TITLE OF THE INVENTION:

AVOIDING COLLISIONS BETWEEN SEMI-PERSISTENT ALLOCATION AND DYNAMIC ALLOCATION IN RADIO ACCESS NETWORKS

BACKGROUND OF THE INVENTION:

Field of the Invention:

[0001] The present invention relates generally to communication networks. More specifically, the present invention relates to apparatuses, systems and methods for allocating resources in such networks.

Description of the Related Art:

[0002] Scheduling and resource allocation is an aspect of telecommunications technology. Developments according to the third generation partnership project (3GPP) are directed to the evolution of the radio access network. Developments according to the long term evolution of radio technology are, in some cases, directed to evolved universal terrestrial radio access networks, also known as E-UTRAN. Proposals regarding scheduling in E-UTRAN include, for example, E-UTRAN being capable of dynamically allocating resources, such as physical resource blocks (PRBs) and modulation coating schemes (MCS), to user equipment at each transmission time interval (TTI) via control channels. User equipment (UE) monitors control channels, such as L1/L2, in order to find potential allocations during downlink when downlink reception is

enabled. Furthermore, radio access networks such as E-UTRAN can allocate predefined downlink resources for transmissions, such as a first hybrid automatic repeat request (HARQ) error control to user equipment. Retransmissions can be explicitly signaled via L1/L2 control channels. If the user equipment cannot identify its cell radio network temporary identifier (C-RNTI) on the control channels in the sub-frames where the user equipment has been pre-assigned resources, a downlink transmission according to a predefined allocation is assumed. The user equipment, therefore, can sometimes perform blind decoding of the predefined resources. Otherwise, in the sub-frames where the user equipment has been pre-assigned resources, if the user equipment finds its C-RNTI on the control channels, the control channel allocation overrides the predefined allocation for the transmission time interval, and user equipment does not perform blind decoding of the predefined resources.

[0003] Regarding uplink scheduling, radio access networks such as E-UTRAN can dynamically allocate the resources to user equipment at each transmission time interval via the same channels. User equipment would typically monitor the L1/L2 control channels for possible allocation for uplink transmission when downlink reception enabled. Such activity is governed by discontinuous reception (DRX).

Additionally, radio access networks such as E-UTRAN can allocate a predefined uplink resource for the first HARQ transmissions and potential retransmissions to user equipment. In sub-frames where the user equipment has been pre-assigned resources, if the user equipment cannot find its C-RNTI on the L1/L2 control channels, uplink transmission according to a predefined allocation assigned to the user equipment in the TTI can be made. The network performs decoding of the predefined PRBs according to the predefined MCS. Otherwise, in sub-frames where the user equipment has been pre-assigned resources, if the user equipment finds its C-RNTI on the control channels, the control channel allocation overrides the predefined allocation for that TTI. As such, the user equipment transmission follows the L1/L2 control, not the predefined allocation. Retransmissions can be exemplarily allocated using the predefined allocation or explicitly allocated via L1/L2 control channels.

[0004] In both uplink and downlink configurations, the possibility of allocating predefined resources for the first HARQ transmissions was introduced to minimize signaling overhead for services that would require frequent scheduling, such as voice over internet protocol (VOIP).

[0005] As described above, two kinds of allocations are possible in E-UTRAN: dynamic allocations and predefined allocations for the first HARQ transmissions. Due to these two types of allocations, collisions may occur between predefined resources for the first HARQ transmission and resources allocated for retransmission. A "collision" occurs when two transmissions are supposed to take place in the same TTI - one following the dynamic allocation and the other following the predefined allocation. It may be desirable to avoid such collisions in communications networks.

SUMMARY OF THE INVENTION

[0006] Certain embodiments of the present invention may provide solutions to the problems and needs in the art that have not yet been fully solved by currently available communication system technologies. For example, certain embodiments of the present invention may provide a method, apparatus, system and computer program for avoiding collisions between semi-persistent allocations and dynamic allocations in radio access networks.

[0007] In one embodiment, a method may include receiving a request for retransmission from user equipment for a predetermined transmission time interval in a communication network, determining whether a collision risk exists between the retransmission and another

transmission during the predetermined time interval, and ignoring the retransmission request when the determined collision risk exists. In some embodiments, a load in the communication network may be sufficiently high that retransmission cannot be scheduled.

[0008] In another embodiment, an apparatus may include a receiving unit configured to receive a request for retransmission from user equipment for a predetermined transmission time interval in a communication network, a determining unit configured to determine whether a collision risk exists between the retransmission and another transmission during the predetermined time interval and an ignoring unit configured to ignore the retransmission request when the determining unit determines that the collision risk exists. In some embodiments, a load in the communication network may be sufficiently high that the apparatus cannot schedule retransmission. In certain embodiments, the apparatus may be an enhanced node B of the third generation partnership project.

[0009] In yet another embodiment, a method may include determining that a transmission from user equipment was unsuccessful, determining whether a retransmission will collide with a predefined resource for a predetermined transmission time interval, and transmitting an

acknowledgement to the user equipment, rather than requesting retransmission, when it is determined that the retransmission will collide with the predefined resource. In some embodiments, collisions may occur due to one or more of synchronous hybrid automatic repeat request and signaling errors in control signaling. In certain embodiments, first transmissions on the predefined allocation may be prioritized over retransmissions.

[0010] In still another embodiment, an apparatus may include a first determining unit configured to determine that a transmission from user equipment was unsuccessful, a second determining unit configured to determine whether a retransmission will collide with a predefined resource for a predetermined transmission time interval, and a transmitting unit configured to transmit an acknowledgement to the user equipment, rather than a request for retransmission, when the second determining unit determines that the retransmission will collide with the predefined resource. In some embodiments, collisions may occur due to one or more of synchronous hybrid automatic repeat request and signaling errors in control signaling. In certain embodiments, first transmissions on the predefined allocation may be prioritized over retransmissions. In certain embodiments, the apparatus

may be an enhanced node B of the third generation partnership project.

[0011] In another embodiment, a method may include receiving a request for retransmission from a node, determining that the request for retransmission collides with a predefined allocation, prioritizing a first transmission on the predefined allocation and the retransmission in accordance with a prioritization rule, and transmitting either the first transmission or the retransmission depending on the prioritization rule. In some embodiments, the prioritization rule may prioritize first transmissions on the predefined allocation over retransmissions. In some embodiments, the prioritization rule may prioritize retransmissions over first transmissions on the predefined allocation.

[0012] In yet another embodiment, an apparatus may include a receiving unit configured to receive a request for retransmission from a node, a determining unit configured to determine that the request for retransmission collides with a predefined allocation, a prioritizing unit configured to prioritize a first transmission on the predefined allocation and the retransmission in accordance with a prioritization rule, and a transmitting unit configured to transmit either the first transmission or the retransmission depending on the prioritization rule.

In some embodiments, the prioritizing unit may prioritize first transmissions on the predefined allocation over retransmissions. In some embodiments, the prioritizing unit may prioritize retransmissions over first transmissions on the predefined allocation. In certain embodiments, the apparatus may be user equipment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] In order that the advantages of certain embodiments of the invention will be readily understood, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments that are illustrated in the appended drawings. While it should be understood that these drawings depict only typical embodiments of the invention and are not therefore to be considered to be limiting of its scope, the invention will be described and explained with additional specificity and detail through the use of the accompanying drawings, in which:

[0014] Fig. 1 is a block diagram illustrating a node configured to avoid downlink collisions between dynamic and semi-persistent allocations in a communication network, in accordance with one embodiment of the present invention.

[0015] Fig. 2 is a flow chart diagram illustrating a method for avoiding downlink collisions between dynamic and semi-persistent allocations in a communication network, in accordance with one embodiment of the present invention.

[0016] Fig. 3 is a block diagram illustrating a node configured to avoid uplink collisions between dynamic and semi-persistent allocations in a communication network, in accordance with one embodiment of the present invention.

[0017] Fig. 4 is a flow chart diagram illustrating a method for avoiding uplink collisions between dynamic and semi-persistent allocations in a communication network, in accordance with one embodiment of the present invention.

[0018] Fig. 5 is a block diagram illustrating user equipment configured to prioritize first transmissions on a predefined allocation and retransmissions, in accordance with one embodiment of the present invention.

[0019] Fig. 6 is a flow diagram illustrating a method for prioritizing first transmissions on a predefined allocation and retransmissions, in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] It will be readily understood that the components of various embodiments of the present invention, as generally described and illustrated in the figures herein, may be arranged and designed in a wide variety of different configurations. Thus, the following more detailed description of the embodiments of an apparatus, system, and method of the present invention, as represented in the attached figures, is not intended to limit the scope of the invention as claimed, but is merely representative of selected embodiments of the invention.

[0021] The features, structures, or characteristics of the invention described throughout this specification may be combined in any suitable manner in one or more embodiments. For example, reference throughout this specification to "certain embodiments," "some embodiments," or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases "in certain embodiments," "in some embodiment," "in other embodiments," or similar language throughout this specification do not necessarily all refer to the same group of embodiments and the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

[0022] As discussed above, two kinds of allocations for radio access networks, such as E-UTRAN, may be utilized - dynamic allocations and predefined allocations for transmissions, such as first HARQ transmissions. However, with two kinds of allocations for the same user equipment, collisions may occur between predefined resources for the first HARQ transmission, and resources allocated for a retransmission. Certain embodiments are directed to avoiding collisions that can occur when two transmissions are intended to take place during a same transmission time interval. In particular, some embodiments are directed to avoiding collisions between a dynamic allocation and a predefined allocation.

[0023] Since only one transmission can typically take place for or from a given piece of user equipment during a given TTI, collisions should generally be avoided. Though an asynchronous HARQ may avoid many collisions through allowing nodes to freely schedule retransmissions, certain high load conditions result in nodes (such as enhanced node B, or eNB) not having the appropriate freedom to schedule a transmission appropriately. In such cases, the eNB may ignore the request from the user equipment for a downlink retransmission. In some embodiments, if a downlink retransmission cannot be scheduled in order to

avoid a collision with the predefined resource, no downlink retransmission takes place at the eNB.

[0024] Fig. 1 is a block diagram illustrating a node 100 configured to avoid downlink collisions between dynamic and semi-persistent allocations in a communication network, in accordance with one embodiment of the present invention. The node 100 includes a receiving unit 110, a determining unit 120, an ignoring unit 130, a processor 140 and memory 150. One skilled in the art will recognize that the "node" could also be embodied as a server, a router, or any other suitable network device, or combination of devices. Presenting the above-described functions as being performed by a "node" is not intended to limit the scope of the present invention in any way, but is intended to provide one example of many embodiments of the present invention. Indeed, methods, systems and apparatuses disclosed herein may be implemented in localized and distributed forms consistent with networking technology. "Memory", as discussed herein, may be, for instance, a hard disk drive, flash device, random access memory (RAM), tape, or any other such medium used to store data.

[0025] The receiving unit 110 may be configured to receive a request for retransmission from user equipment for a predetermined transmission time interval in a

communication network. The determining unit 120 may be configured to determine whether a collision risk exists between the retransmission and another transmission during the predetermined time interval. The ignoring unit 130 may be configured to ignore the retransmission request when the determining unit 120 determines that the collision risk exists. A load in the communication network may be sufficiently high that the node 100 cannot schedule retransmission. The node 100 may be an eNB of the third generation partnership project.

[0026] It should be noted that many of the functional features described in this specification have been presented as units, in order to more particularly emphasize their implementation independence. For example, a unit may be implemented as a hardware circuit comprising custom very large scale integration (VLSI) circuits or gate arrays, off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. A unit may also be implemented in programmable hardware devices such as field programmable gate arrays, programmable array logic, programmable logic devices or the like.

[0027] Units may also be at least partially implemented in software for execution by various types of processors. An identified unit of executable code may, for instance, comprise one or more physical or logical blocks of

computer instructions which may, for instance, be organized as an object, procedure, or function. Nevertheless, the executables of an identified unit need not be physically located together, but may comprise disparate instructions stored in different locations which, when joined logically together, comprise the unit and achieve the stated purpose for the unit. Units may be stored on a computer-readable medium, which may be, for instance, a hard disk drive, flash device, random access memory (RAM), tape, or any other such medium used to store data.

[0028] Indeed, a unit of executable code could be a single instruction, or many instructions, and may even be distributed over several different code segments, among different programs, and across several memory devices. Similarly, operational data may be identified and illustrated herein within units, and may be embodied in any suitable form and organized within any suitable type of data structure. The operational data may be collected as a single data set, or may be distributed over different locations including over different storage devices, and may exist, at least partially, merely as electronic signals on a system or network.

[0029] Fig. 2 is a flow chart diagram illustrating a method for avoiding downlink collisions between dynamic

and semi-persistent allocations in a communication network, in accordance with one embodiment of the present invention. In certain embodiments, the operations of the method depicted in Fig. 2 may be executed by the node 100 of Fig. 1. The method includes receiving a request for retransmission 200 from user equipment for a predetermined transmission time interval in a communication network, determining whether a collision risk exists 210 between the retransmission and another transmission during the predetermined time interval, and ignoring the retransmission request 220 when the determined collision risk exists. A load in the communication network may be sufficiently high that retransmission cannot be scheduled.

[0030] In uplink conditions, collisions in some embodiments may be more likely due to synchronous HARQ, and signaling errors in the L1/L2 control signaling. If an uplink retransmission is known to collide with a predefined resource, the eNB may acknowledge the transmission, and avoid requesting retransmission. If an eNB requests an uplink retransmission that would result in a collision with a predefined resource, the eNB may acknowledge the uplink transmissions from the user equipment, even though unsuccessful. As a result, the user equipment will not be asked to perform a

retransmission, and the collision with a first transmission on a predefined resource may be avoided.

[0031] Fig. 3 is a block diagram illustrating a node 300 configured to avoid uplink collisions between dynamic and semi-persistent allocations in a communication network, in accordance with one embodiment of the present invention. The node 300 includes a first determining unit 310, a second determining unit 320, a transmitting unit 330, a processor 340 and memory 350. The first determining unit 310 may be configured to determine that a transmission from user equipment was unsuccessful. The second determining unit 320 may be configured to determine whether a retransmission will collide with a predefined resource for a predetermined transmission time interval. The transmitting unit 330 may be configured to transmit an acknowledgement to the user equipment, rather than a request for retransmission, when the second determining unit 320 determines that the retransmission will collide with the predefined resource.

[0032] Collisions may occur due to one or more of synchronous hybrid automatic repeat request and signaling errors in control signaling. First transmissions on the predefined allocation may be prioritized over retransmissions. The node 300 may be an eNB of the third generation partnership project.

[0033] Fig. 4 is a flow chart diagram illustrating a method for avoiding uplink collisions between dynamic and semi-persistent allocations in a communication network, in accordance with one embodiment of the present invention. In certain embodiments, the operations of the method depicted in Fig. 4 may be executed by the node 300 of Fig. 3. The method includes determining that a transmission from user equipment was unsuccessful 400, determining whether a retransmission will collide with a predefined resource for a predetermined transmission time interval 410, and transmitting an acknowledgement to the user equipment 420, rather than requesting retransmission, when it is determined that the retransmission will collide with the predefined resource. Collisions may occur due to one or more of synchronous hybrid automatic repeat request and signaling errors in control signaling. First transmissions on the predefined allocation may be prioritized over retransmissions.

[0034] However, since signaling errors can occur in any event, the user equipment may still be requested to perform a retransmission although it collides with the predefined allocation. In such case, the user equipment may prioritize first transmission on the predefined allocation over retransmissions. The user equipment can therefore be configured to prioritize first transmissions

on the predefined allocation over requested retransmissions.

[0035] In some embodiments, the user equipment may be configured to prioritize retransmission to occur prior to the predefined allocation. The determination of which prioritization rule to use may depend on a particular application or the particular needs of the particular application. The implementation of a prioritization rule may be implemented in either the user equipment or in a node, such as an eNB, as appropriate.

[0036] Fig. 5 is a block diagram illustrating user equipment 500 configured to prioritize first transmissions on a predefined allocation and retransmissions, in accordance with one embodiment of the present invention. The user equipment 500 includes a receiving unit 510, a determining unit 520, a prioritizing unit 530, a transmitting unit 540, a processor 550 and memory 560. One skilled in the art will readily understand that "user equipment" may include a cellular phone, a pager, a personal data assistant (PDA), a personal computer, or any other device capable of performing the operations associated with the "user equipment" as described herein.

[0037] The receiving unit 510 may be configured to receive a request for retransmission from a node. In some

embodiments, the node may be the node 100 or the node 300 illustrated in Figs. 1 and 3, respectively. The determining unit 520 may be configured to determine that the request for retransmission collides with a predefined allocation. The prioritizing unit 530 may be configured to prioritize a first transmission on the predefined allocation and the retransmission in accordance with a prioritization rule. The transmitting unit 540 may be configured to transmit either the first transmission or the retransmission depending on the prioritization rule. The prioritizing unit 540 may prioritize first transmissions on the predefined allocation over retransmissions. The prioritizing unit 540 may also prioritize retransmissions over first transmissions on the predefined allocation.

[0038] Fig. 6 is a flow diagram illustrating a method for prioritizing first transmissions on a predefined allocation and retransmissions, in accordance with one embodiment of the present invention. In certain embodiments, the operations of the method depicted in Fig. 6 may be executed by the user equipment 500 of Fig. 5. The method includes receiving a request for retransmission from a node 600, determining that the request for retransmission collides with a predefined allocation 610, prioritizing a first transmission on the predefined

allocation and the retransmission in accordance with a prioritization rule 620, and transmitting either the first transmission or the retransmission depending on the prioritization rule 630. The prioritization rule may prioritize first transmissions on the predefined allocation over retransmissions. The prioritization rule may also prioritize retransmissions over first transmissions on the predefined allocation.

[0039] In the above embodiments, signaling between the user equipment and node, such as eNB, may occur on appropriate control channels. For example, the L1/L2 control channels may be used, since user equipment may monitor L1/L2 control channels in order to identify possible allocations when downlink reception is enabled.

[0040] One having ordinary skill in the art will readily understand that the invention as discussed above may be practiced with steps in a different order, and/or with hardware elements in configurations which are different than those which are disclosed. Therefore, although the invention has been described based upon these preferred embodiments, it would be apparent to those of skill in the art that certain modifications, variations, and alternative constructions would be apparent, while remaining within the spirit and scope of the invention. In order to determine the metes and bounds of the

invention, therefore, reference should be made to the appended claims.

[0041] It should be noted that reference throughout this specification to features, advantages, or similar language does not imply that all of the features and advantages that may be realized with the present invention should be or are in any single embodiment of the invention. Rather, language referring to the features and advantages is understood to mean that a specific feature, advantage, or characteristic described in connection with an embodiment is included in at least one embodiment of the present invention. Thus, discussion of the features and advantages, and similar language, throughout this specification may, but do not necessarily, refer to the same embodiment.

[0042] Furthermore, the described features, advantages, and characteristics of the invention may be combined in any suitable manner in one or more embodiments. One skilled in the relevant art will recognize that the invention can be practiced without one or more of the specific features or advantages of a particular embodiment. In other instances, additional features and advantages may be recognized in certain embodiments that may not be present in all embodiments of the invention.

WE CLAIM:

1. A method for scheduling transmissions upon collision between semi-persistent allocation and dynamic allocation in radio access network, comprising:

receiving a request for retransmission from a node;

determining that the request for retransmission collides with a predefined allocation;

prioritizing a first transmission on the predefined allocation and the retransmission in accordance with a prioritization rule; and

transmitting either the first transmission or the retransmission depending on the prioritization rule.

2. The method of claim 1, wherein the prioritization rule prioritizes first transmissions on the predefined allocation over retransmissions.

3. The method of claim 1, wherein the prioritization rule prioritizes retransmissions over first transmissions on the predefined allocation.

4. An apparatus for scheduling transmissions upon collision between semi-persistent allocation and dynamic allocation in radio access network, comprising:

a receiving unit configured to receive a request for retransmission from a node;

a determining unit configured to determine that the request for retransmission collides with a predefined allocation;

prioritizing unit configured to prioritize a first transmission on the predefined allocation and the retransmission in accordance with a prioritization rule; and

a transmitting unit configured to transmit either the first transmission or the retransmission depending on the prioritization rule.

5. The apparatus of claim 4, wherein the prioritizing unit is configured to prioritize first transmissions on the predefined allocation over retransmissions.

6. The apparatus of claim 4, wherein the prioritizing unit is configured to prioritize retransmissions over first transmissions on the predefined allocation.

7. The apparatus of claim 4, wherein the apparatus comprises user equipment.

8. A computer-readable medium comprising a computer program, for scheduling transmissions upon collision between semi-persistent allocation and dynamic allocation in radio access network, the computer program controlling a processor to perform a process, the process comprising:

receiving a request for retransmission from a node;

determining that the request for retransmission collides with a predefined allocation;

prioritizing a first transmission on the predefined allocation and the retransmission in accordance with a prioritization rule; and

transmitting either the first transmission or the retransmission depending on the prioritization rule.

9. The computer-readable medium of claim 8, wherein the prioritization rule prioritizes first transmissions on the predefined allocation over retransmissions.

10. The computer-readable medium of claim 8, wherein the prioritization rule prioritizes retransmissions over first transmissions on the predefined allocation.

11. An apparatus for scheduling transmissions upon collision between semi-persistent allocation and dynamic allocation in radio access network, comprising:

receiving means for receiving a request for retransmission from a node;

determining means for determining that the request for retransmission collides with a predefined allocation;

prioritizing means for prioritizing a first transmission on the predefined allocation and the retransmission in accordance with a prioritization rule; and

transmitting means for transmitting either the first transmission or the retransmission depending on the prioritization rule.