FILTERING SEMI-PERSISTENT SCHEDULING FALSE ALARMS

CLAIM OF PRIORITY UNDER 35 U.S.C. §119

[0001] The present Application for Patent claims priority to Provisional Application No. 61/038,037 entitled "A Method and Apparatus for Using Dual Layer of Error Checking to Reduce False CRC Matching" filed March 19, 2008, assigned to the assignee hereof and hereby expressly incorporated by reference herein.

FIELD OF INVENTION

[0002] The exemplary and non-limiting aspects described herein relate generally to wireless communications systems, methods, computer program products and devices, and more specifically to techniques for semi-persistent scheduling on an uplink channel.

BACKGROUND

[0003] Wireless communication systems are widely deployed to provide various types of communication content such as voice, data, and so on. These systems may be multiple-access systems capable of supporting communication with multiple users by sharing the available system resources (e.g., bandwidth and transmit power). Examples of such multiple-access systems include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, and orthogonal frequency division multiple access (OFDMA) systems.

[0004] 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-signal-out or a multiple-in-multiple-out (MIMO) system.

[0005] Universal Mobile Telecommunications System (UMTS) is one of the third-generation (3G) cell phone technologies. UTRAN, short for UMTS Terrestrial Radio Access Network, is a collective term for the Node-B's and Radio Network Controllers which make up the UMTS radio access network. This communications network can

carry many traffic types from real-time Circuit Switched to IP based Packet Switched. The UTRAN allows connectivity between the UE (user equipment) and the core network. The UTRAN contains the base stations, which are called Node Bs, and Radio Network Controllers (RNC). The RNC provides control functionalities for one or more Node Bs. A Node B and an RNC can be the same device, although typical implementations have a separate RNC located in a central office serving multiple Node B's. Despite the fact that they do not have to be physically separated, there is a logical interface between them known as the Iub. The RNC and its corresponding Node Bs are called the Radio Network Subsystem (RNS). There can be more than one RNS present in an UTRAN.

[0006] 3GPP LTE (Long Term Evolution) is the name given to a project within the Third Generation Partnership Project (3GPP) to improve the UMTS mobile phone standard to cope with future requirements. Goals include improving efficiency, lowering costs, improving services, making use of new spectrum opportunities, and better integration with other open standards. The LTE system is described in the Evolved UTRA (EUTRA) and Evolved UTRAN (EUTRAN) series of specifications.

[0007] Semi-persistent scheduling (SPS) is a set of techniques for efficiently assigning resources for periodic traffic in a wireless communication system to support resource assignment with as little overhead as possible in order to improve system capacity.

[0008] Current communication system uses a 16-bit cyclic redundancy check (CRC) on all physical downlink control channel (PDCCH) formats. Several formats exist for PDCCH, including downlink (DL), DL compact, UL, and power control. In addition various groupings can be done. As a result the UE must perform about 40 blind decodes per PDCCH per subframe. After decoding is done, UE computes a CRC (X-CRC) over the decoded bits. The X-CRC is checked against the CRC indicated in the PDCCH. If there is a match, the PDCCH is deemed for the UE, its content is interpreted and appropriate actions are performed, i.e. either a transmission or a reception occurs.

[0009] A false alarm occurs when the X-CRC matches with the CRC, however, that PDCCH is not meant for that UE. The PDCCH payload can be considered to largely contain random bits in this instance yet the UE performs actions as indicated. Assuming PDCCH bits are random, a false alarm occurs on average every 2^{16} times the CRC check is done. In the worst case the UE performs 40 blind decodes per subframe, and

there are 1000 subframes per second. In that case a false alarm will occur for that UE every 2^{16} / (40*1000) = 1.6 seconds.

[0010] When dynamic scheduling is used, the consequence of false alarms is limited to one set of HARQ (Hybrid Automatic-Repeat-Request) transmission and possible subsequent retransmissions. Therefore the consequences are limited.

[0011] However when a UE is configured for semi-persistent scheduling (SPS), the consequences can be more serious, especially on the uplink. The evolved base node (eNB) uses a PDCCH with a SPS indication to start SPS. The grant indicated in PDCCH will then repeat every serving interval until revoked. A typical serving interval is 20ms for VoIP.

SUMMARY

[0012] The following presents a simplified summary in order to provide a basic understanding of some aspects of the disclosed aspects. This summary is not an extensive overview and is intended to neither identify key or critical elements nor delineate the scope of such aspects. Its purpose is to present some concepts of the described features in a simplified form as a prelude to the more detailed description that is presented later.

[0013] In accordance with one or more aspects and corresponding disclosure thereof, various aspects are described in connection with encoding by a base node such that a user equipment (UE) can perform a multiple error checking to reduce false alarms by passing CRC (cyclic redundancy check) even if data was corrupted when processing data on physical downlink control channel (PDCCH). The PDCCH can be used to indicate a grant to the UE. In this description, a grant may be for reception on downlink channel or transmission on uplink channel.

[0014] In one aspect, a method is provided for receiving a scheduling indication. A grant or assignment is detected on a control channel. A constraint verified on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity. Transmitting or receiving is performed in accordance with the payload on the control channel in response to a determination that the constraint on the portion of a payload is verified.

[0015] In another aspect, at least one processor is provided for receiving a scheduling indication. A first module detects a grant or assignment on a control channel. A second module verifies a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity. A third module transmits or receives in accordance with the payload on the control channel in response to a determination that the constraint on the portion of a payload is verified.

[0016] In an additional aspect, a computer program product is provided for receiving a scheduling indication. A computer-readable storage medium comprises a first set of codes for causing a computer to detect a grant or assignment on a control channel. A second set of codes causes the computer to verify a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity. A third set of codes causes the computer to transmit or receiving in accordance with the payload on the control channel in response to a determination that the constraint on the portion of a payload is verified.

[0017] In another additional aspect, an apparatus is provided for receiving a scheduling indication. Means are provided for detecting a grant or assignment on a control channel. Means are provided for verifying a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity. Means are provided for transmitting or receiving in accordance with the payload on the control channel in response to a determination that the constraint on the portion of a payload is verified.

[0018] In a further aspect, an apparatus is provided for receiving a scheduling indication. A receiver detects a grant or assignment on a control channel. A computing platform verifies a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity. A transmitter and the receiver transmits or receives in accordance with the payload on the control channel in response to a determination that the constraint on the portion of a payload is verified.

[0019] In yet one aspect, a method is provided for transmitting a scheduling indication. A control channel payload is encoded for indicating a grant or assignment. A constraint is imposed on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity. A grant or assignment comprising the payload is transmitted on a control channel.

[0020] In yet another aspect, at least one processor is provided for transmitting a scheduling indication. A first module encodes a control channel payload for indicating a grant or assignment. A second module imposes a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity. A third module transmits a grant or assignment comprising the payload on a control channel.

[0021] In yet an additional aspect, a computer program product is provided for transmitting a scheduling indication. A computer-readable storage medium comprises a set first of codes for causing a computer to encode a control channel payload for indicating a grant or assignment. A second set of codes causes the computer to impose a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity. A third set of codes causes the computer to transmit a grant or assignment comprising the payload on a control channel.

[0022] In yet another additional aspect, an apparatus is provided for transmitting a scheduling indication. Means are provided for encoding a control channel payload for indicating a grant or assignment. Means are provided for imposing a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity. Means are provided for transmitting a grant or assignment comprising the payload on a control channel.

[0023] In yet a further aspect, an apparatus is provided for transmitting a scheduling indication. A computing platform encodes a control channel payload for indicating a grant or assignment. The computing platform imposes a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity. A transmitter transmits a grant or assignment comprising the payload on a control channel.

[0024] To the accomplishment of the foregoing and related ends, one or more aspects comprise the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth in detail certain illustrative aspects and are indicative of but a few of the various ways in which the principles of the aspects may be employed. Other advantages and novel features will become apparent from the following detailed description when considered in conjunction with the drawings and the disclosed aspects are intended to include all such aspects and their equivalents.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The features, nature, and advantages of the present disclosure will become more apparent from the detailed description set forth below when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

[0026] FIG. 1 depicts a block diagram of a communication system employing a augmented cyclic redundancy checking ("virtual" CRC);

[0027] FIG. 2 depicts a block diagram of a communication system including an evolved Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access Network (E-UTRAN) that incorporates an augmented cyclic redundancy checking for random access responses capability between at last one radio access network user equipment;

[0028] FIG. 3 depicts a diagram of a communication system incorporating a legacy General Packet Radio Service (GPRS) core and an evolved packet core supporting augmented cyclic redundancy checking in random access responses;

[0029] FIG. 4 depicts a diagram of a multiple access wireless communication system according to one aspect for augmented cyclic redundancy checking in random access responses;

[0030] FIG. 5 depicts a schematic block diagram of a communication system for supporting augmented cyclic redundancy checking in random access responses;

[0031] FIG. 6 depicts a flow diagram of a methodology for transmitting augmented CRC (cyclic redundancy check) in an LTE (Long Term Evolution) PDCCH for SPS;

[0032] FIG. 7 depicts a flow diagram of a methodology 700 is depicted for receiving augmented CRC in LTE PDCCH (physical downlink control channel) for SPS at the UE;

[0033] FIG. 8 depicts a methodology comprising a set of conditions (constraint rules) for uplink (UL) SPS grants;

[0034] FIG. 9 depicts a methodology for evaluating constraints rules for UL SPS grants at the UE;

[0035] FIG. 10 depicts a methodology comprised of a set of rules used by an evolved base node (eNB) for downlink (DL) compact;

[0036] FIG. 11, a methodology 1100 utilizes an illustrative set of constraint rules used by eNB for SIMO (Single Input Multiple Output) DL;

[0037] FIG. 12 depicts a methodology comprising a set of rules used by eNB for MIMO (multiple input multiple output) DL;

[0038] FIG. 13 illustrates a block diagram of an access terminal having modules for receiving augmented cyclic redundancy checking in random access responses; and

[0039] FIG. 14 illustrates a block diagram of an access node having modules for transmitting augmented cyclic redundancy checking in random access responses;

DETAILED DESCRIPTION

[0040] A scheduled data communication system of an access node and terminal supports recurring communications of small data amounts such as Voice over IP (VoIP). In order to make error checking more robust in a random access response (RAR), such as for semi-persistent scheduling (SPS) for VoIP, a portion of a grant or assignment payload has a constraint imposed that can be verified as a condition precedent to determining a valid grant or assignment rather than only relying upon a validity check field, such as a cyclic redundancy check (CRC). Thereby, incorrect validation of a grant or assignment is avoided for dynamic scheduling or for semi-persistent scheduling, the latter causing a persistent error. . Because a validation is performed on a portion of a payload, the constrained portion of payload may also be referred to as 'virtual CRC'.

[0041] As used in this application, the terms "component", "module", "system", and the like are intended to refer to a computer-related entity, either hardware, a combination of hardware and software, software, or software in execution. For example, a component may be, but is not limited to being, a process running on a processor, a processor, an object, an executable, a thread of execution, a program, and/or a computer. By way of illustration, both an application running on a server and the server can be a component. One or more components may reside within a process and/or thread of execution and a component may be localized on one computer and/or distributed between two or more computers.

[0042] The word "exemplary" is used herein to mean serving as an example, instance, or illustration. Any aspect or design described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects or designs.

[0043] Furthermore, the one or more versions may be implemented as a method, apparatus, or article of manufacture using standard programming and/or engineering techniques to produce software, firmware, hardware, or any combination thereof to control a computer to implement the disclosed aspects. The term "article of manufacture" (or alternatively, "computer program product") as used herein is intended to encompass a computer program accessible from any computer-readable device, carrier, or media. For example, computer readable media can include but are not limited to magnetic storage devices (*e.g.*, hard disk, floppy disk, magnetic strips…), optical disks (*e.g.*, compact disk (CD), digital versatile disk (DVD)…), smart cards, and flash memory devices (*e.g.*, card, stick). Additionally it should be appreciated that a carrier wave can be employed to carry computer-readable electronic data such as those used in transmitting and receiving electronic mail or in accessing a network such as the Internet or a local area network (LAN). Of course, those skilled in the art will recognize many modifications may be made to this configuration without departing from the scope of the disclosed aspects.

[0044] Various aspects will be presented in terms of systems that may include a number of components, modules, and the like. It is to be understood and appreciated that the various systems may include additional components, modules, *etc.* and/or may not include all of the components, modules, *etc.* discussed in connection with the figures. A combination of these approaches may also be used. The various aspects disclosed herein can be performed on electrical devices including devices that utilize touch screen display technologies and/or mouse-and-keyboard type interfaces. Examples of such devices include computers (desktop and mobile), smart phones, personal digital assistants (PDAs), and other electronic devices both wired and wireless.

[0045] Various aspects are now described with reference to the drawings. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of one or more aspects. It may be evident, however, that the various aspects may be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form in order to facilitate describing these aspects.

[0046] Referring initially to **FIG. 1**, a communication system **100** of an access node (AN) **102** communicates via an over-the-air (OTA) link **104** with an access terminal (AT) **106**, also referred herein as user equipment (UE), in a fully scheduled manner on both a downlink (DL) **108** and an uplink (UL) **110** for dynamic scheduling, the latter depicted in particular as a dynamically scheduled uplink **112**. The AT **106** is advantageously capable of transmitting on the UL **110** with semi-persistent scheduling (SPS) on an SPS uplink **114**. In anticipation of a talk spurt for VoIP communication (e.g., an SPS request on a random access channel (RACH) **116**), for instance, the AN **102** can present an indication for SPS (e.g., DL assignment, UL grant) as part of a message **118** on a physical downlink control channel (PDCCH) **120**. The message **118** comprises a PDCCH payload **122** and a check field, depicted as a 16-bit CRC (cyclic redundancy check) **124**.

[0047] Some types of communication lend themselves to semi-persistent scheduling (SPS), such as VoIP. The recurring nature but relatively small amounts of data transmitted warrant a relaxation in the overhead of fully scheduling the uplink transmissions. Advantageously the AN **102** utilizes a grant/assignment encoder **126** and the AT **106** utilizes a grant/assignment decoder **128** that incorporate a more robust check encoding/decoding that used for conventional dynamic or SPS scheduling. In particular, an augmented check **130** is achieved by applying a constraint **132** to the PDCCH payload **122** in conjunction with or as a condition precedent to determining validity based upon the CRC **124**. Thereby, the probability of a false positive validity determination can be substantially reduced.

[0048] It should be appreciated with the benefit of the present disclosure that the exemplary versions described herein utilize a grant or assignment on a downlink control channel that has particular advantages on an uplink channel and for semi-persistent scheduling. However, applications consistent with aspects of the present innovation can be applied to validity checking for a message received on an uplink and also for dynamic scheduling as well.

[0049] In **FIG. 2**, in one aspect, a communication system **200** includes an evolved Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access Network (E-UTRAN) **212** that incorporates an augmented cyclic redundancy checking for random access responses capability **214** between at last one radio access network (RAN), depicted as an evolved base node (eNode B) **216** and a user equipment (UE) device 218. In the illustrative version, the UE device **218** is being dynamically

scheduled via downlink (DL) **220** for communication on an uplink (UL) **222**. The E-TRAN **212** also includes eNode Bs **226**, **228**.

[0050] The eNode Bs **216, 226**, **228** provide an UMTS Terrestrial Radio Access (E-UTRA) user plane and control plane (RRC) protocol terminations towards the UEs **218**. The user plane can comprise of 3GPP (3rd Generation Partnership Project) Packet Data Convergence Protocol (PDCP), radio link control (RLC), medium access control (MAC) and physical layer control (PHY). The eNode Bs **216**, **226**, **228** are interconnected with each other by means of X2 interface ("X2"). The eNode Bs **216**, **226**, **228** are also connected by means of an S1 interface ("S1") to an EPC (Evolved Packet Core), more specifically to mobility management entities/ serving gateways (MME/S-GW) **230**, **232** connected to a data packet network **234**. The S1 interface supports a many-to-many relation between MMEs/S-GW **226**, **228** and eNode Bs **216**, **226**, **228**.

[0051] The eNode Bs **216**, **226**, **228** hosts the following functions: radio resource management: radio bearer control, radio admission control, connection mobility control, dynamic allocation of resources to UEs in both uplink and downlink (scheduling); IP header compression and encryption of user data stream; selection of an MME at UE attachment; routing of user plane data towards serving gateway; scheduling and transmission of paging messages (originated from the MME); scheduling and transmission of broadcast information; and measurement and measurement reporting configuration for mobility and scheduling.

[0052] The MME hosts the following functions: distribution of paging messages to the eNodes Bs **216**, **226**, **228**; security control; idle state mobility control; System Architecture Evolution (SAE) bearer control; ciphering and integrity protection of Non-Access Stratum (NAS) signaling. The Serving Gateway hosts the following functions termination of U-plane packets for paging reasons and switching of U-plane for support of UE mobility.

[0053] The DL **220** from the eNode B **216** includes a plurality of communication channels relevant to download allocation that should be mapped to uplink location(s) for ACK discussed below, including a Physical Downlink Control Channel (PDCCH) **236**, Physical Random Access Channel (PRACH) **242**, and a semi-persistently scheduled communication channel depicted as Voice over IP (VoIP) **244**. Mitigating any likelihood of a CRC being found correct when the data is in error, the eNB **216** has a

random access response (RAR) Uplink (UL) grant with augmented CRC encoder **246**. Similar, the UE **218** has an RAR UL Grant with Augmented CRC decoder **248**.

[0054] Three different types of physical (PHY) channels are defined for the LTE downlink **220**. One common characteristic of physical channels is that they all convey information from higher layers in the LTE stack. This is in contrast to physical signals, which convey information that is used exclusively within the PHY layer.

[0055] LTE DL physical channels are Physical Downlink Shared Channel (PDSCH), Physical Downlink Control Channel (PDCCH) 236, and Common Control Physical Channel (CCPCH) (not shown). Physical channels map to transport channels, which are service access points (SAPs) for the L2/L3 layers. Each physical channel has defined algorithms for bit scrambling, modulation, layer mapping, cyclic delay diversity (CDD) precoding, resource element assignment; layer mapping and pre-coding are related to MIMO applications. A layer corresponds to a spatial multiplexing channel.

[0056] A Broadcast Channel (BCH) has a fixed format and is broadcast over an entire coverage area of a cell. A Downlink Shared Channel (DL-SCH) supports Hybrid Automatic Repeat-reQuest (HARQ), supports dynamic link adaption by varying modulation, coding and transmit power, is suitable for transmission over entire cell coverage area, is suitable for use with beamforming, supports dynamic and semi-static resource allocation, and supports discontinuous receive (DRX) for power save. A Paging Channel (PCH) supports UE DRX, requires broadcast over entire cell coverage area, and is mapped to dynamically allocated physical resources. A Multicast Channel (MCH) is required for broadcast over entire cell coverage area, supports Multicast/broadcast – single frequency network (MB-SFN), supports semi-static resource allocation. Supported transport channels are Broadcast channel (BCH), Paging channel (PCH), Downlink shared channel (DL-SCH), and Multicast channel (MCH). Transport channels provide the following functions: structure for passing data to/from higher layers, a mechanism by which higher layers can configure the PHY status indicators (packet error, CQI etc.) to higher layers, and support for higher-layer peer-to-peer signaling. Transport channels are mapped to physical channels as follows: BCH maps to CCPCH, although mapping to PDSCH under consideration. PCH and DL-SCH maps to PDSCH. MCH may be mapped to PDSCH.

[0057] In **FIG. 3**, in another aspect, a communication system **300** that can encompass the communication systems **100**, **200** of **FIGS. 1-2** includes support for interfacing an evolved packet core **302** via an interface S4 with a legacy General Packet Radio Service (GPRS) core **304**, whose Serving GPRS Support Node (SGSN) **306** is interfaced in turn by a Gb interface to a Global System for Mobile Communications (GSM)/Edge Radio Access Network (GERAN) **308** and via an lu interface to a UTRAN **310**. The S4 provides the user plane with related control and mobility support between GPRS Core **304** and a 3GPP Anchor **312** of an Inter Access Stratum Anchor (IASA) **314** and is based on a Gn reference point as defined between SGSN **306** and Gateway GPRS Serving/Support Node (GGSN) (not shown). The IASA **314** also includes a system architecture evolved (SAE) anchor **316** interfaced to the 3GPP anchor **312** by an S5b interface that provides the user plane with related control and mobility support. The 3GPP anchor **312** communicates with an MME UPE **318** via interface S5a. Mobility Management entity (MME) pertains to distribution of paging messages to the eNBs and User Plane Entity (UPE) pertains to IP header compression and encryption of user data streams, termination of U-plane packets for paging reasons, and switching of U-plane for support of UE mobility. The MME UPE 318 communicates via interface S1 to an evolved RAN **320** for wirelessly communicating with UE devices **322**.

[0058] An S2b interface provides the user plane with related control and mobility support between the SAE Anchor **316** and an evolved Packet Data Gateway (ePDG) **324** of a wireless local access network (WLAN) 3GPP IP Access component **326** that also includes a WLAN Access network (NW) **328**. An SGi interface is the reference point between the Inter AS Anchor **316** and a packet data network **330**. Packet data network **330** may be an operator external public or private packet data network or an intra operator packet data network, e.g. for provision of IP Multimedia Subsystem (IMS) services. This SGi reference point corresponds to Gi and Wi functionalities and supports any 3GPP and non-3GPP access systems. An Rx+ interface provides communication between the packet data network **330** and a policy and charging rules function (PCRF) **332**, which in turn communicates via an S7 interface to the evolved packet core **302**. The S7 interface provides transfer of (QoS) policy and charging rules from PCRF **332** to Policy and Charging Enforcement Point (PCEP) (not shown). An S6 interface (i.e., AAA interface) enables transfer of subscription and authentication data for authenticating/authorizing user access by interfacing the evolved packet core **302** to a

home subscriber service (HSS) **334**. An S2a interface provides the user plane with related control and mobility support between a trusted non 3GPP IP access **336** and the SAE Anchor **316**.

[0059] It should be appreciated that wireless communication systems are widely deployed to provide various types of communication content such as voice, data, and so on. These systems may be multiple-access systems capable of supporting communication with multiple users by sharing the available system resources (e.g., bandwidth and transmit power). Examples of such multiple-access systems include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, 3GPP LTE systems, and orthogonal frequency division multiple access (OFDMA) systems.

[0060] 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-signal-out or a multiple-in-multiple-out (MIMO) system.

[0061] A MIMO system employs multiple (N_T) transmit antennas and multiple (N_R) receive antennas for data transmission. A MIMO channel formed by the N_T transmit and N_R receive antennas may be decomposed into N_S independent channels, which are also referred to as spatial channels, where $N_S \leq \min\{N_T, N_R\}$. Each of the N_S independent channels corresponds to a dimension. The MIMO system can provide improved performance (e.g., higher throughput and/or greater reliability) if the additional dimensionalities created by the multiple transmit and receive antennas are utilized.

[0062] A MIMO system supports a time division duplex (TDD) and frequency division duplex (FDD) systems. In a TDD system, the forward and reverse link transmissions are on the same frequency region so that the reciprocity principle allows the estimation of the forward link channel from the reverse link channel. This enables the access point to extract transmit beamforming gain on the forward link when multiple antennas are available at the access point.

[0063] Referring to **FIG. 4**, a multiple access wireless communication system according to one aspect is illustrated. An access point **350** (AP) includes multiple antenna groups, one including **354** and **356**, another including **358** and **360**, and an additional including **362** and **364**. In **FIG. 4**, only two antennas are shown for each antenna group, however, more or fewer antennas may be utilized for each antenna group. Access terminal (AT) **366** is in communication with antennas **362** and **364**, where antennas **362** and **364** transmit information to access terminal **366** over forward link **370** and receive information from access terminal **366** over reverse link **368**. Access terminal **372** is in communication with antennas **356** and **358**, where antennas **356** and **358** transmit information to access terminal **372** over forward link **376** and receive information from access terminal **372** over reverse link **374**. In a FDD system, communication links **368**, **370**, **374** and **376** may use different frequency for communication. For example, forward link **370** may use a different frequency then that used by reverse link **368**. 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 **350**. In the aspect, antenna groups each are designed to communicate to access terminals **366**, **372** in a sector of the areas covered by access point **350**.

[0064] In communication over forward links **370** and **376**, the transmitting antennas of access point **350** utilize beamforming in order to improve the signal-to-noise ratio of forward links for the different access terminals **366** and **374**. 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.

[0065] An access point **350** may be a fixed station used for communicating with the terminals and may also be referred to as an access point, a Node B, or some other terminology. An access terminal **366**, **372** may also be called user equipment (UE), a wireless communication device, terminal, access terminal or some other terminology.

[0066] **FIG. 5** is a block diagram of an aspect of a transmitter system **410** (also known as the access point) and a receiver system **450** (also known as access terminal) in a MIMO system **400**. At the transmitter system **410**, traffic data for a number of data streams is provided from a data source **412** to a transmit (TX) data processor **414**.

[0067] In an aspect, each data stream is transmitted over a respective transmit antenna. TX data processor **414** 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.

[0068] 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 **430**.

[0069] The modulation symbols for all data streams are then provided to a TX MIMO processor **420**, which may further process the modulation symbols (e.g., for OFDM). TX MIMO processor **420** then provides N_T modulation symbol streams to N_T transmitters (TMTR) **422a** through **422t**. In certain implementations, TX MIMO processor **420** applies beamforming weights to the symbols of the data streams and to the antenna from which the symbol is being transmitted.

[0070] Each transmitter **422** 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 **422a** through **422t** are then transmitted from N_T antennas **424a** through **424t**, respectively.

[0071] At receiver system **450**, the transmitted modulated signals are received by N_R antennas 452a through 452r and the received signal from each antenna **452** is provided to a respective receiver (RCVR) **454a** through **454r**. Each receiver **454** 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.

[0072] An RX data processor **460** then receives and processes the N_R received symbol streams from N_R receivers **454** based on a particular receiver processing technique to provide N_T "detected" symbol streams. The RX data processor **460** then

demodulates, deinterleaves, and decodes each detected symbol stream to recover the traffic data for the data stream. The processing by RX data processor **460** is complementary to that performed by TX MIMO processor 420 and TX data processor **414** at transmitter system **410**.

[0073] A processor **470** periodically determines which pre-coding matrix to use (discussed below). Processor **470** formulates a reverse link message comprising a matrix index portion and a rank value portion.

[0074] 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 **438**, which also receives traffic data for a number of data streams from a data source **436**, modulated by a modulator **480**, conditioned by transmitters **454a** through **454r**, and transmitted back to transmitter system **410**.

[0075] At transmitter system 410, the modulated signals from receiver system **450** are received by antennas **424**, conditioned by receivers **422**, demodulated by a demodulator **440**, and processed by a RX data processor **442** to extract the reserve link message transmitted by the receiver system **450**. Processor **430** then determines which pre-coding matrix to use for determining the beamforming weights then processes the extracted message.

[0076] In an aspect, logical channels are classified into Control Channels and Traffic Channels. Logical Control Channels comprises Broadcast Control Channel (BCCH), which is DL channel for broadcasting system control information. Paging Control Channel (PCCH), which is DL channel that transfers paging information. Multicast Control Channel (MCCH) which is Point-to-multipoint DL channel used for transmitting Multimedia Broadcast and Multicast Service (MBMS) scheduling and control information for one or several MTCHs. Generally, after establishing RRC connection this channel is only used by UEs that receive MBMS (Note: old MCCH+MSCH). Dedicated Control Channel (DCCH) is Point-to-point bi-directional channel that transmits dedicated control information and used by UEs having an RRC connection. In aspect, Logical Traffic Channels comprises a Dedicated Traffic Channel (DTCH), which is Point-to-point bi-directional channel, dedicated to one UE, for the

transfer of user information. In addition, a Multicast Traffic Channel (MTCH) for Point-to-multipoint DL channel for transmitting traffic data.

[0077] In an aspect, Transport Channels are classified into DL and UL. DL Transport Channels comprises a Broadcast Channel (BCH), Downlink Shared Data Channel (DL-SDCH) and a Paging Channel (PCH), the PCH for support of UE power saving (DRX cycle is indicated by the network to the UE), broadcasted over entire cell and mapped to PHY resources which can be used for other control/traffic channels. The UL Transport Channels comprises a Random Access Channel (RACH), a Request Channel (REQCH), an Uplink Shared Data Channel (UL-SDCH) and plurality of PHY channels. The PHY channels comprise a set of DL channels and UL channels.

[0078] The DL PHY channels comprises: Common Pilot Channel (CPICH); Synchronization Channel (SCH); Common Control Channel (CCCH); Shared DL Control Channel (SDCCH); Multicast Control Channel (MCCH); Shared UL Assignment Channel (SUACH); Acknowledgement Channel (ACKCH); DL Physical Shared Data Channel (DL-PSDCH); UL Power Control Channel (UPCCH); Paging Indicator Channel (PICH); Load Indicator Channel (LICH); The UL PHY Channels comprises: Physical Random Access Channel (PRACH); Channel Quality Indicator Channel (CQICH); Acknowledgement Channel (ACKCH); Antenna Subset Indicator Channel (ASICH); Shared Request Channel (SREQCH); UL Physical Shared Data Channel (UL-PSDCH); Broadband Pilot Channel (BPICH).

[0079] In **FIG. 6**, a methodology **600** is depicted for transmitting augmented CRC in an LTE (Long Term Evolution) PDCCH for SPS. At the eNB, a determination is made that SPS is warranted (block **602**), and if not the methodology exits (block **604**) continuing to perform dynamic scheduling. If warranted, then SPS constraint rules for PDCCH payload are accessed (block **606**). These constraint rules are applied on the PDCCH payload in order to augment validity checking at the UE (block **608**). The PDCCH payload is then computer for CRC and the CRC is added to the payload (block **610**).

[0080] In **FIG. 7**, a methodology **700** is depicted for receiving augmented CRC in LTE PDCCH for SPS at the UE. If false alarm PDCCH SPS grant is decoded as an uplink grant, the UE will repeatedly transmit on some random resources every serving interval. UE will look for Ack/Nak feedback on PHICH and will randomly decode an

Ack or Nak. If Nak is decoded UE will keep on retransmitting on a resource that it does not own. This transmission may collide with other UL-SCH transmissions and therefore hurt system throughput. The corresponding VoIP frames from the UE experiencing false alarm get lost on the air, eNB is not trying to decode them, and UE may receive Ack for them. eNB cannot find out which UE is jamming, because it does not know what to look for.

[0081] As discussed above, false alarm grants can have quite serious consequences when semi persistent scheduling is used. Advantageously, the disclosed innovations can be made to discriminate false alarms from authentic grants. Standardizing a set of rules can dictate if a grant that indicate SPS is authentic or false alarm. In this description we focus on the uplink, because the consequences of uplink jamming are more severe than the consequences of false alarm on the downlink, although it should be appreciated that aspects disclosed herein can be applied to the downlink.

[0082] Continuing with **FIG. 7**, the UE receives a message on PDCCH (block **702**). This message can be power control **704**, uplink (UL) grant **706**, compact downlink (DL) assignment **708**, DL assignment **710** for a SIMO (single input multiple output) UE, DL assignment **712** for a MIMO (multiple input multiple output) UE. In block **714**, the type of PDCCH message is determined. A determination is made as to whether this PDCCH message is a semi-persistent scheduling (SPS) grant (block **716**), if not the methodology **700** exits at **718**. If SPS is indicated, then the UE performs augmented SPS grant/assignment validity checking as depicted at **720**.

[0083] In block **722**, constraint rule(s) are accessed for the type of PDCCH message. In an exemplary aspect, an illustrative format of PDCCH for UL grants is indicated in TABLE 1.

Format 0 – UL-SCH assignments	N_RB = 25	N_RB = 50	N_RB = 100	
Field	**Bit-Width**	**Bit-Width**	**Bit-Width**	**Notes**
Flag format0/format1A differentiation	1	1	1	
Hopping flag	1	1	1	
Resource allocation & explicit hopping	9	11	13	Starting RB & number of consecutive RBs
MCS	5	5	5	32 levels of MCS (compute TBS from RB assignment

NDI	1	1	1	Separate new data indicator (1 bit). New data transmissions transmitted with RV=0. Other RVs indicated with 3 reserved MCS values for scheduled re-transmissions
TPC	2	2	2	TPC command for PUSCH
Cyclic shift for DM RS	3	3	3	Necessary for SDMA (less than 8 users)
UL index (TDD only)	0	0	0	Indicate which subframe(s) the grant is valid for. Necessary for TDD. Bit width depends on DL/UL allocation
Aperiodic CQI request	1	1	1	
CRC	16	16	16	CRC masked by UE MAC ID
Total:	39	41	43	

TABLE 1. PDCCH Formats and Contents – Format 0 for UL Grants.

[0084] In an aspect, as depicted at block **724**, a determination is made if the constraint rule(s) are satisfied. Restrictions or constraints on the possible formats of SPS PDCCH provide an augmentation for CRC validity checking (virtual CRC). If satisfied, then a computed validity check value (X-CRC) is determined for the PDDCH message payload (block **726**). Then a determination is made as to whether the computed validity check value (X-CRC) matches the appended CRC (block **728**). If so, then in block **730 the** eNB transmits only the allowed SPS PDCCH grants. Thus, with reference back at block **724**, the UE ignores SPS PDCCH grants that do not meet the rules. This augmented checking ensures that more false alarms SPS PDCCH grants are ignored by UE.

[0085] In exemplary aspect, the following eNB constraint rules can be used.

In **FIG. 8**, a methodology **800** can comprise a set of conditions (constraint rules) for UL SPS grants. The eNB can satisfy constraints rules as follows:

(a) Set format flag to UL grant (1bit) (block **802**);

(b) Set NDI to a defined value (new transmission) (1 bit) (block **804**);

(c) Set Aperiodic CQI to a defined value (e.g., Aperiodic CQI not reported) (1 bit) (block **806**);

(d) Resource allocation must allocate less than a defined fractions of the bandwidth (1 bit) (block **808**);

(e) Possible restrict MCS, such that the highest modulation is not used (1 bit) (block **810**);

(f) The transmit power control (TPC) command must be set to a pre-defined value (2

bits) (block **812**); and

(g) The cyclic shift for demodulation reference signal (DM-RS) must be set to a pre-defined value (3 bits) (block **814**).

If not satisfied, then the UE does not continue evaluating the PDCCH SPS for validity based solely on CRC.

[0086] Similarly, in FIG. 9, a methodology **900** is depicted for evaluating constraints rules for UL SPS grants at the UE. It should be appreciated that the UE can determine whether the PDCCH is otherwise indicating dynamic scheduling rather than semi-persistent scheduling. After figuring that a grant is a SPS grant, the UE obeys the SPS grant only if for UL grants a set of rules is matched such as for example: (a) The format flag indicates UL grant (block **902**); (b) The NDI is set to the defined value (new transmission) (block **904**); (c) The Aperiodic CQI is set to the defined value (e.g., Aperiodic CQI not reported) (block **906**); (d) The Resource allocation is valid, i.e. it does not allocate more than the defined fraction of the bandwidth (block **908**); and (e) The MCS is a valid MCS for SPS, given the restrictions (block **910**).

[0087] These rules constrain 5 bits on the PDCCH payload bits. Therefore the technique above is similar to extending the PDCCH CRC to 21 bits for SPS grants.

[0088] While false alarms on downlink grants have less serious consequences, similar techniques can be applied. There are three formats for downlink grants, the compact DL (See TABLE 2), the SIMO DL (See TABLE 3) and the MIMO DLA (See TABLE 4).

Format 1A – Compact DL-SCH assignments	N_RB = 25	N_RB = 50	N_RB = 100	
Field	**Bit-Width**	**Bit-Width**	**Bit-Width**	**Notes**
Flag format0/format1A differentiation	1	1	1	
Distributed transmission flag	1	1	1	
Resource allocation	9	11	13	Starting VRB & number of consecutive VRBs
MCS	5	5	5	32 levels of MCS (compute TBS from RB assignment. Reduction in number of bits for MCS in FFS.
HARQ process id	3	3	3	HARQ process ID derived from the subframe ID (4b for TDD)
Retransmission sequence number	3	3	3	Separate new data indicator (1 bit) & redundancy versions (2 bits)

TPC	2	2	2	TPC command for PUCCH
CRC	16	16	16	CRC masked by UE MAC ID
Total:	40	42	44	

TABLE 2. PDCCH Formats and Contents – Format 1A for compact DL assignments.

[0089] In **FIG. 10**, an illustrative set of rules used by eNB for DL compact is depicted as methodology **1000**: (1) set to format 1A (TABLE 1) (block **1002**); (2) Distributed transmission flag indicates not distributed (block **1004**); (3) Resource allocation must allocate less than a defined fractions of the bandwidth (1-bit) (block **1006**); (4) Possible restrict MCS, such that the highest modulation is not used (1 bit) (block **1008**); and (5) Retransmission sequence number indicates a first HARQ transmission (3 bits) (block **1010**).

Format 1 –DL-SCH assignments for SIMO	N_RB = 25	N_RB = 50	N_RB = 100	
Field	**Bit-Width**	**Bit-Width**	**Bit-Width**	**Notes**
Resource allocation header	1	1	1	Indication of resource allocation type 0 or type 1
Resource allocation	13	17	25	Bitmap with allocation for type 0, set indication & bitmap therein for type 1
MCS	5	5	5	32 levels of MCS (compute TBS from RB assignment.
HARQ process id	3	3	3	Maximum 8 HARQ processes
Retransmission sequence number	3	3	3	Separate new data indicator (1 bit) & redundancy versions (2 bits)
TPC	2	2	2	TPC command for PUCCH
CRC	16	16	16	CRC masked by UE MAC ID
Total:	43	49	55	

TABLE 3. PDCCH Formats and Contents – Format 1 for DL assignments in SIMO.

[0090] In FIG. 11, a methodology **1100** utilizes an illustrative set of constraint rules used by eNB for SIMO (Single Input Multiple Output) DL in accordance to a Format 1 of TABLE 3: (1) Distributed transmission flag indicates not distributed (block **1102**); (2) Resource allocation allocates less than a pre-defined fraction of the bandwidth (1 bit) (block **1104**); (3) Possible restrict MCS, such that the highest modulation is not used (1 bit) (block **1106**); (4) Retransmission sequence number indicates a first HARQ transmission (3 bits) (block **1108**).

[0091] As a first exemplary option, consider the following set of rules used by eNB for MIMO DL: In an exemplary aspect, MIMO DL cannot be used with SPS, thus the UE disregards any PDCCH indicating SPS and MIMO.

Format 2–DL-SCH assignments for MIMO	N_RB = 25	N_RB = 50	N_RB = 100	
Field	**Bit-Width**	**Bit-Width**	**Bit-Width**	**Notes**
Resource allocation header	1	1	1	Indication of resource allocation type 0 or type 1
Resource allocation	13	17	25	Bitmap with allocation for type 0, set indication & bitmap therein for type 1
TPC	2	2	2	TPC command for PUCCH
HARQ process ID	3	3	3	3bits for FDD, 4 bits for TDD
HARQ swap flag	1	1	1	
MCS first Transport Block (TrBlk)	5	5	5	32 levels of MCS (compute TBS from RB assignment.
Retransmission sequence number 1st TrBlk	3	3	3	Separate new data indicator (1 bit) & redundancy versions (2 bits)
MCS second TrBlk	5	5	5	***FFS if possible to reduce to 3 bits by interpretation together with MCS for first CW***
Retransmission sequence number second TrBlk	3	3	3	Separate new data indicator (1 bit) & redundancy versions (2 bits)
Precoding information	3	3	3	Precoding matrix (4 bits for 4 Tx, 1-3 bits for 2 Tx), FFS if this field can be removed & semi-static configuration is used instead
CRC	16	16	16	CRC masked by UE MAC ID
Total:	55	59	67	

TABLE 4. PDCCH Formats and Contents – Format 2 for DL assignments in MIMO.

[0092] In **FIG. 12**, as a second exemplary option, consider the following set of constraint rules depicted as a methodology **1200** comprising the following set of rules used by eNB for MIMO DL of TABLE 4: (1) Distributed transmission flag indicates not distributed (block **1202**); (2) Resource allocation must allocate less than a defined fractions of the bandwidth (1 bit) (block **1204**); (3) Possible restrict MCS for each of the two transport blocks, such that the highest modulation is not used (1 bit) (block **1206**); and (4) Retransmission sequence number indicates a first HARQ transmission (3 bits) for first and second transport block (block **1208**).

[0093] In **FIG. 13**, an access terminal (e.g., user equipment) **600** has computing platform **1302** that provides means for receiving a semi-persistent scheduling indication from an access node (FIG. 14). In particular, the computing platform **1302** comprises sets of instructions or code (modules) **1304-1312** executable by a processor **1314** that also controls transmission and reception by a transceiver ("Tx/Rx") **1316**. In particular, means (module) **1304** are provided for detecting a grant for semi-persistent scheduling (SPS) on a control channel. Means (module) **1306** are provided for verifying a constraint on a portion of a payload carried on the control channel indicative of valid semi-persistent scheduling as a condition for determining payload validity. Means (module) **608** are provided for computing cyclic redundancy check (CRC) for the payload. Means (module) **610** are provided for comparing the computed cyclic redundancy check with a CRC field accompanying the payload. Means (module) **612** are provided for transmitting semi-persistent scheduled data in accordance with the validated payload. Thereby, the access node **600** provides that the verified unused control field that augments the check field to mitigate possibility of the check field indicating correct reception with an error in the random access response.

[0094] In **FIG. 14**, an access node (e.g., eNB) **1400** has computing platform **1402** that provides means for causing a computer for transmitting a semi-persistent scheduling indication for enhanced validity determination by an access terminal (e.g., user equipment). In particular, the computing platform **1402** comprises sets of instructions or code (modules) **1404-1410** executable by a processor **1414** that also controls transmission and reception by a transceiver ("Tx/Rx") **1416**. In particular, means (module) **1404** are provided for setting a grant for semi-persistent scheduling (SPS) on a control channel. Means (module) **1406** are provided for imposing a constraint on a portion of a payload carried on the control channel indicative of valid semi-persistent scheduling as a condition for determining payload validity. Means (module) **1408** are provided for computing cyclic redundancy check (CRC) for the payload. Means (module) **1410** are provided for transmitting the computed cyclic redundancy check as a CRC field accompanying the payload for granting transmission of semi-persistent scheduled data in accordance with the validated payload and CRC field by user equipment.

[0095] What has been described above includes examples of the various aspects. It is, of course, not possible to describe every conceivable combination of components or

methodologies for purposes of describing the various aspects, but one of ordinary skill in the art may recognize that many further combinations and permutations are possible. Accordingly, the subject specification intended to embrace all such alterations, modifications, and variations that fall within the spirit and scope of the appended claims.

[0096] In particular and in regard to the various functions performed by the above described components, devices, circuits, systems and the like, the terms (including a reference to a "means") used to describe such components are intended to correspond, unless otherwise indicated, to any component which performs the specified function of the described component (*e.g.*, a functional equivalent), even though not structurally equivalent to the disclosed structure, which performs the function in the herein illustrated exemplary aspects. In this regard, it will also be recognized that the various aspects include a system as well as a computer-readable medium having computer-executable instructions for performing the acts and/or events of the various methods.

[0097] In addition, while a particular feature may have been disclosed with respect to only one of several implementations, such feature may be combined with one or more other features of the other implementations as may be desired and advantageous for any given or particular application. To the extent that the terms "includes," and "including" and variants thereof are used in either the detailed description or the claims, these terms are intended to be inclusive in a manner similar to the term "comprising." Furthermore, the term "or" as used in either the detailed description of the claims is meant to be a "non-exclusive or".

[0098] Furthermore, as will be appreciated, various portions of the disclosed systems and methods may include or consist of artificial intelligence, machine learning, or knowledge or rule based components, sub-components, processes, means, methodologies, or mechanisms (e.g., support vector machines, neural networks, expert systems, Bayesian belief networks, fuzzy logic, data fusion engines, classifiers . . .). Such components, inter alia, can automate certain mechanisms or processes performed thereby to make portions of the systems and methods more adaptive as well as efficient and intelligent. By way of example and not limitation, the evolved RAN (e.g., access point, eNode B) can infer or predict when a robust or augmented check field has been employed.

[0099] In view of the exemplary systems described supra, methodologies that may be implemented in accordance with the disclosed subject matter have been described

with reference to several flow diagrams. While for purposes of simplicity of explanation, the methodologies are shown and described as a series of blocks, it is to be understood and appreciated that the claimed subject matter is not limited by the ***order*** of the blocks, as some blocks may occur in different orders and/or concurrently with other blocks from what is depicted and described herein. Moreover, not all illustrated blocks may be required to implement the methodologies described herein. Additionally, it should be further appreciated that the methodologies disclosed herein are capable of being stored on an article of manufacture to facilitate transporting and transferring such methodologies to computers. The term article of manufacture, as used herein, is intended to encompass a computer program accessible from any computer-readable device, carrier, or media.

[00100] It should be appreciated that any patent, publication, or other disclosure material, in whole or in part, that is said to be incorporated by reference herein is incorporated herein only to the extent that the incorporated material does not conflict with existing definitions, statements, or other disclosure material set forth in this disclosure. As such, and to the extent necessary, the disclosure as explicitly set forth herein supersedes any conflicting material incorporated herein by reference. Any material, or portion thereof, that is said to be incorporated by reference herein, but which conflicts with existing definitions, statements, or other disclosure material set forth herein, will only be incorporated to the extent that no conflict arises between that incorporated material and the existing disclosure material.

CLAIMS

What is claimed is:

1. A method for receiving a scheduling indication, comprising:

detecting a grant or assignment on a control channel;

verifying a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity; and

transmitting or receiving in accordance with the payload on the control channel in response to a determination that the constraint on the portion of a payload is verified.

2. The method of claim 1, further comprising taking no action if the constraint is not met even if cyclic redundancy check is met.

3. The method of claim 1, wherein the grant or assignment is for semi-persistent scheduling.

4. The method of claim 1, further comprising verifying the constraint on the portion of the payload by detecting an uplink grant flag, a new data indicator set to a pre-defined value, an aperiodic channel quality indicator set to a pre-defined value, a resource allocation allocated to less than a pre-defined fraction of bandwidth, and a restricted modulation and coding scheme that does not use highest modulations.

5. The method of claim 1, further comprising verifying the constraint on the portion of the payload by detecting an uplink grant flag.

6. The method of claim 1, further comprising verifying the constraint on the portion of the payload by detecting a new data indicator set to a pre-defined value.

7. The method of claim 1, further comprising verifying the constraint on the portion of the payload by detecting an aperiodic channel quality indicator set to a pre-defined value.

8. The method of claim 1, further comprising verifying the constraint on the portion of the payload by detecting a resource allocation allocated to less than a pre-defined fraction of bandwidth.

9. The method of claim 1, further comprising verifying the constraint on the portion of the payload by detecting a restricted modulation and coding scheme that does not use highest modulations.

10. The method of claim 1, further comprising detecting a compact downlink assignment for semi-persistent scheduling.

11. The method of claim 10, further comprising verifying the constraint on the portion of the payload by detecting a distributed transmission flag set to not indicated,

12. The method of claim 10, further comprising verifying the constraint on the portion of the payload by detecting a resource allocation allocated less than a pre-defined fraction of bandwidth.

13. The method of claim 10, further comprising verifying the constraint on the portion of the payload by detecting a restricted modulation and coding scheme that does not use a highest modulation.

14. The method of claim 10, further comprising verifying the constraint on the portion of the payload by detecting a retransmission sequence number indicating a first Hybrid Automatic Repeat-reQuest (HARQ) transmission.

15. The method of claim 10, further comprising verifying the constraint on the portion of the payload by detecting distributed transmission flag set to not indicated, a resource allocation allocated less than a pre-defined fraction of bandwidth, a restricted modulation and coding scheme that does not use a highest modulation, and a retransmission sequence number indicating a first Hybrid Automatic Repeat-reQuest (HARQ) transmission.

16. The method of claim 1, further comprising detecting a downlink assignment for single input multiple output (SIMO) semi-persistent scheduling.

17. The method of claim 16, further comprising verifying the constraint on the portion of the payload by detecting a distributed transmission flag indicating not distributed.

18. The method of claim 16, further comprising verifying the constraint on the portion of the payload by detecting a resource allocation allocated less than a pre-defined fraction of bandwidth.

19. The method of claim 16, further comprising verifying the constraint on the portion of the payload by detecting a restricted modulation and coding scheme that does not use a highest modulation.

20. The method of claim 16, further comprising verifying the constraint on the portion of the payload by detecting a retransmission sequence number indicating a first Hybrid Automatic Repeat-reQuest (HARQ) transmission.

21. The method of claim 16, further comprising verifying the constraint on the portion of the payload by detecting a distributed transmission flag indicating not distributed, a resource allocation allocated less than a pre-defined fraction of bandwidth, a restricted modulation and coding scheme that does not use a highest modulation, and a retransmission sequence number indicating a first Hybrid Automatic Repeat-reQuest (HARQ) transmission.

22. The method of claim 21, further comprising determining invalidity of the portion of the payload by detecting an indication for MIMO semi-persistent scheduling.

23. The method of claim 21, further comprising verifying the constraint on the portion of the payload by detecting a distributed transmission flag indicating not distributed.

24. The method of claim 21, further comprising verifying the constraint on the portion of the payload by detecting a resource allocation allocated less than a pre-defined fraction of bandwidth.

25. The method of claim 21, further comprising verifying the constraint on the portion of the payload by detecting a restricted modulation and coding scheme for each of two transport blocks that does not use a highest modulation.

26. The method of claim 21, further comprising verifying the constraint on the portion of the payload by detecting a retransmission sequence number indicating a first Hybrid Automatic Repeat-reQuest (HARQ) transmission.

27. The method of claim 21, further comprising verifying the constraint on the portion of the payload by detecting a distributed transmission flag indicating not distributed, a resource allocation allocated less than a pre-defined fraction of bandwidth, a restricted modulation and coding scheme for each of two transport blocks that does not use a highest modulation, and a retransmission sequence number indicating a first Hybrid Automatic Repeat-reQuest (HARQ) transmission.

28. At least one processor for receiving a scheduling indication, comprising:

a first module for detecting a grant or assignment on a control channel;

a second module for verifying a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity; and

a third module for transmitting or receiving in accordance with the payload on the control channel in response to a determination that the constraint on the portion of a payload is verified.

29. A computer program product for receiving a scheduling indication, comprising:

a computer-readable storage medium comprising,

a first set of codes for causing a computer to detect a grant or assignment on a control channel;

a second set of codes for causing the computer to verify a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity; and

a third set of codes for causing the computer to transmit or receiving in accordance with the payload on the control channel in response to a determination that the constraint on the portion of a payload is verified.

30. An apparatus for receiving a scheduling indication, comprising:

means for detecting a grant or assignment on a control channel;

means for verifying a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity; and

means for transmitting or receiving in accordance with the payload on the control channel in response to a determination that the constraint on the portion of a payload is verified.

31. An apparatus for receiving a scheduling indication, comprising:

a receiver for detecting a grant or assignment on a control channel;

a computing platform for verifying a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity; and

a transmitter and the receiver for transmitting or receiving in accordance with the payload on the control channel in response to a determination that the constraint on the portion of a payload is verified.

32. The apparatus of claim 31, further comprising the computing platform for taking no action if the constraint is not met even if cyclic redundancy check is met.

33. The apparatus of claim 31, further comprising the receiver for detecting a semi-persistent scheduling grant or assignment.

34. The apparatus of claim 31, further comprising the computing platform for verifying the constraint on the portion of the payload by detecting an uplink grant flag, a new data indicator set to a pre-defined value, an aperiodic channel quality

indicator set to a pre-defined value, a resource allocation allocated to less than a pre-defined fraction of bandwidth, or a restricted modulation and coding scheme that does not use highest modulations.

35. The apparatus of claim 31, further comprising the receiver for detecting a compact downlink assignment for semi-persistent scheduling.

36. The apparatus of claim 31, further comprising the computing platform for verifying the constraint on the portion of the payload by detecting a format indication for compact downlink SPS, distributed transmission flag set to not indicated, a resource allocation allocated less than a pre-defined fraction of bandwidth, a restricted modulation and coding scheme that does not use a highest modulation, and a retransmission sequence number indicating a first Hybrid Automatic Repeat-reQuest (HARQ) transmission.

37. The apparatus of claim 31, further comprising the receiver for detecting a downlink assignment for single input multiple output (SIMO) semi-persistent scheduling.

38. The apparatus of claim 37, further comprising the computing platform for verifying the constraint on the portion of the payload by detecting a distributed transmission flag indicating not distributed, a resource allocation allocated less than a pre-defined fraction of bandwidth, a restricted modulation and coding scheme that does not use a highest modulation, and a retransmission sequence number indicating a first Hybrid Automatic Repeat-reQuest (HARQ) transmission.

39. The apparatus of claim 31, further comprising the receiver for detecting a downlink assignment for multiple input multiple output (MIMO) semi-persistent scheduling.

40. The apparatus of claim 39, further comprising the computing platform for determining invalidity of the portion of the payload by detecting an indication for MIMO semi-persistent scheduling.

41. The apparatus of claim 39, further comprising the computing platform for verifying the constraint on the portion of the payload by detecting a distributed transmission flag indicating not distributed, a resource allocation allocated less than a pre-defined fraction of bandwidth, a restricted modulation and coding scheme for each of two transport blocks that does not use a highest modulation, and a retransmission sequence number indicating a first Hybrid Automatic Repeat-reQuest (HARQ) transmission.

42. A method for transmitting a scheduling indication, comprising:

encoding a control channel payload for indicating a grant or assignment;

imposing a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity; and

transmitting a grant or assignment comprising the payload on a control channel.

43. The method of claim 42, further comprising imposing the constraint so that no action is to be taken if cyclic redundancy check is met.

44. The method of claim 42, wherein the grant or assignment is for semi-persistent scheduling.

45. The method of claim 42, further comprising imposing the constraint on the portion of the payload by setting an uplink grant flag, a new data indicator set to a pre-defined value, an aperiodic channel quality indicator set to a pre-defined value, a resource allocation allocated to less than a pre-defined fraction of bandwidth, or a restricted modulation and coding scheme that does not use highest modulations.

46. The method of claim 42, further comprising setting a compact downlink assignment for semi-persistent scheduling.

47. The method of claim 42, further comprising imposing the constraint on the portion of the payload by setting a format indication for compact downlink SPS, distributed transmission flag set to not indicated, a resource allocation allocated less than a pre-defined fraction of bandwidth, a restricted modulation and coding scheme

that does not use a highest modulation, and a retransmission sequence number indicating a first Hybrid Automatic Repeat-reQuest (HARQ) transmission.

48. The method of claim 42, further comprising setting a downlink assignment for single input multiple output (SIMO) semi-persistent scheduling.

49. The method of claim 48, further comprising imposing the constraint on the portion of the payload by setting a distributed transmission flag indicating not distributed, a resource allocation allocated less than a pre-defined fraction of bandwidth, a restricted modulation and coding scheme that does not use a highest modulation, and a retransmission sequence number indicating a first Hybrid Automatic Repeat-reQuest (HARQ) transmission.

50. The method of claim 42, further comprising setting a downlink assignment for multiple input multiple output (MIMO) semi-persistent scheduling.

51. The method of claim 50, further comprising imposing the constraint on the portion of the payload by setting an indication for MIMO semi-persistent scheduling.

52. The method of claim 50, further comprising imposing the constraint on the portion of the payload by setting a distributed transmission flag indicating not distributed, a resource allocation allocated less than a pre-defined fraction of bandwidth, a restricted modulation and coding scheme for each of two transport blocks that does not use a highest modulation, and a retransmission sequence number indicating a first Hybrid Automatic Repeat-reQuest (HARQ) transmission.

53. At least one processor for transmitting a scheduling indication, comprising:

a first module for encoding a control channel payload for indicating a grant or assignment;

a second module for imposing a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity; and

a third module for transmitting a grant or assignment comprising the payload on a control channel.

54. A computer program product for transmitting a scheduling indication, comprising:

a computer-readable storage medium comprising,

a first set of codes for causing a computer to encode a control channel payload for indicating a grant or assignment;

a second set of codes for causing the computer to impose a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity; and

a third set of codes for causing the computer to transmit a grant or assignment comprising the payload on a control channel.

55. An apparatus for transmitting a scheduling indication, comprising:

means for encoding a control channel payload for indicating a grant or assignment;

means for imposing a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity; and

means for transmitting a grant or assignment comprising the payload on a control channel.

56. An apparatus for transmitting a scheduling indication, comprising:

a computing platform for encoding a control channel payload for indicating a grant or assignment;

the computing platform for imposing a constraint on a portion of a payload carried on the control channel indicative of valid grant or assignment as a condition for determining payload validity; and

a transmitter for transmitting a grant or assignment comprising the payload on a control channel.

57. The apparatus of claim 56, further comprising the computing platform for imposing the constraint so that no action is to be taken if cyclic redundancy check is met.

58. The apparatus of claim 56, wherein the grant or assignment is for semi-persistent scheduling.

59. The apparatus of claim 56, further comprising the computing platform for imposing the constraint on the portion of the payload by setting an uplink grant flag, a new data indicator set to a pre-defined value, an aperiodic channel quality indicator set to a pre-defined value, a resource allocation allocated to less than a pre-defined fraction of bandwidth, or a restricted modulation and coding scheme that does not use highest modulations.

60. The apparatus of claim 56, further comprising the computing platform for setting a compact downlink assignment for semi-persistent scheduling.

61. The apparatus of claim 56, further comprising the computing platform for imposing the constraint on the portion of the payload by setting a format indication for compact downlink SPS, distributed transmission flag set to not indicated, a resource allocation allocated less than a pre-defined fraction of bandwidth, a restricted modulation and coding scheme that does not use a highest modulation, and a retransmission sequence number indicating a first Hybrid Automatic Repeat-reQuest (HARQ) transmission.

62. The apparatus of claim 56, further comprising the computing platform for setting a downlink assignment for single input multiple output (SIMO) semi-persistent scheduling.

63. The apparatus of claim 62, further comprising the computing platform for imposing the constraint on the portion of the payload by setting a distributed transmission flag indicating not distributed, a resource allocation allocated less than a pre-defined fraction of bandwidth, a restricted modulation and coding scheme that does

not use a highest modulation, and a retransmission sequence number indicating a first Hybrid Automatic Repeat-reQuest (HARQ) transmission.

64. The apparatus of claim 56, further comprising the computing platform for setting a downlink assignment for multiple input multiple output (MIMO) semi-persistent scheduling.

65. The apparatus of claim 64, further comprising the computing platform for imposing the constraint on the portion of the payload by setting an indication for MIMO semi-persistent scheduling.

66. The apparatus of claim 64, further comprising the computing platform for imposing the constraint on the portion of the payload by setting a distributed transmission flag indicating not distributed, a resource allocation allocated less than a pre-defined fraction of bandwidth, a restricted modulation and coding scheme for each of two transport blocks that does not use a highest modulation, and a retransmission sequence number indicating a first Hybrid Automatic Repeat-reQuest (HARQ) transmission.