, a pseudo noise
(PN) sequence, a Zadoff-Chu sequence, and a Walsh-Hadamard
code.

19. The method of claim 17, wherein the first transmission
code comprises a sparse multiple access code.

20. The method of claim 16, wherein the first transmission
code is assigned exclusively to the first mobile device without
   being assigned to other mobile devices in the group of mobile
devices.

21. The method of claim 16, wherein the first transmission
code is assigned to multiple mobile devices of the group
   of mobile devices.

22. The method of claim 16, wherein transmitting the
   packet over the resources using the first transmission code
   comprises:
   transmitting, by the first mobile device, the packet over the
   resources of the uplink channel using the first transmis-
sion code; and
   re-transmitting the packet if a collision resulted from the
   earlier transmission.

23. The method of claim 16, wherein determining the first
   transmission code for the first mobile device comprises:
   independently deriving the first transmission code by the
   first mobile device in accordance with a connection sig-
nature of the first mobile device.

24. The method of claim 16, wherein determining the first
   transmission code for the first mobile device comprises:
   receiving, by the first mobile device, a transmission code
   assignment over a slow-signaling channel, the slow-signaling
   channel being communicated less frequently than a control
   channel used to communicate uplink grant informa-
tion.

25. The method of claim 16, wherein the access space
   comprises time-frequency resources of the uplink channel.

26. The method of claim 16, wherein the access space
   comprises spatial resources of the uplink channel.

27. A mobile station comprising:
   a processor; and
   a computer readable storage medium storing programming
   for execution by the processor, the programming includ-
   ing instructions to:
   identify an access space for a group of mobile stations,
   the access space comprising resources of an uplink
   channel, wherein the group of mobile stations com-
   prises at least a first mobile station;
   determine that a first transmission code in a set of trans-
   mission codes has been assigned to the first mobile
   station; and
   transmit a packet over the resources of the uplink chan-
   nel using the first transmission code without obtaining
   an uplink grant.
28. A method comprising:
identifying an access space for a group of mobile devices,
the access space comprising resources of an uplink channel;
identifying a set of transmission codes associated with
access space; and
receiving, by a base station, packets communicated over
the resources of the uplink channel using blind detection.

29. The method of claim 28, wherein the packets are
received without communicating uplink grant information to
the group of mobile devices.

30. A base station comprising:
a processor; and
a computer readable storage medium storing programming
for execution by the processor, the programming includ-
ing instructions to:
identify an access space for a group of mobile devices,
the access space comprising resources of an uplink channel;
identify a set of transmission codes associated with
access space; and
receive packets communicated over the resources of the
uplink channel using blind detection.

31. A method comprising:
communicating capability information between a mobile
device and a base station, the capability information
indicating a grant-free communication mode capability;
and
communicating grant-free signaling parameters between
the mobile device and the base station, the grant-free
signaling parameters defining a search space or an
access space for the grant-free communication mode.

32. The method of claim 31, wherein the grant-free com-
unication mode capability indicates that the base station
supports grant-free communications over an uplink or down-
link channel.

33. The method of claim 31, wherein the grant-free com-
unication mode capability indicates that the mobile device
is capable of performing grant-free communications over an
uplink channel, receiving grant-free communications over a
downlink channel, or both.

34. The method of claim 31, wherein communicating
grant-free signaling parameters between the mobile device
and the base station comprises:
communicating the grant-free signaling parameters over a
slow-signaling channel, the slow-signaling channel
being communicated less frequently than a control channel
used to communicate uplink grant information.

35. The method of claim 31, wherein the grant-free signal-
ing parameters include a set of candidate transmission codes.