

METHOD AND APPARATUS FOR DETERMINING HARQ TIMING IN COMMUNICATION SYSTEMS

TECHNICAL FIELD

[0001] Embodiments of the present invention generally relate to a wireless communication system, and more particularly to methods, apparatuses, a base station, a user equipment and a computer program for determining Hybrid Automatic Repeat Request (HARQ) timing in a communication system supporting Carrier Aggregation (CA).

BACKGROUND

[0002] This section introduces aspects that may facilitate a better understanding of the invention(s). Accordingly, the statements of this section are to be read in this light and are not to be understood as admissions about what is in the prior art or what is not in the prior art.

[0003] Long Term Evolution (LTE) and LTE-Advanced (LTE-A) standards and/or protocols defined by the Third Generation Partnership Project (3GPP, 3GPP2) are one of the next generation cellular communication standards. According to the multiplexing method, LTE and LTE-A systems include two modes, Frequency Division Duplex (FDD) and Time Division Duplex (TDD). Service providers are expected to implement both types of systems depending on the circumstances of the deployment scenario. The advantages to deploying a TDD system include providing flexible resource utilization (e.g., based on traffic characteristics) through different uplink-downlink (UL-DL) configurations.

[0004] To meet LTE-A requirements, support of wider transmission bandwidths is required than the 20 MHz bandwidth specified in 3GPP Release 8/9. The preferred solution to this is Carrier Aggregation (CA). In CA, two or more Component Carriers (CCs) are aggregated in order to support wider transmission bandwidths up to 100MHz. A user equipment (UE) may simultaneously receive or transmit on one or multiple CCs depending on its capabilities. Combined with inter-band CA, more flexibility can be achieved using carrier aggregation of FDD band and TDD band.

[0005] In LTE Release 10, carrier aggregation of FDD and carrier aggregation of TDD with same UL-DL configuration are supported to get higher data rate and higher spectral efficiency. In LTE Release 11, carrier aggregation of TDD with different UL-DL configurations on different bands is also supported to further improve the data rate and spectral efficiency. In 3GPP TSG RAN meeting #58, RP-122022, "Further LTE Carrier Aggregation Enhancements", carrier aggregation of FDD and TDD is proposed as a work item. In CA of FDD and TDD, either TDD or FDD can be configured as primary cell (Pcell).

[0006] Pcell is the cell operating on the primary frequency, in which the UE either performs the initial connection establishment procedure or initiates the connection re-establishment procedure, or the cell indicated as the primary cell in the handover procedure. Secondary cell (Scell) is a cell operating on a secondary frequency, which may be configured once an RRC connection is established and which may be used to provide additional radio resources. For a UE in RRC_CONNECTED configured with CA, the term “serving cells” is used to denote the set of one or more cells comprising of the primary cell and all secondary cells.

[0007] In order to prepare against a decoding failure that occurs at initial transmission, LTE/LTE-A adopts Hybrid Automatic Repeat Request (HARQ) for retransmission of the decoding-failed data on the physical layer.

[0008] HARQ is a technique in which, when decoding fails, the receiver sends the transmitter a Negative ACKnowledgement (NACK) such that the transmitter retransmits the decoding-failed data. If the data is decoded successfully, the receiver sends the transmitter an ACKnowledgement (ACK) such that the transmitter sends new data.

[0009] Normally, the HARQ feedback corresponding to physical downlink channel, for example, Physical Downlink Shared CHannel (PDSCH) is transmitted on physical uplink channel, such as Physical Uplink Control Channel (PUCCH) or Physical Uplink Shared Channel (PUSCH), according to predefined timing, and the HARQ feedback corresponding to physical uplink channel, for example, Physical Uplink Shared CHannel (PUSCH) is transmitted on physical downlink channel, such as Physical Hybrid ARQ Indicator CHannel (PHICH), according to predefined timing.

[0010] In European patent application EP2530863A2, a method for defining physical channel transmit/receiving timings and resource allocation is provided for use in a TDD system supporting CA.

[0011] However, in the prior art, there is no solution for defining HARQ feedback timing for a communication system supporting CA of FDD and TDD.

SUMMARY

[0012] ~~To better address one or more of the above concerns, in a first aspect of the invention, a method for receiving, at a base station, a Hybrid Automatic Repeat Request (HARQ) feedback from a user equipment in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell is provided. The primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD). The method comprises: transmitting a downlink physical channel through one of the primary and secondary cells; receiving the HARQ feedback corresponding to the downlink physical channel of the primary cell at a first timing predetermined for the primary~~

cell; and receiving the HARQ feedback corresponding to the downlink physical channel of the secondary cell at a second timing. The second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules.

According to a first aspect of the present invention, there is provided a method for receiving, at a base station, a Hybrid Automatic Repeat Request (HARQ) feedback from a user equipment in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell, wherein said primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD), said method comprising: transmitting a downlink physical channel through one of the primary and secondary cells; receiving the HARQ feedback corresponding to the downlink physical channel of the primary cell at a first timing predetermined for the primary cell; and receiving the HARQ feedback corresponding to the downlink physical channel of the secondary cell at a second timing, wherein said second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules, wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier of the primary cell.

[0013] In some embodiments, the duplex mode is selected from TDD and FDD, the scheduling mode is selected from self scheduling and cross carrier scheduling, and the predefined rules comprise the HARQ feedback can only be transmitted on a component carrier of the primary cell.

[0014] In some embodiments, the second timing is identical with the first timing, for both self scheduling and cross carrier scheduling of the secondary cell, when the primary cell is configured as FDD.

[0015] In some embodiments, the second timing is identical with the first timing, for cross carrier scheduling of the secondary cell, when the primary cell is configured as TDD.

[0016] In some embodiments, the second timing is determined according to any one of the following, for self scheduling of the secondary cell, when the primary cell is configured as TDD and said secondary cell is configured as FDD: being identical with the first timing; being identical with a third timing for a TDD configuration which has more available downlink subframes than the TDD configuration of the primary cell; and a fourth timing specific to said secondary cell.

[0017] In further embodiments, the fourth timing is determined as below: for a first downlink subframe which is also downlink subframe in the primary cell, the timing of

the first downlink subframe is identical with the first timing; and for a second downlink subframe which is uplink subframe in the primary cell, the timing of the second downlink subframe is identical with a maximum of a timing of a downlink subframe of the primary cell which is closest to the second downlink subframe and a processing delay. Optionally, the fourth timing is further adjusted according to the number of uplink subframes of the primary cell to balance the HARQ feedback among the uplink subframes of the primary cell, meanwhile minimizing HARQ feedback delay.

[0018] ~~In a second aspect of the invention, a method for transmitting, at a user equipment, a Hybrid Automatic Repeat Request (HARQ) feedback to a base station in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell is provided. The primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD). The method comprises: receiving a downlink physical channel through one of the primary and secondary cells; transmitting the HARQ feedback corresponding to the downlink physical channel of the primary cell at a first timing predetermined for the primary cell; and transmitting the HARQ feedback corresponding to the downlink physical channel of the secondary cell at a second timing. The second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules.~~

According to a second aspect of the present invention, there is provided a method for transmitting, at a user equipment, a Hybrid Automatic Repeat Request (HARQ) feedback to a base station in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell, wherein said primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD), said method comprising: receiving a downlink physical channel through one of the primary and secondary cells; transmitting the HARQ feedback corresponding to the downlink physical channel of the primary cell at a first timing predetermined for the primary cell; and transmitting the HARQ feedback corresponding to the downlink physical channel of the secondary cell at a second timing, wherein said second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules, wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier of the primary cell.

[0019] ~~In a third aspect of the invention, a method for transmitting, at a base station, a Hybrid Automatic Repeat Request (HARQ) feedback to a user equipment in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one~~

secondary cell is provided. The primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD). The method comprises: receiving an uplink physical channel through one of the primary and secondary cells; transmitting the HARQ feedback corresponding to the uplink physical channel of the primary cell at a first timing predetermined for the primary cell; and transmitting the HARQ feedback corresponding to the uplink physical channel of the secondary cell at a second timing. The second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules.

According to a third aspect of the present invention, there is provided a method for transmitting, at a base station, a Hybrid Automatic Repeat Request (HARQ) feedback to a user equipment in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell, wherein said primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD), said method comprising: receiving an uplink physical channel through one of the primary and secondary cells; transmitting the HARQ feedback corresponding to the uplink physical channel of the primary cell at a first timing predetermined for the primary cell; and transmitting the HARQ feedback corresponding to the uplink physical channel of the secondary cell at a second timing, wherein said second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules, wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier which carries an uplink grant scheduling the uplink physical channel.

[0020] In some embodiments, the duplex mode is selected from TDD and FDD, the scheduling mode is selected from self scheduling and cross carrier scheduling, and the predefined rules comprise the HARQ feedback can only be transmitted on a component carrier which carries an uplink grant.

[0021] In some embodiments, for self scheduling, the second timing is identical with a timing predetermined for the secondary cell.

[0022] In some embodiments, for cross carrier scheduling, the second timing is further determined according to the duplex modes of a scheduling cell and a scheduled cell.

[0023] In further embodiments, the second timing is identical with a timing predetermined for the secondary cell when the secondary cell is a scheduling cell.

[0024] In further embodiments, the second timing is identical with a timing predetermined for the secondary cell when the secondary cell is configured as TDD and scheduled by a FDD component carrier cell.

[0025] Further, the second timing is determined according to any one of the

following, when the secondary cell is configured as FDD and scheduled by a TDD component carrier cell: being identical with the first timing; and being identical with a third timing for a TDD configuration which can use uplink subframes of the secondary cell as much as possible.

[0026] ~~In a fourth aspect of the invention, a method for receiving, at a user equipment, a Hybrid Automatic Repeat Request (HARQ) feedback from a base station in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell is provided. The primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD). The method comprises: transmitting an uplink physical channel through one of the primary and secondary cells; receiving the HARQ feedback corresponding to the uplink physical channel of the primary cell at a first timing predetermined for the primary cell; and receiving the HARQ feedback corresponding to the uplink physical channel of the secondary cell at a second timing. The second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules.~~

According to a fourth aspect of the present invention, there is provided a method for receiving, at a user equipment, a Hybrid Automatic Repeat Request (HARQ) feedback from a base station in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell, wherein said primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD), said method comprising: transmitting an uplink physical channel through one of the primary and secondary cells; receiving the HARQ feedback corresponding to the uplink physical channel of the primary cell at a first timing predetermined for the primary cell; and receiving the HARQ feedback corresponding to the uplink physical channel of the secondary cell at a second timing, wherein said second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules, wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier which carries an uplink grant scheduling the uplink physical channel.

[0027] ~~In a fifth aspect of the invention, an apparatus is provided to implement various embodiments of the method of the first aspect of the invention. The apparatus comprises a transmitter configured to transmit a downlink physical channel through one of the primary and secondary cells. The apparatus further comprises a receiver configured to receive the HARQ feedback corresponding to the downlink physical channel of the primary cell at a first timing predetermined for the primary cell; and to receive the HARQ feedback corresponding to the downlink physical channel of the secondary cell at a second timing. The second timing is determined according to one or more of duplex modes of the primary~~

cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules.

According to a fifth aspect of the present invention, there is provided an apparatus for receiving, at a base station, a Hybrid Automatic Repeat Request (HARQ) feedback from a user equipment in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell, wherein said primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD), said apparatus comprising: a transmitter configured to transmit a downlink physical channel through one of the primary and secondary cells; and a receiver configured to receive the HARQ feedback corresponding to the downlink physical channel of the primary cell at a first timing predetermined for the primary cell, and to receive the HARQ feedback corresponding to the downlink physical channel of the secondary cell at a second timing; wherein said second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules, wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier of the primary cell.

[0028] ~~In a sixth aspect of the invention, an apparatus is provided to implement various embodiments of the method of the second aspect of the invention. The apparatus comprises a receiver configured to receive a downlink physical channel through one of the primary and secondary cells. The apparatus further comprise a transmitter configured to transmit the HARQ feedback corresponding to the downlink physical channel of the primary cell at a first timing predetermined for the primary cell; and to transmit the HARQ feedback corresponding to the downlink physical channel of the secondary cell at a second timing. The second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules.~~

According to a sixth aspect of the present invention, there is provided an apparatus for transmitting, at a use equipment, a Hybrid Automatic Repeat Request (HARQ) feedback to a base station in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell, wherein said primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD), said apparatus comprising: a receiver configured to receive a downlink physical channel through one of the primary and secondary cells; and a transmitter configured to transmit the HARQ feedback corresponding to the downlink physical channel of the primary cell at a first timing predetermined for the primary cell, and to transmit the HARQ feedback corresponding to the downlink physical channel of the secondary cell at a second timing; wherein said second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules, wherein said

duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier of the primary cell.

[0029] ~~In a seventh aspect of the invention, an apparatus is provided to implement various embodiments of the method of the third aspect of the invention. The apparatus comprises a receiver configured to receive an uplink physical channel through one of the primary and secondary cells. The apparatus further comprises a transmitter configured to transmit the HARQ feedback corresponding to the uplink physical channel of the primary cell at a first timing predetermined for the primary cell; and to transmit the HARQ feedback corresponding to the uplink physical channel of the secondary cell at a second timing. The second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules.~~

According to a seventh aspect of the present invention, there is provided an apparatus for transmitting, at a base station, a Hybrid Automatic Repeat Request (HARQ) feedback to a user equipment in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell, wherein said primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD), said apparatus comprising: a receiver configured to receive an uplink physical channel through one of the primary and secondary cells; and a transmitter configured to transmit the HARQ feedback corresponding to the uplink physical channel of the primary cell at a first timing predetermined for the primary cell, and to transmit the HARQ feedback corresponding to the uplink physical channel of the secondary cell at a second timing; wherein said second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules, wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier which carries an uplink grant scheduling the uplink physical channel.

[0030] ~~In an eighth aspect of the invention, an apparatus is provided to implement various embodiments of the method of the fourth aspect of the invention. The apparatus comprises a transmitter configured to transmit an uplink physical channel through one of the primary and secondary cells. The apparatus further comprises a receiver configured to receive the HARQ feedback corresponding to the uplink physical channel of the primary cell at a first timing predetermined for the primary cell; and to receive the HARQ feedback corresponding to the uplink physical channel of the secondary cell at a second timing. The second timing is determined according to one or more of duplex modes of the primary cell~~

and the secondary cell, a scheduling mode of the secondary cell, and predefined rules.

According to an eighth aspect of the present invention, there is provided an apparatus for receiving, at a user equipment, a Hybrid Automatic Repeat Request (HARQ) feedback from a base station in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell, wherein said primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD), said apparatus comprising: a transmitter configured to transmit an uplink physical channel through one of the primary and secondary cells; and a receiver configured to receive the HARQ feedback corresponding to the uplink physical channel of the primary cell at a first timing predetermined for the primary cell, and to receive the HARQ feedback corresponding to the uplink physical channel of the secondary cell at a second timing; wherein said second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules, wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier which carries an uplink grant scheduling the uplink physical channel.

[0031] ~~In a ninth aspect of the invention,~~ Disclosed herein is an apparatus is provided, which comprises at least one processor and at least one memory including computer program code. The memory and the computer program code are configured to cause the apparatus to perform embodiments of the method of the first, the second, the third or the fourth aspect of the invention.

[0032] ~~In a tenth aspect of the invention,~~ Disclosed herein is a computer program product is provided, which, comprises at least one computer readable storage medium having a computer readable program code portion stored thereon. The computer readable program code portion comprises program code instructions for perform embodiments of the method of the first, the second, the third or the fourth aspect of the invention.

[0033] With particular embodiments of the techniques described in this specification, the HARQ feedback timing is defined for communication systems supporting CA of FDD and TDD. In some embodiment, high peak rate can be maintained, meanwhile minimizing the feedback delay.

[0034] Other features and advantages of the embodiments of the present invention

WHAT IS CLAIMED IS: CLAIMS

1. A method for receiving, at a base station, a Hybrid Automatic Repeat Request (HARQ) feedback from a user equipment in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell, wherein said primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD), said method comprising:

transmitting a downlink physical channel through one of the primary and secondary cells;

receiving the HARQ feedback corresponding to the downlink physical channel of the primary cell at a first timing predetermined for the primary cell; and

receiving the HARQ feedback corresponding to the downlink physical channel of the secondary cell at a second timing,

wherein said second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules,

wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier of the primary cell.

~~2. The method of claim 1, wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier of the primary cell.~~

~~32. The method of claim 21, wherein the second timing is determined according to any one of the following, for self scheduling of the secondary cell, when the primary cell is configured as TDD and said secondary cell is configured as FDD:~~

~~being identical with the first timing;~~

~~being identical with a third timing for a TDD configuration which has more available downlink subframes than the TDD configuration of the primary cell; and~~

~~a fourth timing specific to said secondary cell.~~

43. The method of claim 32, wherein the fourth timing is determined as below:

for a first downlink subframe which is also downlink subframe in the primary cell, the timing of the first downlink subframe is identical with the first timing; and

for a second downlink subframe which is uplink subframe in the primary cell, the timing of the second downlink subframe is identical with a maximum of a timing of a downlink subframe of the primary cell which is closest to the second downlink subframe and a processing delay.

54. The method of claim 43, wherein the fourth timing is further adjusted according to the number of uplink subframes of the primary cell to balance the HARQ feedback among the uplink subframes of the primary cell, meanwhile minimizing HARQ feedback delay.

65. The method of any of claims 2-51-4, wherein the second timing is identical with the first timing, for both self scheduling and cross carrier scheduling of the secondary cell, when the primary cell is configured as FDD.

76. The method of any of claims 2-61-5, wherein the second timing is identical with the first timing, for cross carrier scheduling of the secondary cell, when the primary cell is configured as TDD.

87. A method for transmitting, at a user equipment, a Hybrid Automatic Repeat Request (HARQ) feedback to a base station in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell, wherein said primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD), said method comprising:

receiving a downlink physical channel through one of the primary and secondary cells;

transmitting the HARQ feedback corresponding to the downlink physical channel of the primary cell at a first timing predetermined for the primary cell; and

transmitting the HARQ feedback corresponding to the downlink physical channel of the secondary cell at a second timing,

wherein said second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules.

wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier of the primary cell.

~~9. The method of claim 8, wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier of the primary cell.~~

108. The method of claim 97, wherein the second timing is determined according to any one of the following, for self scheduling of the secondary cell, when the primary cell is configured as TDD and said secondary cell is configured as FDD:

being identical with the first timing;

being identical with a third timing for a TDD configuration which has more available downlink subframes than the TDD configuration of the primary cell; and

a fourth timing specific to said secondary cell.

119. The method of claim 108, wherein the fourth timing is determined as below:

for a first downlink subframe which is also downlink subframe in the primary cell, the timing of the first downlink subframe is identical with the first timing; and

for a second downlink subframe which is uplink subframe in the primary cell, the timing of the second downlink subframe is identical with a maximum of a timing of a downlink subframe of the primary cell which is closest to the second downlink subframe and a processing delay.

1210. The method of claim 119, wherein the fourth timing is further adjusted according to the number of uplink subframes of the primary cell to balance the HARQ feedback among the uplink subframes of the primary cell, meanwhile minimizing HARQ feedback delay.

1311. The method of any of claims 9-127-10, wherein the second timing is identical with the first timing, for both self scheduling and cross carrier scheduling of the secondary cell, when the primary cell is configured as FDD.

~~1412.~~ The method of any of claims ~~9-13~~7-11, wherein the second timing is identical with the first timing, for cross carrier scheduling of the secondary cell, when the primary cell is configured as TDD.

~~1513.~~ A method for transmitting, at a base station, a Hybrid Automatic Repeat Request (HARQ) feedback to a user equipment in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell, wherein said primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD), said method comprising:

receiving an uplink physical channel through one of the primary and secondary cells;
transmitting the HARQ feedback corresponding to the uplink physical channel of the primary cell at a first timing predetermined for the primary cell; and

transmitting the HARQ feedback corresponding to the uplink physical channel of the secondary cell at a second timing,

wherein said second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules,

wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier which carries an uplink grant scheduling the uplink physical channel.

~~16. The method of claim 15, wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise the HARQ feedback can only be transmitted on a component carrier which carries an uplink grant scheduling the uplink physical channel.~~

~~1714.~~ The method of claim ~~16~~13, wherein for cross carrier scheduling, the second timing is further determined according to the duplex modes of a scheduling cell and a scheduled cell.

~~1815.~~ The method of claim ~~17~~14, wherein the second timing is identical with a timing predetermined for the secondary cell when the secondary cell is a scheduling cell.

~~19~~16. The method of any of claims ~~17-18~~14-15, wherein the second timing is identical with a timing predetermined for the secondary cell when the secondary cell is configured as TDD and scheduled by a FDD component carrier cell.

~~20~~17. The method of any of claims ~~17-19~~14-16, wherein the second timing is determined according to any one of the following, when the secondary cell is configured as FDD and scheduled by a TDD component carrier cell:

being identical with a timing of the scheduling cell; and

being identical with a third timing for a TDD configuration which can use uplink subframes of the secondary cell as much as possible.

~~21~~18. The method of any of claims ~~16-20~~13-17, wherein for self scheduling, the second timing is identical with a timing predetermined for the secondary cell.

~~22~~19. A method for receiving, at a user equipment, a Hybrid Automatic Repeat Request (HARQ) feedback from a base station in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell, wherein said primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD), said method comprising:

transmitting an uplink physical channel through one of the primary and secondary cells;

receiving the HARQ feedback corresponding to the uplink physical channel of the primary cell at a first timing predetermined for the primary cell; and

receiving the HARQ feedback corresponding to the uplink physical channel of the secondary cell at a second timing,

wherein said second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules,

wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier which carries an uplink grant scheduling the uplink physical channel.

~~23. The method of claim 22, wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise the HARQ feedback can only be transmitted on a component carrier which carries an uplink grant scheduling the uplink physical channel.~~

2420. The method of claim ~~23~~19, wherein for cross carrier scheduling, the second timing is further determined according to the duplex modes of a scheduling cell and a scheduled cell.

2521. The method of claim 2420, wherein the second timing is identical with a timing predetermined for the secondary cell when the secondary cell is a scheduling cell.

~~2622~~. The method of any of claims ~~24-25~~20-21, wherein the second timing is identical with a timing predetermined for the secondary cell when the secondary cell is configured as TDD and scheduled by a FDD component carrier cell.

~~2723~~. The method of any of claims ~~24-26~~20-22, wherein the second timing is determined according to any one of the following, when the secondary cell is configured as FDD and scheduled by a TDD component carrier cell:

being identical with a timing of the scheduling cell; and

being identical with a third timing for a TDD configuration which can use uplink subframes of the secondary cell as much as possible.

~~2824~~. The method of any of claims ~~23-27~~19-23, wherein for self scheduling, the second timing is identical with a timing predetermined for the secondary cell.

2925. An apparatus for receiving, at a base station, a Hybrid Automatic Repeat Request (HARQ) feedback from a user equipment in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell, wherein said primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD), said apparatus comprising:

a transmitter configured to transmit a downlink physical channel through one of the primary and secondary cells; and

a receiver configured to receive the HARQ feedback corresponding to the downlink

physical channel of the primary cell at a first timing predetermined for the primary cell, and to receive the HARQ feedback corresponding to the downlink physical channel of the secondary cell at a second timing;

wherein said second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules,

wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier of the primary cell.

3026. An apparatus for transmitting, at a use equipment, a Hybrid Automatic Repeat Request (HARQ) feedback to a base station in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell, wherein said primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD), said apparatus comprising:

a receiver configured to receive a downlink physical channel through one of the primary and secondary cells; and

a transmitter configured to transmit the HARQ feedback corresponding to the downlink physical channel of the primary cell at a first timing predetermined for the primary cell, and to transmit the HARQ feedback corresponding to the downlink physical channel of the secondary cell at a second timing;

wherein said second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules,

wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier of the primary cell.

3127. An apparatus for transmitting, at a base station, a Hybrid Automatic Repeat Request (HARQ) feedback to a user equipment in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell, wherein said primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD), said apparatus comprising:

a receiver configured to receive an uplink physical channel through one of the

primary and secondary cells; and

a transmitter configured to transmit the HARQ feedback corresponding to the uplink physical channel of the primary cell at a first timing predetermined for the primary cell, and to transmit the HARQ feedback corresponding to the uplink physical channel of the secondary cell at a second timing;

wherein said second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules,

wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier which carries an uplink grant scheduling the uplink physical channel.

3228. An apparatus for receiving, at a user equipment, a Hybrid Automatic Repeat Request (HARQ) feedback from a base station in a communication system supporting Carrier Aggregation (CA) of a primary cell and at least one secondary cell, wherein said primary cell and secondary cell support either Frequency Divisional Duplex (FDD) or Time Divisional Duplex (TDD), said apparatus comprising:

a transmitter configured to transmit an uplink physical channel through one of the primary and secondary cells; and

a receiver configured to receive the HARQ feedback corresponding to the uplink physical channel of the primary cell at a first timing predetermined for the primary cell, and to receive the HARQ feedback corresponding to the uplink physical channel of the secondary cell at a second timing;

wherein said second timing is determined according to one or more of duplex modes of the primary cell and the secondary cell, a scheduling mode of the secondary cell, and predefined rules,

wherein said duplex mode is selected from TDD and FDD, said scheduling mode is selected from self scheduling and cross carrier scheduling, and said predefined rules comprise that the HARQ feedback can only be transmitted on a component carrier which carries an uplink grant scheduling the uplink physical channel.