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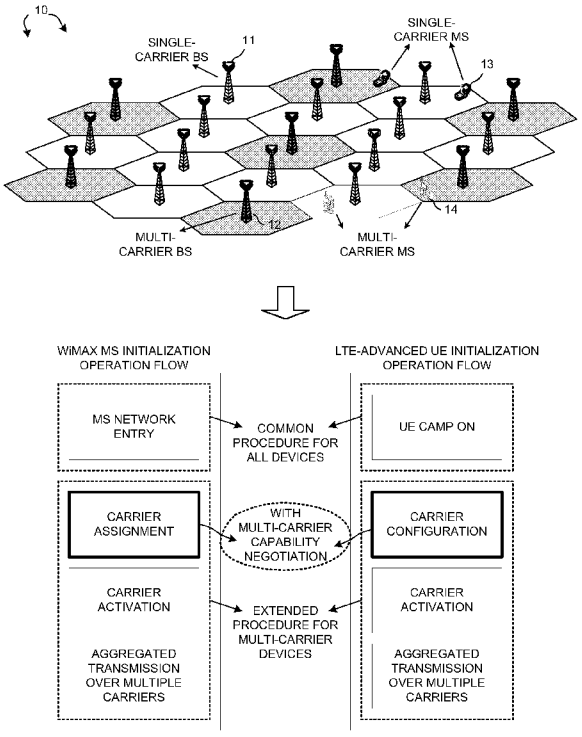


FIG. 1

(57) Abstract: In a carrier assignment procedure, a mobile station and its serving base station exchange and negotiate carrier deployment and multi-carrier capability information, and make a well- informed carrier assignment decision based on the negotiation result. The carrier assignment procedure ensures that the assigned secondary carriers are not only supported by both the serving BS and the MS, but are also desirable under additional requirements and considerations. Furthermore, the carrier assignment decision may be updated based on additional considerations such as channel quality measurement and network load condition over the assigned carriers. Such updated assignment decision may be made by the base station in unsolicited manner, or based on a carrier re-assignment request from the mobile station.

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METHOD AND APPARATUS OF CARRIER ASSIGNMENT IN MULTI-CARRIER OFDM SYSTEMS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001]This application claims priority under 35 U.S.C. §119 from U.S. Provisional Application Number 61/172,344, entitled "Method of Capability Negotiation to Support Prioritized Carrier Assignment in OFDMA Multi-Carrier Systems," filed on April 24, 2009; U.S. Provisional Application Number 61/291,448, entitled "Method of Carrier Assignment in Multi-Carrier OFDM Systems," filed on December 31, 2009, the subject matter of which is incorporated herein by reference.

TECHNICAL FIELD

[0002]The disclosed embodiments relate generally to wireless network communications, and, more particularly, to carrier assignment in OFDM multi-carrier systems.

BACKGROUND

[0003] Multi-carrier OFDM systems have become the baseline system architecture in IEEE 802.16m (i.e. for WiMAX 2.0 system) and 3GPP Release 10 (i.e. for LTE-Advanced system) draft standards to fulfill next generation wireless system requirements. For example, multi-carrier OFDM technology can be used to achieve 1Gbps peak transmission rate as required by ITU-R for IMT-Advanced systems such as the 4th generation ("4G") mobile communication systems. Based on multi-carrier OFDM, various multiple access schemes such as OFDMA, OFDM/CDMA, and OFDM/TDMA have been developed and utilized in multi-carrier OFDM wireless systems. Network deployment, however, normally takes an evolution path, rather than a revolution one. For example, during the first stage of a 4G network upgrade (also referred to as the "4G Hotspot Deployment"), 4G air interface is selectively deployed in a few hotspots such as urban areas, bus stops, etc., while the remaining areas can only be served by 3G air interface. During the second stage of

the 4G network upgrade (also referred to as the "4G Overlay Deployment"), all areas can be served by both 3G and 4G air interface. During the third stage of the 4G network upgrade (also referred to as the "4G Greenfield Deployment"), all areas can only be served by 4G air interface. It is thus necessary to ensure that a multi-carrier OFDM system can work well under different network deployment stages.

[0004] To support multi-carrier data transmission, one or more secondary carriers need to be assigned and activated between a base station and a mobile station. The base station thus needs to know the multi-carrier capability supported by the mobile station. Because of different hardware implementations on RF transceiver architecture, however, it is difficult for the base station to know which carriers and carrier aggregation combinations can be supported by the mobile station for multi-carrier data transmission. In some IEEE 802.16m contributions, an AAI_MC-REQ message (multi-carrier request message) is defined for a mobile station to inform its multi-carrier capability information to a serving base station. For example, the AAI_MC-REQ message may include the maximum processing bandwidth (i.e., 20MHz) and the maximum number of simultaneous RF carriers (i.e., 4) of a mobile station. Knowing such information, however, the serving base station still would not know exactly which combinations the MS could simultaneously process with an aggregated 20MHz bandwidth (i.e., 10+10, 5+10+5, and 5+5+5+5 etc.). It thus remains a challenge to communicate multi-carrier capability information between base stations and mobile stations such that multi-carrier data transmission can be effectively supported in a multi-carrier OFDM system.

SUMMARY

[0005]When a mobile station (MS) initializes to access a multi-carrier OFDM network, a two-stage network entry procedure is performed. During a first common network entry procedure, the MS selects one of its supported RF carriers as the primary carrier to perform network entry with a serving base station (BS). In a second stage of extended network entry procedure, the MS performs carrier assignment and carrier activation procedures with the serving BS, and is then ready for aggregated data transmission over multiple RF carriers. In one novel aspect, the MS and its serving BS exchange and negotiate carrier deployment and multi-carrier capability information, and make a well-informed carrier assignment decision based

on the negotiation result. The carrier assignment procedure ensures that the assigned secondary carriers are not only supported by both the serving BS and the MS, but are also desirable under additional requirements and considerations.

[0006]During the carrier assignment procedure, the BS first informs the MS its carrier deployment information. Carrier deployment information comprises physical information of a set of available RF carriers supported by the BS. Based on the carrier deployment information, the MS informs the BS its multi-carrier capability information. Multi-carrier capability information comprises the RF carriers that can be simultaneously supported by the MS. Next, the BS assigns a set of secondary carriers to the MS for multi-carrier data transmission. The assigned secondary carriers are determined by the BS based on the multi-carrier capability information of the MS, as well as additional consideration such as channel quality measurement results and network traffic loading condition. Finally, the MS replies to confirm the assigned secondary carriers, or requests the BS to re-assign an updated set of secondary carriers. The updated assignment decision may be made by the BS in unsolicited manner, or based on the carrier re-assignment request from the MS.

[0007]Other embodiments and advantages are described in the detailed description below. This summary does not purport to define the invention. The invention is defined by the claims.

BRIEF DESCRIPTION OF DRAWINGS

[0008]The accompanying drawings, where like numerals indicate like components, illustrate embodiments of the invention.

[0009]Figure 1 illustrates a general initialization operation flow of a mobile station in a multi-carrier OFDM network in accordance with one novel aspect.

[0010]Figure 2 illustrates an operation flow of a carrier assignment procedure between a base station and a mobile station in a multi-carrier OFDM network.

[0011]Figure 3 illustrates one embodiment of a multi-carrier advertisement (MC-ADV) message broadcasted by a serving base station to inform its carrier deployment information.

[0012]Figure 4 illustrates one embodiment of a global carrier configuration (GLOBAL-CONFIG) message transmitted by a serving base station to a mobile station right after network entry completes.

[0013]Figure 5 illustrates different scenarios of carrier aggregation of a mobile station supporting an aggregated bandwidth of 20MHz.

[0014]Figure 6A illustrates a first hardware implementation of an RF transceiver to support multi-carrier capability of a mobile station.

[0015]Figure 6B illustrates a second hardware implementation of an RF transceiver to support multi-carrier capability of a mobile station.

[0016]Figure 7 illustrates one embodiment of a multi-carrier request (MC-REQ) message sent by a mobile station to inform its multi-carrier capability information.

[0017]Figure 8 illustrates one embodiment of a multi-carrier response (MC-RSP) message sent by a base station to assign secondary carriers.

[0018]Figure 9 illustrates mathematical notifications defining solution spaces of information exchanged in a carrier assignment procedure.

[0019]Figure 10 illustrates specific examples of a carrier assignment procedure between a base station and a mobile station.

DETAILED DESCRIPTION

[0020]Reference will now be made in detail to some embodiments of the invention, examples of which are illustrated in the accompanying drawings.

[0021]Figure 1 illustrates a general initialization operation flow of a mobile station in a wireless multi-carrier OFDM network 10 in accordance with one novel aspect. Wireless OFDM network 10 comprises a mixed single-carrier and multi-carrier base stations and mobile stations, for example, a single-carrier base station BS11, a multi-carrier base station BS12, a single-carrier mobile station MS13, and a multi-carrier mobile station MS14. When a mobile station starts to initialize and access the wireless network, it performs a two-stage network entry procedure. The two-stage network entry procedure can be used between either a single-carrier or a multi-carrier base station, and either a single-carrier or a multi-carrier mobile stations.

[0022] The two-stage network entry procedure for both WiMAX system and LTE-Advanced system is illustrated in Figure 1. For WiMAX system, in a first stage of common network entry procedure for all devices, a mobile station (MS) selects one of its supported RF carriers as the primary carrier to perform network entry with a serving base station (BS). In a second stage of extended network entry procedure for multi-carrier devices, the mobile station performs carrier assignment and carrier

activation procedures with the serving base station, and is then ready for aggregated data transmission over multiple RF carriers. For additional details on the two-stage network entry procedure, see: U.S. Patent Application Serial Number 12/387,633 entitled "Method of Network Entry in OFDM Multi-Carrier Wireless Communications Systems", filed on May 4, 2009, by I-Kang Fu (the subject matter of which is incorporated herein by reference).

[0023] Similarly, for LTE-Advanced system, in a first stage of common camp on procedure for all devices, a user equipment (UE) selects one of its supported RF carriers as the primary carrier to perform network entry with a serving base station. In a second stage of extended network entry procedure for multi-carrier devices, the user equipment performs carrier configuration and carrier activation procedures with the serving base station, and is then ready for aggregated data transmission over multiple RF carriers. While the two-stage network entry procedure is applicable for both WiMAX and LTE-advanced wireless systems, the remaining embodiments/examples are made only with respect to WiMAX OFDM networks.

[0024] In one novel aspect, during the carrier assignment procedure, the mobile station and the serving base station exchange and negotiate carrier deployment and multi-carrier capability information, and make a well-informed carrier assignment decision based on the negotiation result. Furthermore, the carrier assignment decision may be updated based on additional considerations. Such updated assignment decision may be made by the base station in unsolicited manner, or based on a carrier re-assignment request from the mobile station.

[0025] In another novel aspect, during the carrier assignment procedure, the mobile station only informs the base station part of the carriers that it can simultaneously support. For example, the mobile station can simultaneously support four of the carriers deployed by the base station. The mobile station only informs base station one of them as its capability, so as to indirectly guide the base station only assign one carrier to the mobile station to reduce the disruption by monitoring the assigned carriers. Another example is that the mobile station does not inform any carriers as its multi-carrier capability at the beginning. Latter on the mobile further request carrier re-assignment to add more assigned carriers that it can supports.

[0026] Figure 2 illustrates an operation flow of a carrier assignment procedure between a base station and a mobile station in multi-carrier OFDM network 10. Base station BS14 comprises memory 21, a processor 22, a multi-carrier capability

negotiation module 23, and an RF transmitter and receiver 24 coupled to an antenna 25. Similarly, mobile station MS14 comprises memory 31, a processor 32, a multi-carrier capability negotiation module 33, and an RF transmitter and receiver 34 coupled to an antenna 35. In one example, the multi-carrier capability negotiation module is implemented within the processor. The multi-carrier capability negotiation module process multi-carrier capability negotiation related messages exchanged between BS12 and MS14 and in response makes carrier assignment decision based on the negotiation results as well as additional considerations such as link measurement results and traffic loading.

[0027] As illustrated in Figure 2, BS12 first informs MS14 its carrier deployment information (step 15). Carrier deployment information comprises physical information of a set of available RF carriers supported by BS12. The physical information includes bandwidth and center frequency of each available RF carriers. Based on the carrier deployment information, MS14 informs BS12 its multi-carrier capability information (step 16). Multi-carrier capability information comprises the RF carriers that can be simultaneously supported by MS14. Next, BS12 assigns a set of secondary carriers to MS14 for multi-carrier data transmission (step 17). The assigned secondary carriers are determined by BS12 based on the multi-carrier capability information of MS14, as well as additional consideration such as channel quality measurement results and network traffic loading condition. Finally, MS14 replies to confirm the assigned secondary carriers, or requests BS12 to re-assign an updated set of secondary carriers (step 18).

[0028] To make a well-informed carrier assignment decision, it is essential for the base station and the mobile station to be able to exchange and negotiate their corresponding carrier deployment and multi-carrier capability information completely and accurately. From the mobile station perspective, it needs to know which carriers are supported by its serving BS, and thereby determine a subset of carriers that the MS can simultaneously support to be used for carrier assignment. From the base station perspective, it needs to know which carriers can be simultaneously supported by the MS, and thereby assign a subset of secondary carriers for multi-carrier data transmission. Because of the complexity of a multi-carrier network environment, the above-illustrated carrier assignment procedure thus ensures that the assigned secondary carriers are not only supported by both the serving BS and the MS, but also desirable under additional requirements based on

network condition. Various embodiments and examples of each step of the carrier assignment procedure are now described below with more details.

[0029] Figure 3 illustrates one embodiment of a multi-carrier advertisement (MC-ADV) message broadcasted by a serving base station to inform its carrier deployment information (step 15 of Figure 2). By periodically broadcasting the MC-ADV message, the serving BS informs its subordinate mobile stations with basic RF carrier configuration for all available carriers supported by the serving BS. In the example of Figure 3, the MC-ADV includes a serving BS carrier number, a serving BS uniformity flag (i.e., "0" means all carriers supported by the serving BS have the same protocol version and "1" means otherwise), a physical carrier index of current RF carrier that broadcasting this message, and a MAC protocol version. In addition, the MC-ADV message also includes a physical carrier index for each supported RF carrier. Each physical carrier index is associated with a specific carrier bandwidth and center frequency. If the serving BS uniformity flag is equal to "1", then a MAC protocol version for each supported RF carrier is also included in the MC-ADV message.

[0030] The physical carrier index used in the MC-ADV message is the same as the physical carrier index defined in a global carrier configuration (GLOBAL-CONFIG) message transmitted by a serving base station to a mobile station right after network entry completes. In IEEE 802.16m systems, the GLOBAL-CONFIG message is transmitted by the serving BS to the MS for indicating physical parameters of each carrier and the associated physical carrier index. Figure 4 illustrates one embodiment of a global carrier configuration (GLOBAL-CONFIG) message. For additional details on the global carrier configuration message, see: U.S. Patent Application Serial Number 12/660,441 entitled "Method and Apparatus for Communicating Carrier Configuration in Multi-Carrier OFDM Systems", filed February 26, 2010, by I-Kang Fu (the subject matter of which is incorporated herein by reference).

[0031] Once a mobile station receives the carrier deployment information from its serving base station via the MC-ADV message, the mobile station is then ready to communicate its multi-carrier capability information back to the serving BS to request for a list of assigned carriers (step 16 of Figure 2). For a multi-carrier MS, however, it is difficult to define a set of parameters that can describe its multi-carrier capability completely and accurately. This is because in addition to basic physical

parameters such as carrier bandwidth and center frequency information of each RF carrier, there could be many different carrier aggregation combinations to be supported by the multi-carrier MS. Depending on different hardware implementations, the multi-carrier MS may be able to support various carrier aggregation scenarios with contiguous or non-contiguous RF carriers, as well as intra-band or inter-band RF carriers.

[0032] Figure 5 illustrates different scenarios of carrier aggregation of a mobile station device supporting an aggregated bandwidth of 20MHz. In a first example depicted in the left side of Figure 5, the mobile station supports two contiguous 10MHz RF carriers. This is referred to as contiguous and intra-band carrier aggregation. In a second example depicted on the right side of Figure 5, the mobile station supports two contiguous 5MHz RF carriers in one band class, and a single 10MHz RF carrier in another band class. This is referred to as non-contiguous and inter-band carrier aggregation. Different carrier aggregation scenarios result from different hardware implementations used by the mobile station.

[0033] Figure 6A illustrates a first hardware implementation of an RF transceiver to support multi-carrier capability of a mobile station. In this transceiver architecture, the mobile station utilizes single FFT and RF to transmit and receive radio signal waveforms across multiple RF carriers. This is done by utilizing the nature of OFDM signal and generating multiple waveforms by digital processing techniques. While this transceiver architecture has low hardware complexity, low cost, and low power consumption, it is less flexible in supporting non-contiguous RF carriers. It may be capable to support non-contiguous carriers within the same frequency band (intra-band scenario), but certainly cannot support carriers in different frequency bands (inter-band scenario) simultaneously.

[0034] Figure 6B illustrates a second hardware implementation of an RF transceiver to support multi-carrier capability of a mobile station. In this transceiver architecture, the mobile station utilizes multiple FFTs to generate OFDMA waveforms separately. In addition, the mobile station may also utilize different RF components (e.g., power amplifier, antenna) to transmit the OFDMA waveforms. This allows more flexibility in supporting various multi-carrier aggregation scenarios, either contiguous or non-contiguous, intra-band or inter-band. However, its hardware complexity, cost and power consumption are higher.

[0035] In general, different transceiver architectures are designed to achieve a desirable tradeoff between performance, complexity, and flexibility. In addition, the transceiver architectures illustrated in Figure 6A and 6B are complementary and may be integrated and combined under various scenarios. Thus, different mobile stations may support different carrier aggregation combinations depending on hardware implementation. Therefore, when a mobile station communicates its multi-carrier capability to its serving base station, it is essential to include such carrier aggregation information as well as physical parameters of each carrier.

[0036] Figure 7 illustrates one embodiment of a multi-carrier request (MC-REQ) message sent by a mobile station to inform its multi-carrier capability information (step 16 of Figure 2). Based on the received MC-ADV message, the carriers included in the MC-REQ message belong to a subset of the available carriers supported by the BS. In the example of Figure 7, MC-REQ message includes a Global_Support bit that indicates whether the MS can process all the available carriers supported by the BS simultaneously (sometimes also referred to as a uniformity indicator). If Global_Support is equal to "0", then the MC-REQ message does not need to include other information related to its multi-carrier capability. On the other hand, if Global_Support is equal to "1", then the MC-REQ message includes a number of candidate combinations (N) indicating the number of carrier combinations the MS can support. For each candidate combination, the MC-REQ message further includes a number of candidate assigned carriers (Nc) indicating the number of carriers the MS can support within that candidate combination, and a physical carrier index for each carrier the MS can simultaneously support within that candidate combination.

[0037] Figure 8 illustrates one embodiment of a multi-carrier response (MC-RSP) message sent by a base station to assign secondary carriers for a mobile station (step 17 of Figure 2). Based on the received MC-REQ message, the assigned secondary carriers included in the MC-RSP message belong to a subset of the carriers that can be simultaneously supported by the MS. In the example of Figure 8, the MC-RSP message includes a Global_Assign bit that indicates whether the BS assigns all the carriers requested by the MS (sometimes also referred to as a uniformity indicator). If Global_Assign is equal to "1", then the MC-RSP message does not need to include other information related to the assigned carriers. On the other hand, if Global_Assign is equal to "0", then the MC-RSP message includes a number of

assigned carriers (N) indicating the number of carriers to be assigned, and a physical carrier index for each carrier to be assigned. The MC-RSP message is typically sent by the BS in response to the MC-REQ message sent by the MS requesting for carrier assignment. However, the MC-RSP message may also be sent by the BS to update the list of assigned carriers in unsolicited manner. For example, the BS may re-assign a new set of secondary carriers based on changed network traffic loading condition.

[0038] After a mobile station receives carrier assignment information of the assigned secondary carriers, the MS may either reply a message to confirm the carrier assignment or send a carrier re-assignment request to its serving base station (step 18 of Figure 2). The carrier re-assignment request may be based on measurement results over the assigned carriers. In one example, the MS discovers that the received signal quality over an assigned carrier is lower than a threshold level. In another example, the received signal quality over a specific carrier is higher than a threshold level but the BS did not assign the specific carrier. The carrier re-assignment request may also be based on other specific conditions. For example, an MS having single RF hardware implementation may prefer to have contiguous assigned carriers instead of non-contiguous assigned carriers. Based on the measurement results or the specific conditions, the MS may make specific carrier assignment recommendation to the BS. In one embodiment, the MS may specifically recommend adding an additional set of carriers, or removing an existing set of assigned carrier, or both. In another embodiment, the MS may send updated multi-carrier capability information via another MC-REQ message. Once the BS receives the carrier re-assignment request, it makes updated carrier assignment decision and transmits the updated set of assigned carriers back to the MS.

[0039] The information exchanged during the above-illustrated carrier assignment procedure can be more precisely expressed in mathematical form. Figure 9 illustrates mathematical notifications defining solution spaces of the carrier deployment, multi-carrier capability, carrier assignment and re-assignment information exchanged between BS12 and MS14 of Figure 2. In step 15, BS12 informs MS14 all the carriers **C** supported by BS12, where **C** represents a set of solutions (i.e., the physical carrier index). In step 16, MS14 informs BS12 a set of carriers **S** that can be simultaneously supported by MS14, where **S** represents a set of solutions (i.e., the physical carrier index) and is a subset of **C**. MS14 may also

inform multiple sets of carriers, and each set of carriers can be simultaneously supported by MS14. In step 17, BS12 informs MS14 a set of assigned carriers **A**, where **A** represents a set of solutions (i.e., the physical carrier index) and is a subset of **S**. Finally, in step 18, MS14 may either confirm the assignment or send a re-assignment request. The re-assignment request may include an indication or another set of carriers **S'** that can be simultaneously supported by MS14, where **S'** is also a subset of **C**. Based on the new set of carriers **S'**, BS12 may adjust its carrier assignment decision and send an updated set of assigned carriers **A'** to MS14. In one example, the physical carrier indexes have a bitmap format.

[0040] Figure 10 illustrates specific examples of a carrier assignment procedure between a base station BS91 and a mobile station MS92. First, through a MC-ADV message 93, BS91 informs MS92 that there are four available carriers #1-#4 supported by BS91 (i.e., **C** = {1, 2, 3, 4}). Next, through a MC-REQ message 94, MS92 informs BS91 that it can simultaneously support two contiguous carriers out of the four available carriers. The MC-REQ message may have different formats. In a first example, MS92 may reply multiple lists to BS91 (e.g., **S1** = {1,2}, **S2** = {2,3}, **S3** = {3,4}). In a second example, MS92 may reply part of the lists based on other consideration (e.g., **S1** = {1,2}, **S3** = {3,4}). In a third example, MS92 may reply only one list (e.g., **S1** = {1,2}) and include an "uniformity indicator" to represent that MS92 can also support other carrier combinations that are associated with the same carrier aggregation scenario. For instance, if carrier #1 and carrier #2 are 10MHz and 5MHz carriers respectively, then "**S1** = {1,2} + uniformity indicator" represents that MS92 can support the assigned carriers to be any carrier combinations which are also "a 10MHz carrier + a 5MHz carrier". Next, through a MC-RSP message 95, BS91 send MS92 the two contiguous assigned carriers (i.e., **A** = {3,4}) selected from **S1**, **S2** and **S3**. Finally, the assigned carriers may be updated by BS91 (i.e., re-transmit **A'** = {1,2}) in unsolicited manner. For example, BS91 re-assigns the carriers because the channel quality measurement result over carrier #4 is very poor. Alternatively, MS92 may send a re-assignment request to ask BS91 make a new assignment. In one example, MS92 may specifically request to add a new set of carriers (i.e., add **S1** = {1,2}) to be assigned, or to remove the already assigned carriers (i.e., remove **S3** = {3,4}). In another example, MS92 may transmit an updated MC-REQ message that contains updated carriers lists that can be

simultaneously supported by MS92 (i.e., **S1** = {1,2}, **S2** = {2,3}) to BS91 such that **S3** = {3,4} will not be re-assigned by BS91.

[0041] Although the present invention has been described in connection with certain specific embodiments for instructional purposes, the present invention is not limited thereto. For example, in LTE-Advanced systems, carrier assignment operation is referred to as carrier configuration operation. While the terminology used is different, the basic concept and idea provided for carrier assignment operation in WiMAX systems is also applicable for carrier configuration operation in LTE-Advanced systems. If the enhanced node B (eNB) support multiple cells within the same carrier, it further comprises serving cell configuration operation. Accordingly, various modifications, adaptations, and combinations of various features of the described embodiments can be practiced without departing from the scope of the invention as set forth in the claims.

CLAIMS

1. A method, comprising:

(a) transmitting carrier deployment information that comprises physical information of a set of available carriers supported by a base station;

(b) receiving multi-carrier capability information that comprises carriers that can be simultaneously supported by a mobile station, wherein the simultaneously supportable carriers are based at least in part on the carrier deployment information; and

(c) transmitting carrier assignment information that comprises a set of assigned carriers of the base station, wherein the assigned carriers are based at least in part on the multi-carrier capability information.

2. The method of Claim 1, wherein the simultaneously supportable carriers belong to a subset of the available carriers, and wherein the assigned carriers belong to a subset of the simultaneously supportable carriers.

3. The method of Claim 1, wherein the carrier deployment information comprises center frequency and bandwidth information of each available carrier.

4. The method of Claim 1, wherein the carrier deployment information comprises a set of carrier indexes, each index is uniquely associated with each available carrier.

5. The method of Claim 4, wherein the carrier indexes have a bitmap format.

6. The method of Claim 1, wherein the assigned carriers are determined by the base station based on channel quality measurement results and traffic loading information of each assigned carrier.

7. The method of Claim 1, wherein the carrier assignment information comprises a uniformity indicator indicates all carriers that are simultaneously supported by the mobile station.

8. The method of Claim 1, further comprising:

updating carrier assignment information that comprises a new set of assigned carriers of the base station.

9. The method of Claim 1, further comprising:

updating carrier assignment information that comprises a new set of assigned carriers of the base station, wherein the new set of assigned carriers is determined by

the base station in response to a carrier re-assignment request from the mobile station.

10. The method of Claim 9, wherein the carrier-reassignment request comprises updated multi-carrier capability information comprising an updated set of carriers that can be simultaneously supported by the mobile station.

11. A method, comprising:

(a) receiving carrier deployment information that comprises physical information of a set of available carriers supported by a base station;

(b) transmitting multi-carrier capability information that comprises carriers that can be simultaneously supported by a mobile station, wherein the simultaneously supportable carriers are based at least in part on the carrier deployment information; and

(c) receiving carrier assignment information that comprises a set of assigned carriers of the base station, wherein the assigned carriers are based at least in part on the multi-carrier capability information.

12. The method of Claim 11, wherein the simultaneously supportable carriers belong to a subset of the available carriers, and wherein the assigned carriers belong to a subset of the simultaneously supportable carriers.

13. The method of Claim 11, wherein the simultaneously supportable carriers are determined based on channel quality measurement results over the carriers by the mobile station.

14. The method of Claim 11, wherein the simultaneously supportable carriers are indicated by one or more sets of carrier indexes.

15. The method of Claim 14, wherein the one or more sets of carrier indexes are updated by the mobile station by transmitting one or more updated sets of carrier indexes to the base station.

16. The method of Claim 14, wherein the carrier indexes have a bitmap format.

17. The method of Claim 11, further comprising:

receiving an updated carrier assignment information that comprises a new set of assigned carriers of the base station.

18. The method of Claim 11, further comprising:

transmitting a carrier-reassignment request; and

receiving an updated carrier assignment information that comprises a new set of assigned carriers determined by the base station in response to the carrier re-assignment request.

19. The method of Claim 18, wherein the carrier re-assignment request comprises updated multi-carrier capability information that comprises updated carriers that can be simultaneously supported by the mobile station.

20. The method of Claim 18, wherein the carrier re-assignment request comprises information on either adding a preferred set of carriers or removing a non-preferred set of carriers for carrier re-assignment.

21. The method of Claim 10, wherein the multi-carrier capability information comprising a uniformity indicator that indicates all available carriers of the base station.

22. The method of Claim 10, wherein the multi-carrier capability information comprises a first set of simultaneously supported carriers and a uniformity indicator that indicates all combinations associated with the first set of simultaneously supported carriers.

23. A base station, comprising:

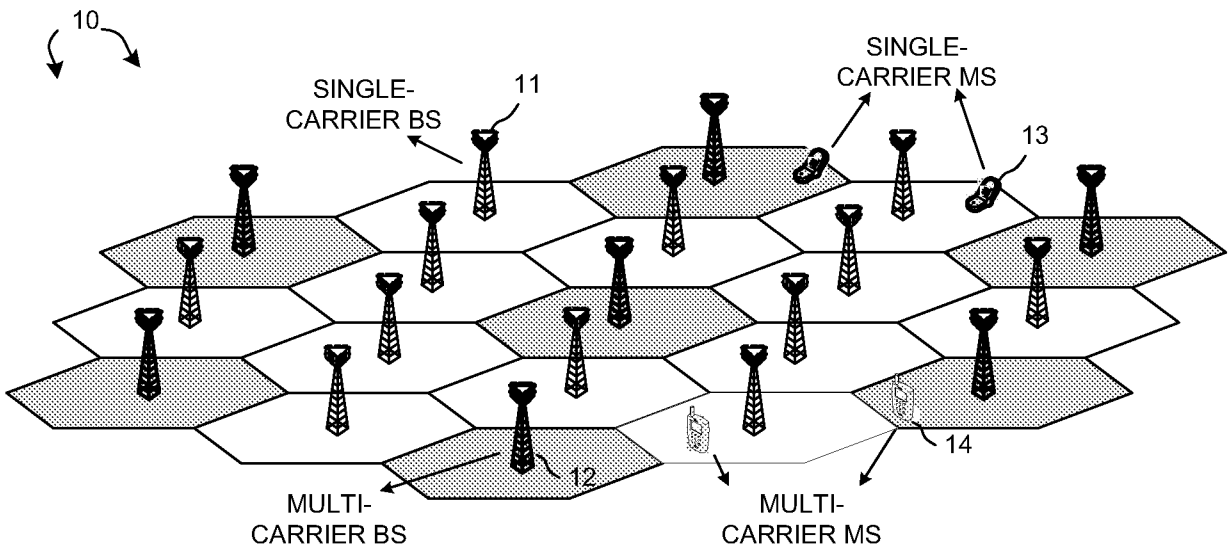
a radio frequency (RF) transceiver that transmits carrier deployment information and in response receives multi-carrier capability information from a mobile station, wherein the carrier deployment information comprises a set of available carriers supported by the base station, and wherein the multi-carrier capability information comprises carriers that can be simultaneously supported by the mobile station; and

a multi-carrier capability negotiation module that determines a set of assigned carriers based at least in part on the carriers that can be simultaneously supported by the mobile station.

24. The base station of Claim 23, wherein the simultaneously supportable carriers belong to a subset of the available carriers, and wherein the assigned carriers belong to a subset of the simultaneously supportable carriers.

25. The base station of Claim 23, wherein the assigned carriers are updated by the base station.

26. The base station of Claim 23, wherein the assigned carriers are updated by the base station in response to a carrier re-assignment request from the mobile station.


10
SINGLE-
CARRIER BS
11
SINGLE-
CARRIER MS
13
14
12
MULTI-
CARRIER BS
MULTI-
CARRIER MS

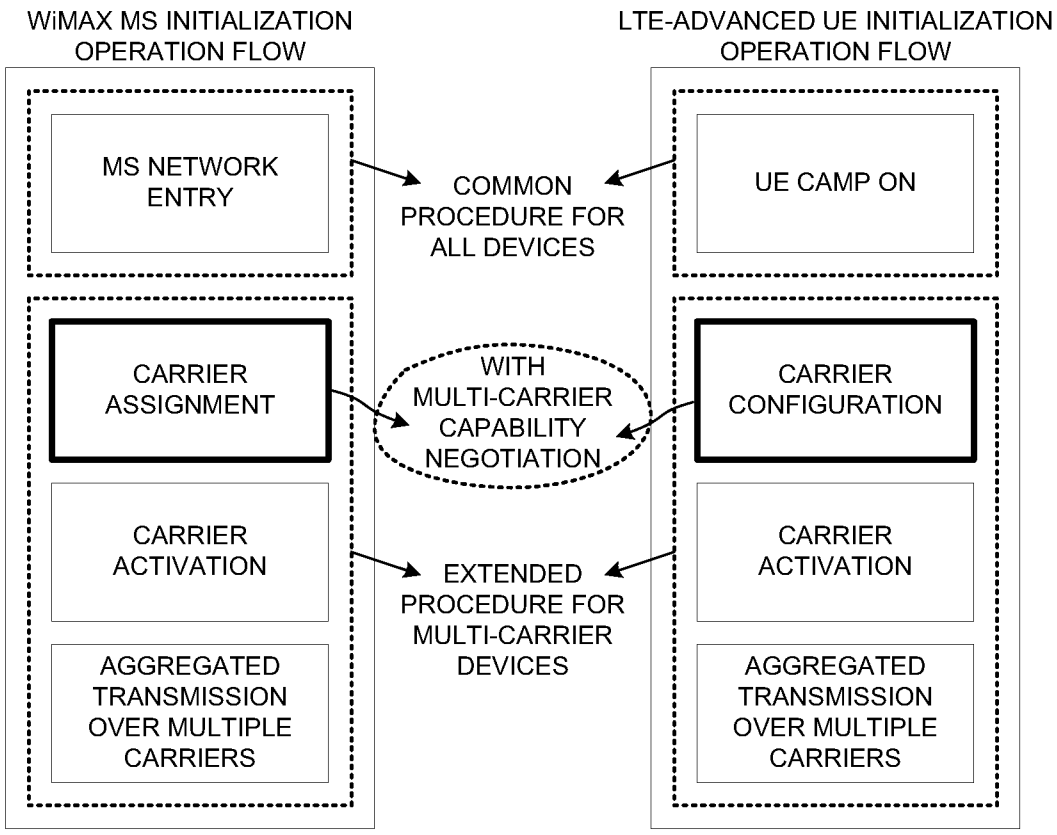
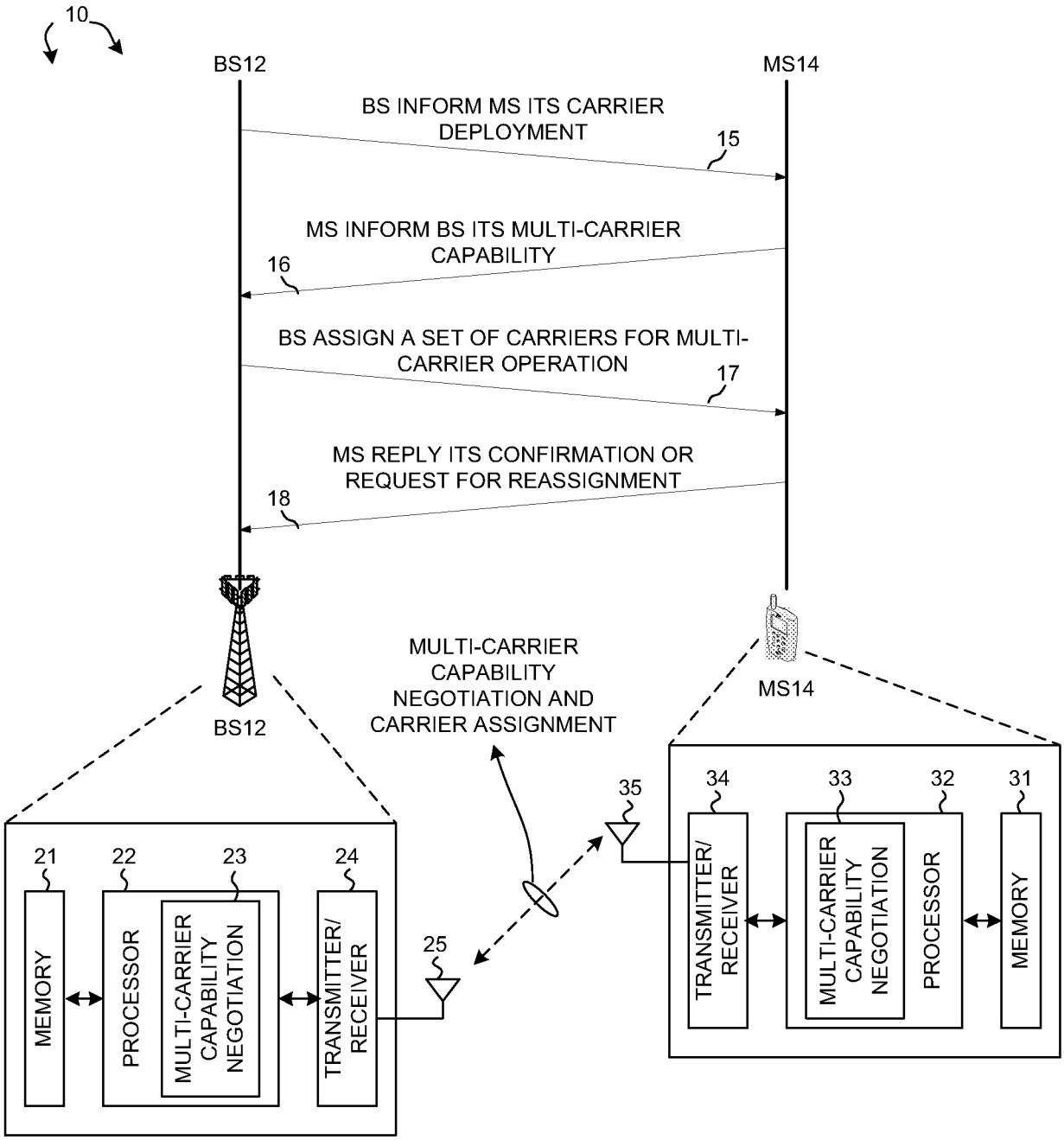

WiMAX MS INITIALIZATION
OPERATION FLOW
LTE-ADVANCED UE INITIALIZATION
OPERATION FLOW
MS NETWORK
ENTRY
UE CAMP ON
COMMON
PROCEDURE FOR
ALL DEVICES
CARRIER
ASSIGNMENT
WITH
MULTI-CARRIER
CAPABILITY
NEGOTIATION
CARRIER
CONFIGURATION
CARRIER
ACTIVATION
CARRIER
ACTIVATION
EXTENDED
PROCEDURE FOR
MULTI-CARRIER
DEVICES
AGGREGATED
TRANSMISSION
OVER MULTIPLE
CARRIERS
AGGREGATED
TRANSMISSION
OVER MULTIPLE
CARRIERS

FIG. 1



NETWORK ASSIGNMENT PROCEDURE FOR MULTI CARRIER OPERATION

FIG. 2

MC-ADV CONTROL MESSAGE FORMAT 30

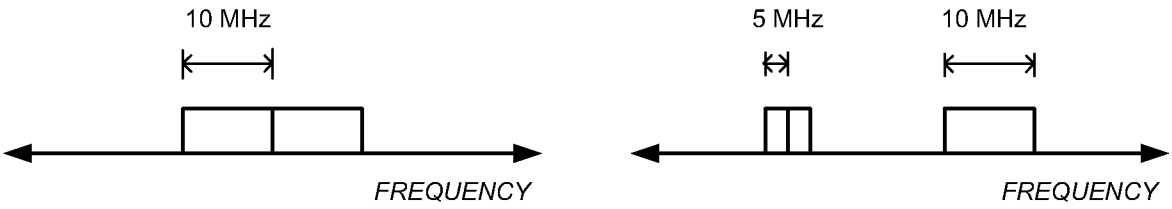
FIELD	SIZE (BIT)	DESCRIPTION
SERVING BS CARRIER NUMBER	3	
SERVING BS UNIFORMITY FLAG	1	0: ALL CARRIERS SUPPORTED BY SERVING BS HAVE THE SAME PROTOCOL VERSION, SFH_INFO 1: OTHERWISE
PHYSICAL CARRIER INDEX OF CURRENT CARRIER	6	THE CARRIER THAT BS BROADCAST THIS MESSAGE
MAC PROTOCOL VERSION	8	
FOR EACH CARRIER {		
PHYSICAL CARRIER INDEX	6	INDEX OF THE PHYSICAL CARRIER
IF SERVING BS UNIFORMITY FLAG ==1 {		
MAC PROTOCOL VERSION	8	

FIG. 3

GLOBAL RF CARRIER CONFIGURATION MESSAGE 40

FIELD	SIZE (BIT)	DESCRIPTION
NUMBER OF CARRIER GROUPS	4	GROUPS OF CONTIGUOUS CARRIERS
FOR EACH CARRIER GROUP {		
MULTI-CARRIER CONFIGURATION INDEX	6	GLOBAL MULTI-CARRIER CONFIGURATION INDEX FOR EACH CARRIER GROUP
START FREQUENCY ASSIGNMENT INDEX	6	FREQUENCY ASSIGNMENT INDEX OF THE FIRST CARRIER IN EACH CARRIER GROUP
NUMBER OF CARRIERS	6	
FOR EACH CARRIER {		
PHYSICAL CARRIER INDEX	6	INDEX OF THE PHYSICAL CARRIER
DUPLEX MODE }	1	"0" FOR TDD "1" FOR FDD
}		
PHYSICAL CARRIER INDEX OF CURRENT CARRIER	6	THE PHYSICAL RF CARRIER THAT BROADCASTS THIS MESSAGE

FIG. 4



DEVICE HARDWARE ARCHITECTURE AND CAPABILITIES TO BE COMMUNICATED DURING CARRIER ASSIGNMENT

FIG. 5

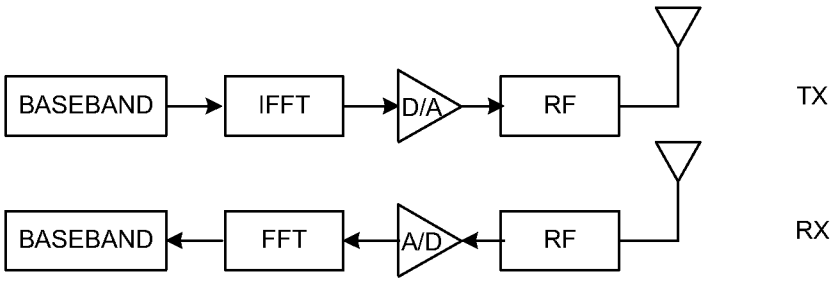


FIG. 6A

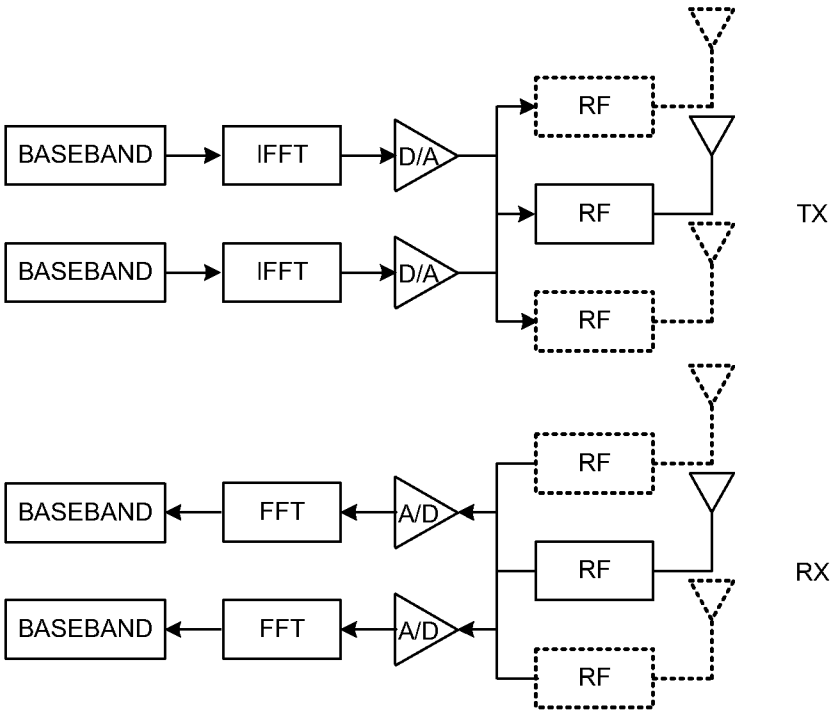


FIG. 6B

MC_REQ MESSAGE FORMAT 70

FIELD	SIZE (BIT)	NOTES
GLOBAL_SUPPORT	1	0b0: THE MS CAN PROCESS A SUBSET OF THE CARRIERS SUPPORTED BY BS 0b1: THE MS CAN PROCESS ALL CARRIERS SUPPORTED BY BS
IF (GLOBAL_SUPPORT ==0) {		
NUMBER OF CANDIDATE COMBINATIONS (N)	4	NUMBER OF CARRIER COMBINATION MS CAN SUPPORT
FOR (i=1; i<N; i++) {		
NUMBER OF CANDIDATE ASSIGNED CARRIER (Nc)	3	NUMBER OF CARRIERS MS CAN SUPPORT
FOR (j=0; j<Nc; j++) {		
PHYSICAL CARRIER INDEX	6	THE CARRIER MS CAN SIMULTANEOUSLY SUPPORT
} } }		

FIG. 7

MC-RSP MESSAGE FORMAT 80

FIELD	SIZE (BIT)	NOTES
GLOBAL_ASSIGN	1	0b0: THE BS ASSIGNS A SUBSET OF THE CARRIERS REQUESTED BY MS 0b1: THE BS ASSIGNS ALL THE CARRIERS REQUESTED BY MS
IF (GLOBAL_ASSIGN ==0) {		
NUMBER OF ASSIGNED CARRIERS (N)	3	NUMBER OF CARRIERS TO BE ASSIGNED
FOR (i=1; i<n; i++) {		
PHYSICAL CARRIER INDEX	6	THE CARRIER TO BE ASSIGNED
} }		

FIG. 8

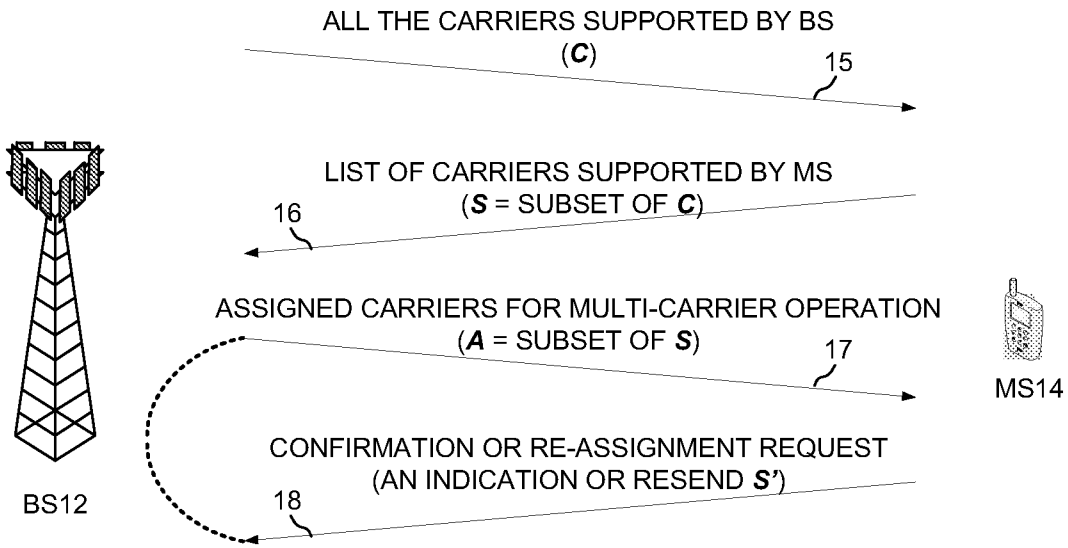

ALL THE CARRIERS SUPPORTED BY BS
(C)
15
LIST OF CARRIERS SUPPORTED BY MS
(S = SUBSET OF C)
16
ASSIGNED CARRIERS FOR MULTI-CARRIER OPERATION
(A = SUBSET OF S)
17
CONFIRMATION OR RE-ASSIGNMENT REQUEST
(AN INDICATION OR RESEND S')
18
BS12
MS14

FIG. 9

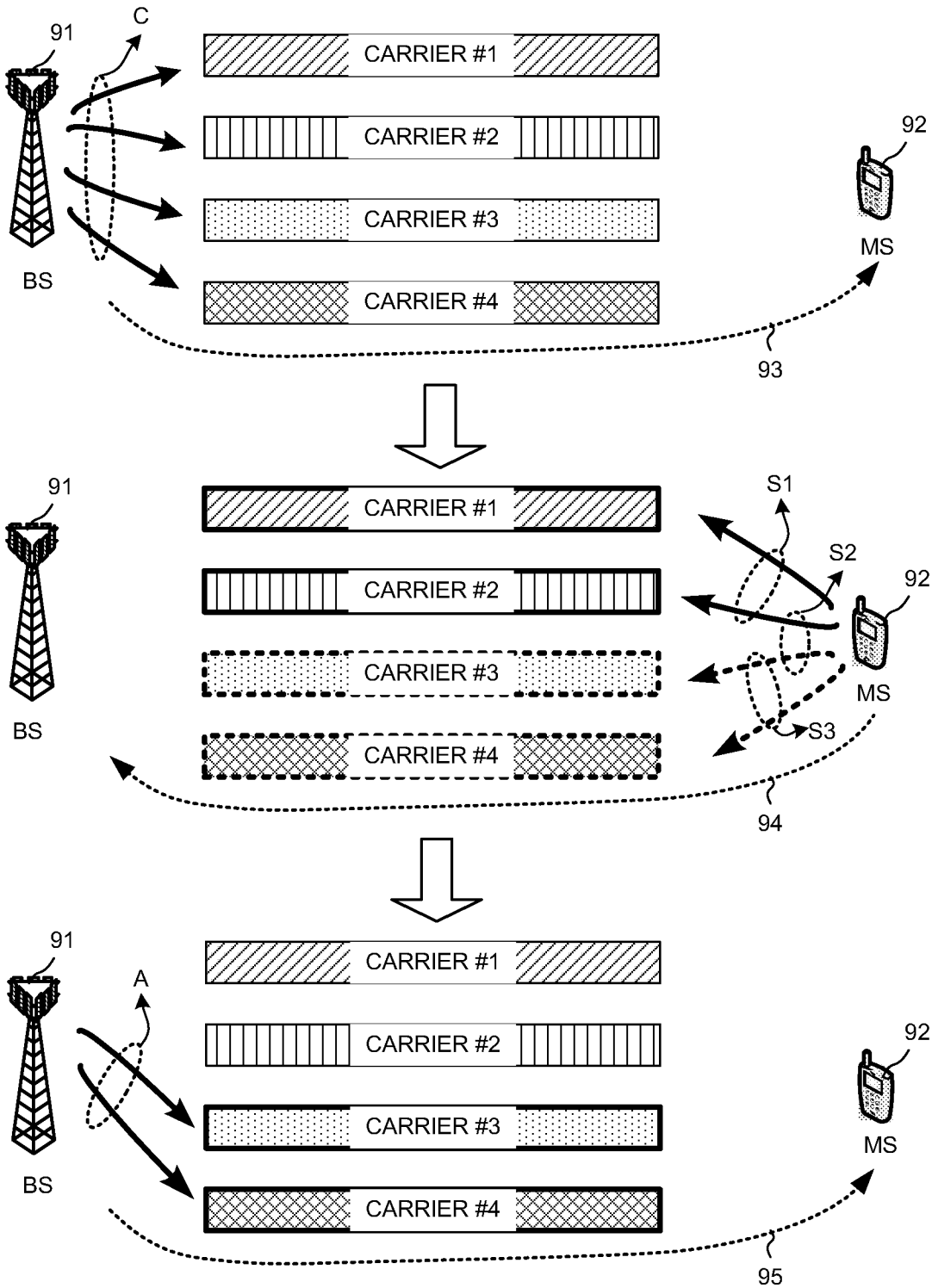

91
C
CARRIER #1
CARRIER #2
CARRIER #3
CARRIER #4
92
MS
BS
93
91
S1
S2
92
CARRIER #1
CARRIER #2
CARRIER #3
CARRIER #4
MS
BS
S3
94
91
A
CARRIER #1
CARRIER #2
CARRIER #3
CARRIER #4
92
MS
BS
95

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2010/072148

A. CLASSIFICATION OF SUBJECT MATTER

H04B7/00 (2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC:H04B7/-; H04Q7/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CPRSABS, CNKI, EPODOC, WPI: CARRIER?, MULTI WCARRIER?, CONFIGURAT+, ASSIGN+, DEPLOY+, ALLOCAT+, DISTRIBUT+?, SUPPORT+, CAPABILITY

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN101345988A (DATANG MOBILE COMM EQUIP CO) 14 Jan. 2009 (14.01.2009) the whole document	1-26
A	CN1889751A (SHANGHAI YUANDONGLI COMMUNICATION SCI TE) 03 Jan.2007 (03.01.2007) the whole document	1-26
A	CN101237602A (HUAWEI TECHNOLOGIES CO LTD)06 Aug. 2008 (06.08.2008) the whole document	1-26
A	KR20070092578A (LG ELECTRONICS INC) 13 Sep.2007 (13.09.2007) the whole document	1-26

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 Jul. 2010 (07.07.2010)	**22 Jul. 2010 (22.07.2010)**
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer JIANG Jingjing Telephone No. (86-10)62411430

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2010/072148

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN101345988A	14.01.2009	None	
CN1889751A	03.01.2007	CN100431374C	05.11.2008
		WO2007000095A1	04.01.2007
		KR20080025130A	19.03.2008
		US20100014467A1	21.01.2010
CN101237602A	06.08.2008	WO2008095434A1	14.08.2008
		EP2028868A1	25.02.2009
KR20070092578A	13.09.2007	None	