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Dural et al.

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(54) **GRANT PROCESSING FOR FLEXIBLE BANDWIDTH CARRIER SYSTEMS**

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(51) **Int. Cl.**

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H04W 74/00	(2009.01)
H04W 72/04	(2009.01)
H04L 5/00	(2006.01)

(52) **U.S. Cl.**

CPC ***H04W 74/002*** (2013.01); ***H04L 5/0053*** (2013.01); ***H04W 72/0446*** (2013.01); *H04L 5/0005* (2013.01); *H04L 5/0085* (2013.01)

(58) **Field of Classification Search**

CPC H04L 74/002; H04L 74/006
USPC 370/338–342
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2005/0043051 A1* 2/2005 Takano et al. 455/522
2009/0180414 A1 7/2009 Maeda et al.
2009/0296643 A1 12/2009 Cave et al.
2009/0316575 A1 12/2009 Gholmieh et al.
2010/0130219 A1 5/2010 Cave et al.
2010/0272078 A1* 10/2010 Pani et al. 370/336
2010/0303039 A1 12/2010 Zhang et al.

(Continued)

FOREIGN PATENT DOCUMENTS

WO WO-2010078365 A1 7/2010
WO WO-2013070751 A1 5/2013

OTHER PUBLICATIONS

3GPP TSG-RAN WG2 Meeting #66: DTX and carrier activation/deactivation for DC-HSUPA, InterDigital, R2-093201, San Francisco, US, May 4-8, 2009, 3 pgs.
Kramer G., et al., Interleaved Polling with Adaptive Cycle Time (IPACT): A Dynamic Bandwidth Distribution Scheme in an Optical Access Network, Jul. 2001, pp. 1-39.
ISA/EPO, International Search Report and Written Opinion of the International Searching Authority, Int'l App. No. PCT/US2014/055843, Dec. 15, 2014, European Patent Office, Rijswijk, NL, 11 pgs.

(Continued)

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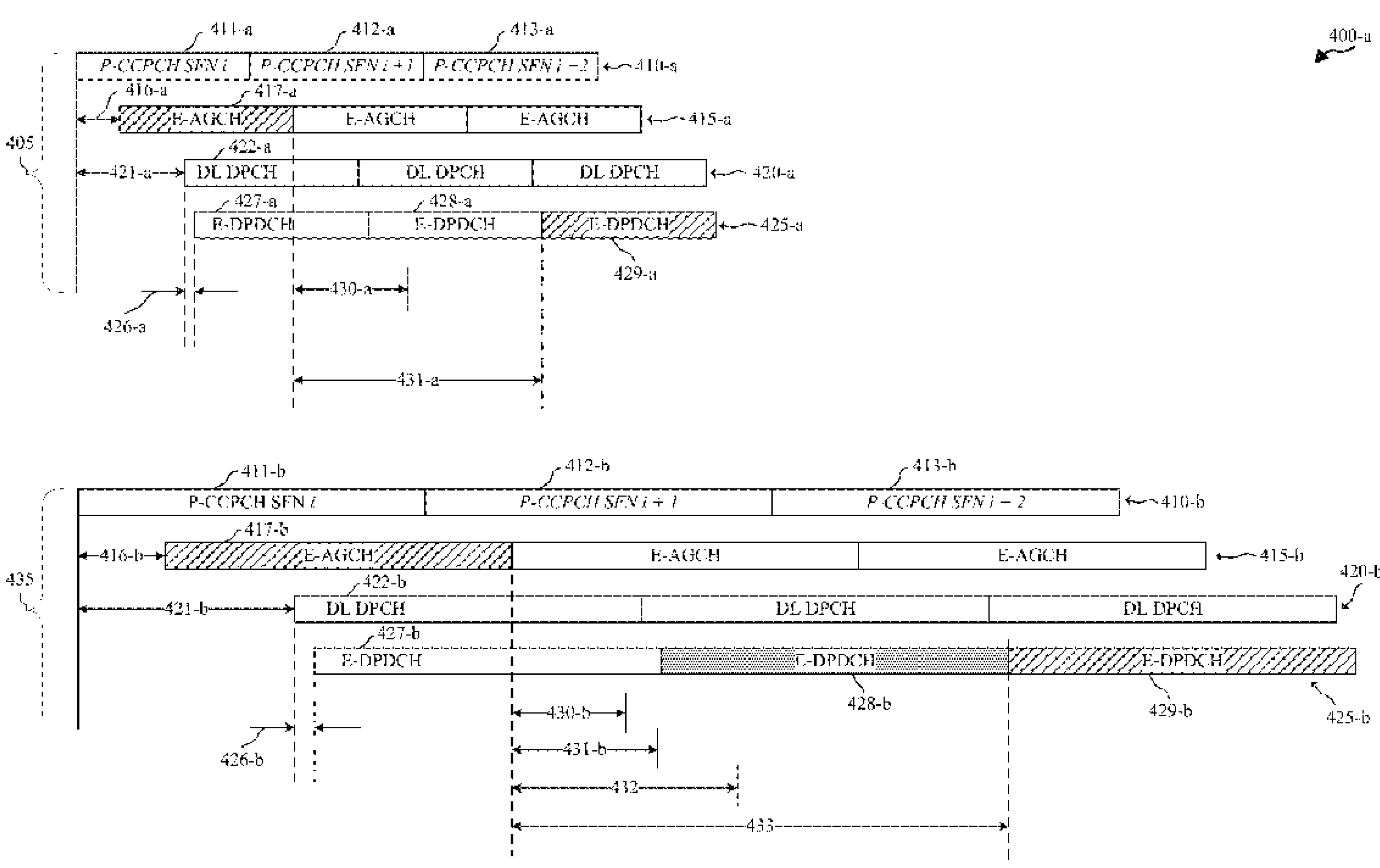
(57) **ABSTRACT**

Methods, systems, and devices are described for control information processing and utilization in a wireless communications system that utilizes one or more flexible bandwidth carriers. The methods may include receiving control information over a first channel of one of the one or more flexible bandwidth carriers, determining a processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers based on a processing time of control information for another bandwidth carrier, and utilizing the received control information over the first channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval of the first channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers.

32 Claims, 13 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2010/0323683	A1	12/2010	Kazmi et al.	
2011/0002281	A1	1/2011	Terry et al.	
2011/0090806	A1	4/2011	Ozturk et al.	
2011/0212742	A1	9/2011	Chen et al.	
2012/0263118	A1*	10/2012	Love et al.	370/329
2012/0307689	A1	12/2012	Kim et al.	
2013/0072208	A1	3/2013	Marinier et al.	
2013/0114473	A1	5/2013	Awoniyi et al.	
2013/0148527	A1*	6/2013	Awiniyi et al.	370/252
2015/0092638	A1	4/2015	Dural et al.	

OTHER PUBLICATIONS

Huawei et al., "Introduction of S-UMTS," 3GPP TSG-RAN WG1 Meeting #72, St Julian's, Malta, Jan. 28-Feb. 1, 2013, R1-130514, 7 pgs., 3rd Generation Partnership Project.

Motorola, "DRX in LTE-A," 3GPP TSG RAN2 #67, Shenzhen, China, Aug. 24-29, 2009, R2-094736, 3 pgs., 3rd Generation Partnership Project.

IPEA/EPO, Second Written Opinion of the International Preliminary Examining Authority, Int'l App. No. PCT/US2014/055843, Aug. 14, 2015, European Patent Office, Rijswijk, NL, 8 pgs.

* cited by examiner

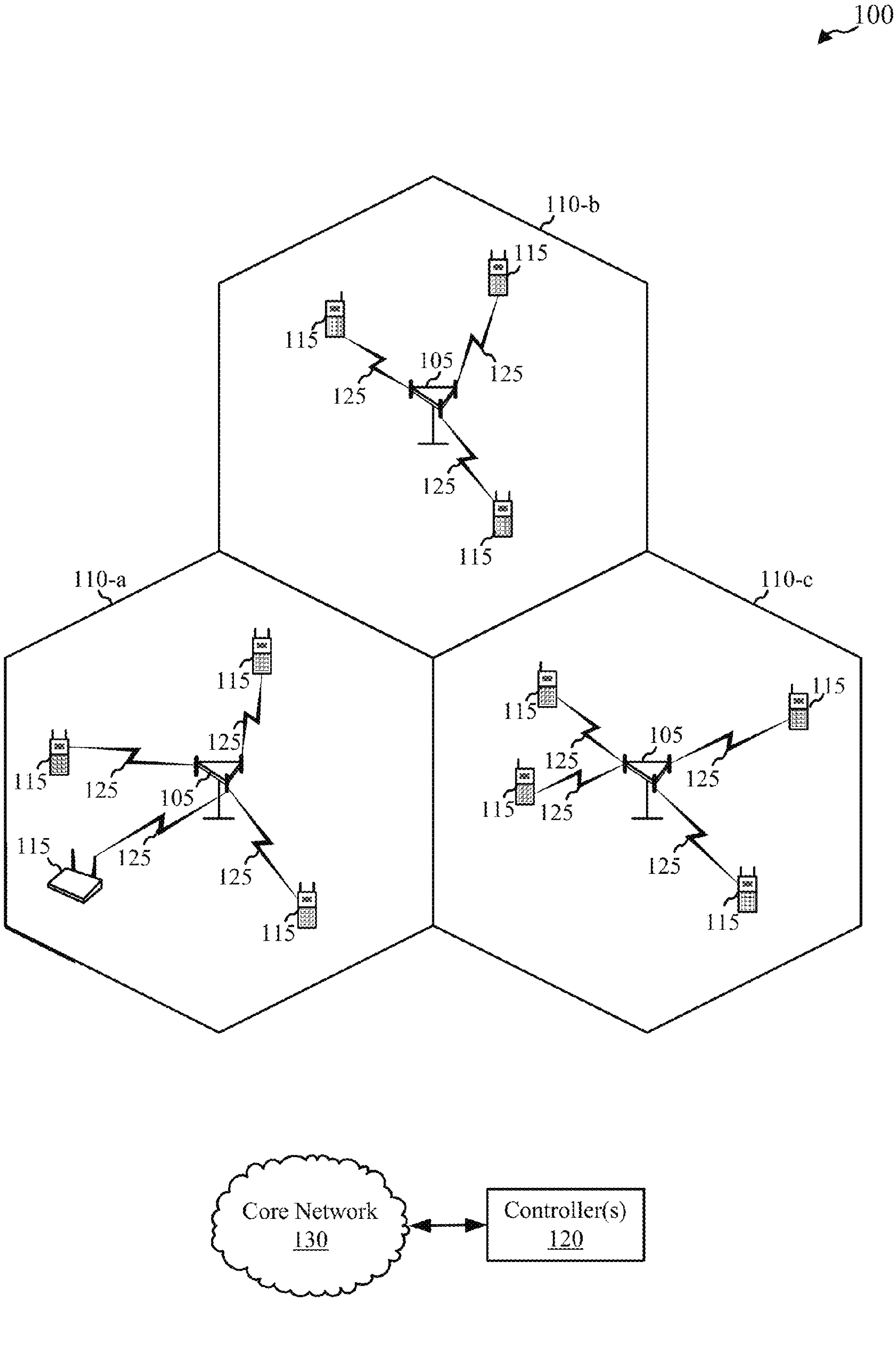

100
110-b
110-a
110-c
115
125
105
Core Network
130
Controller(s)
120

FIG. 1

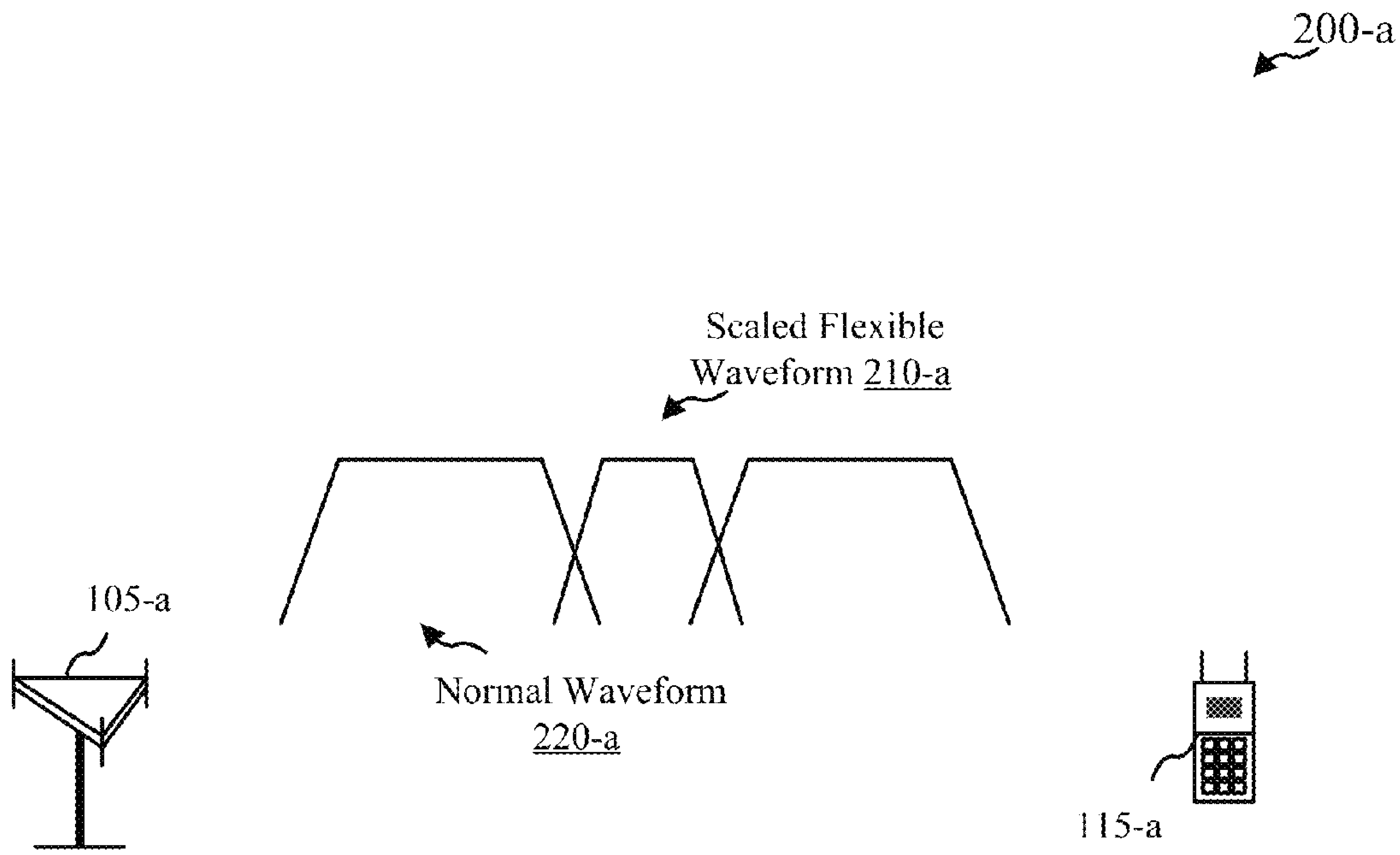

200-a
Scaled Flexible Waveform 210-a
105-a
Normal Waveform 220-a
115-a

FIG. 2A

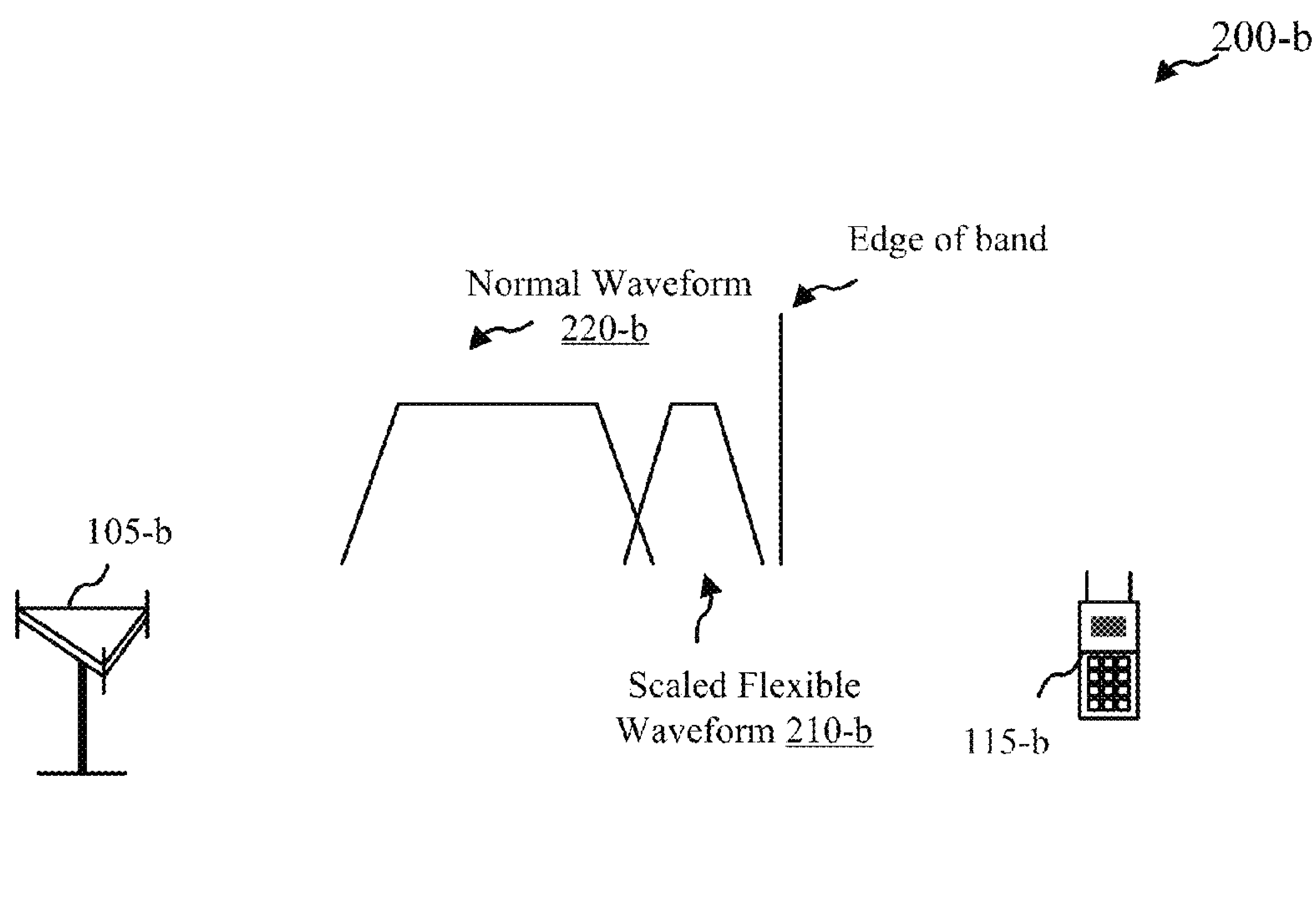

200-b
Edge of band
Normal Waveform 220-b
105-b
Scaled Flexible Waveform 210-b
115-b

FIG. 2B

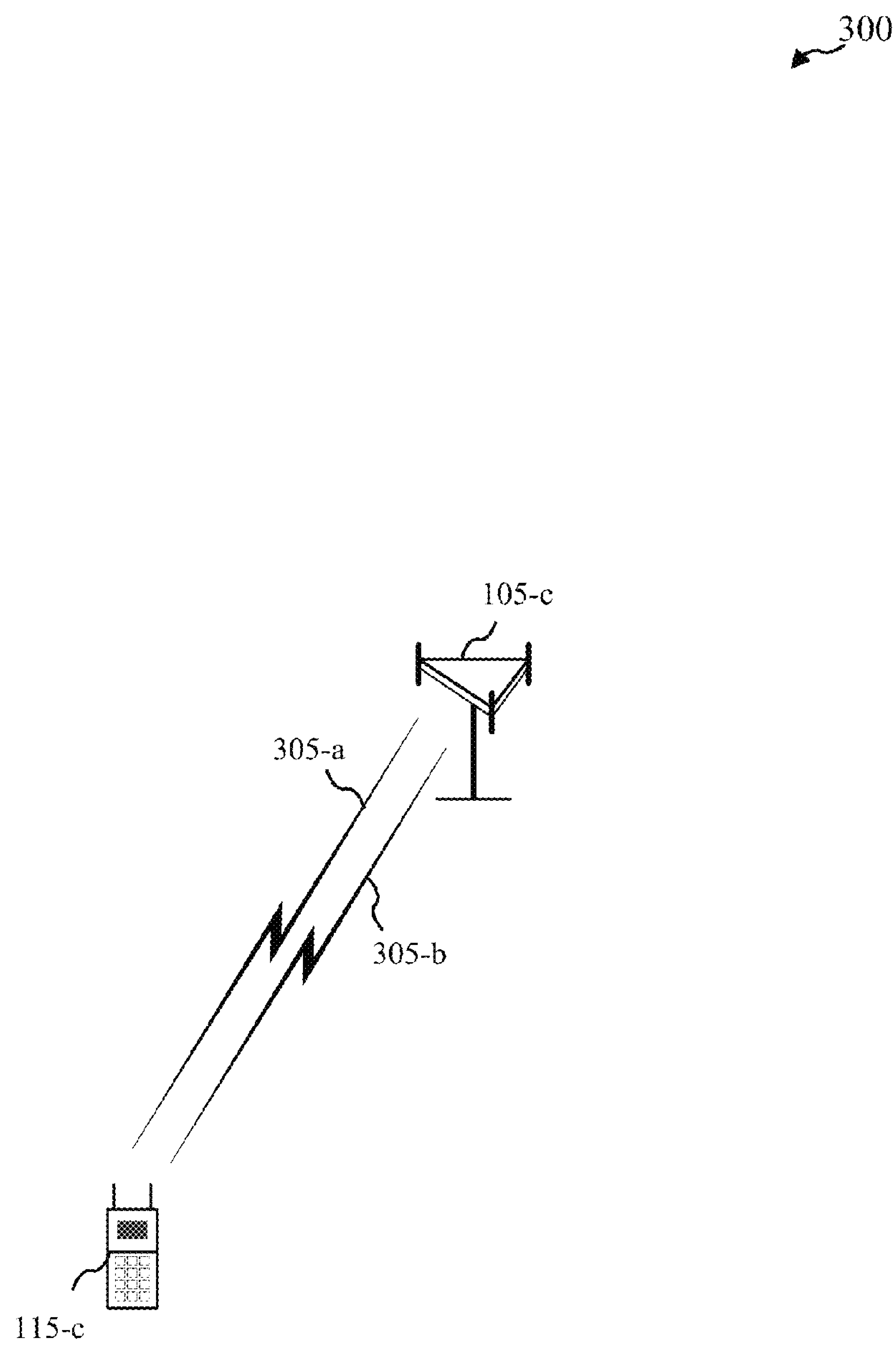


FIG. 3

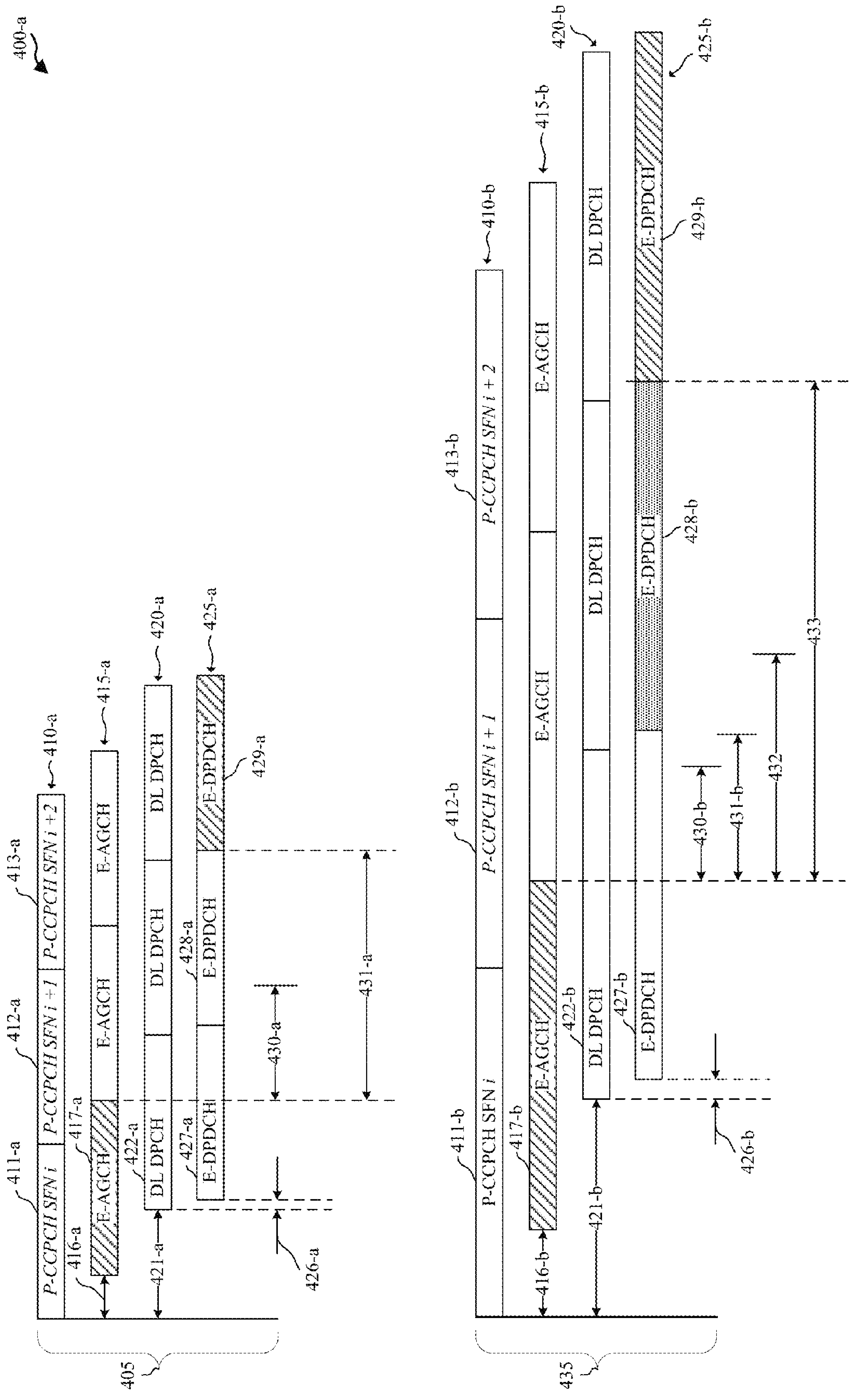

400-a
P-CCPCH SFN i
P-CCPCH SFN i +1
P-CCPCH SFN i +2
E-AGCH
DL DPCH
E-DPDCH
405
410-a
411-a
412-a
413-a
415-a
416-a
417-a
420-a
421-a
422-a
425-a
426-a
427-a
428-a
429-a
430-a
431-a
435
410-b
411-b
412-b
413-b
415-b
416-b
417-b
420-b
421-b
422-b
425-b
426-b
427-b
428-b
429-b
430-b
431-b
432
433

FIG. 4A

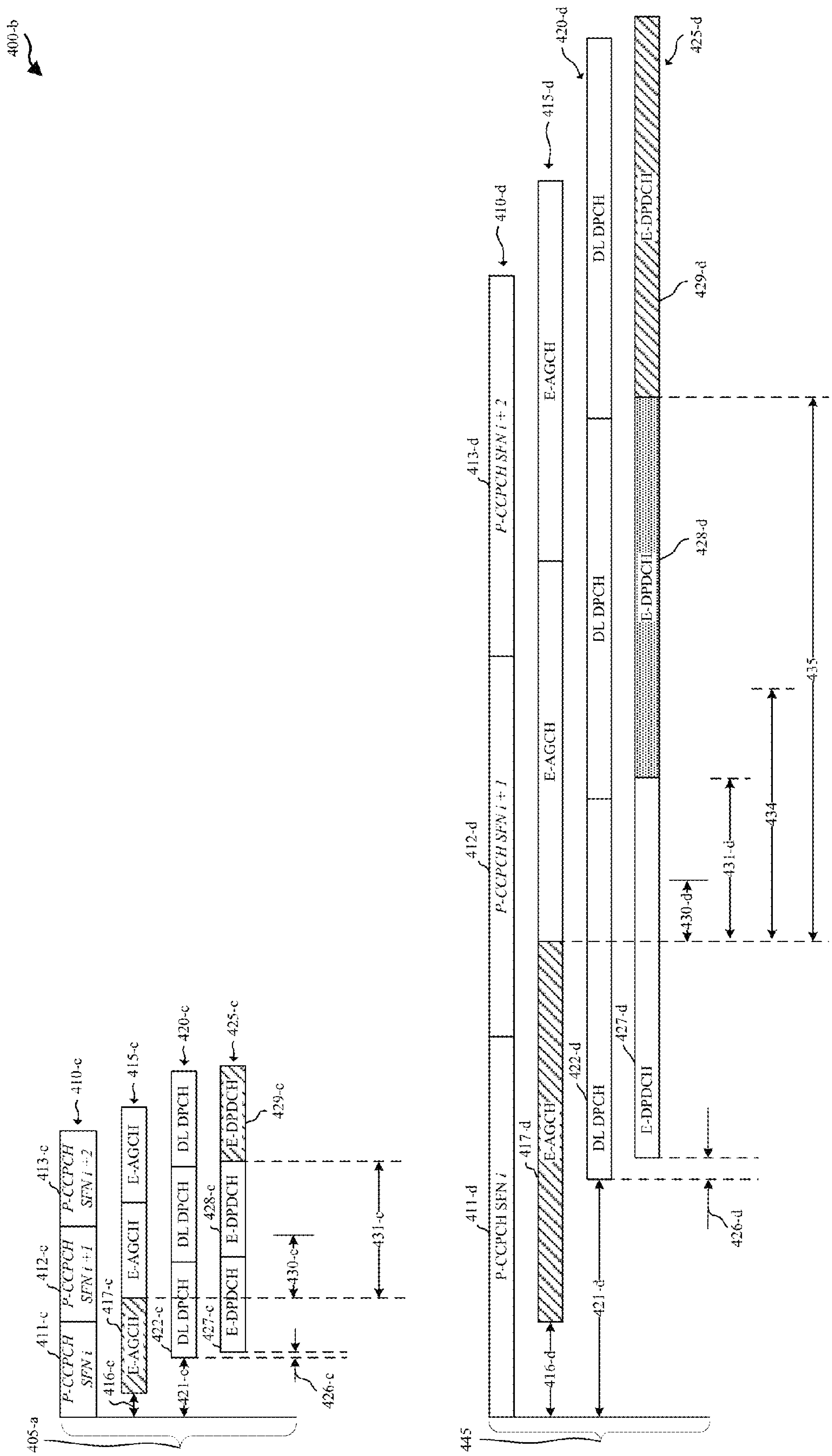

400-b
405-a
410-c
411-c
412-c
413-c
P-CCPCH SFN i
P-CCPCH SFN i+1
P-CCPCH SFN i+2
415-c
416-c
417-c
E-AGCH
E-AGCH
E-AGCH
420-c
421-c
422-c
DL DPCH
DL DPCH
DL DPCH
DL DPCH
425-c
426-c
427-c
428-c
429-c
E-DPDCH
E-DPDCH
E-DPDCH
E-DPDCH
430-c
431-c
445
410-d
411-d
412-d
413-d
P-CCPCH SFN i
P-CCPCH SFN i + 1
P-CCPCH SFN i + 2
415-d
416-d
417-d
E-AGCH
E-AGCH
E-AGCH
E-AGCH
420-d
421-d
422-d
DL DPCH
DL DPCH
DL DPCH
425-d
426-d
427-d
428-d
429-d
E-DPDCH
E-DPDCH
E-DPDCH
430-d
431-d
434
435

FIG. 4B

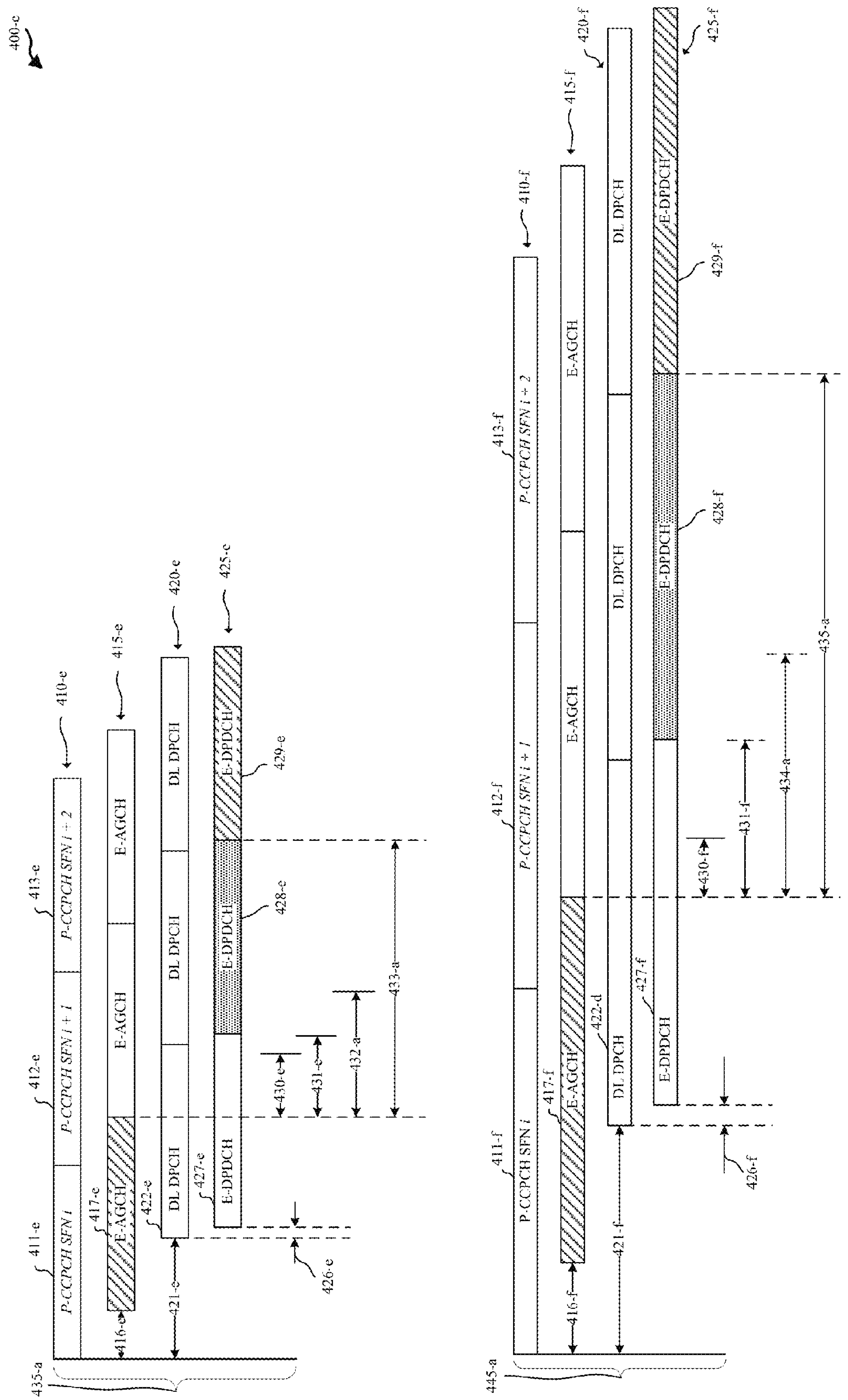

400-e
410-e
411-e
412-e
413-e
P-CCPCH SFN i
P-CCPCH SFN i + 1
P-CCPCH SFN i + 2
415-e
416-e
417-e
E-AGCH
E-AGCH
E-AGCH
420-e
421-e
422-e
DL DPCH
DL DPCH
DL DPCH
425-e
426-e
427-e
428-e
429-e
E-DPDCH
E-DPDCH
E-DPDCH
430-e
431-e
432-a
433-a
435-a
410-f
411-f
412-f
413-f
P-CCPCH SFN i
P-CCPCH SFN i + 1
P-CCPCH SFN i + 2
415-f
416-f
417-f
E-AGCH
E-AGCH
E-AGCH
420-f
421-f
422-d
DL DPCH
DL DPCH
DL DPCH
425-f
426-f
427-f
428-f
429-f
E-DPDCH
E-DPDCH
E-DPDCH
430-f
431-f
434-a
435-a
445-a

FIG. 4C

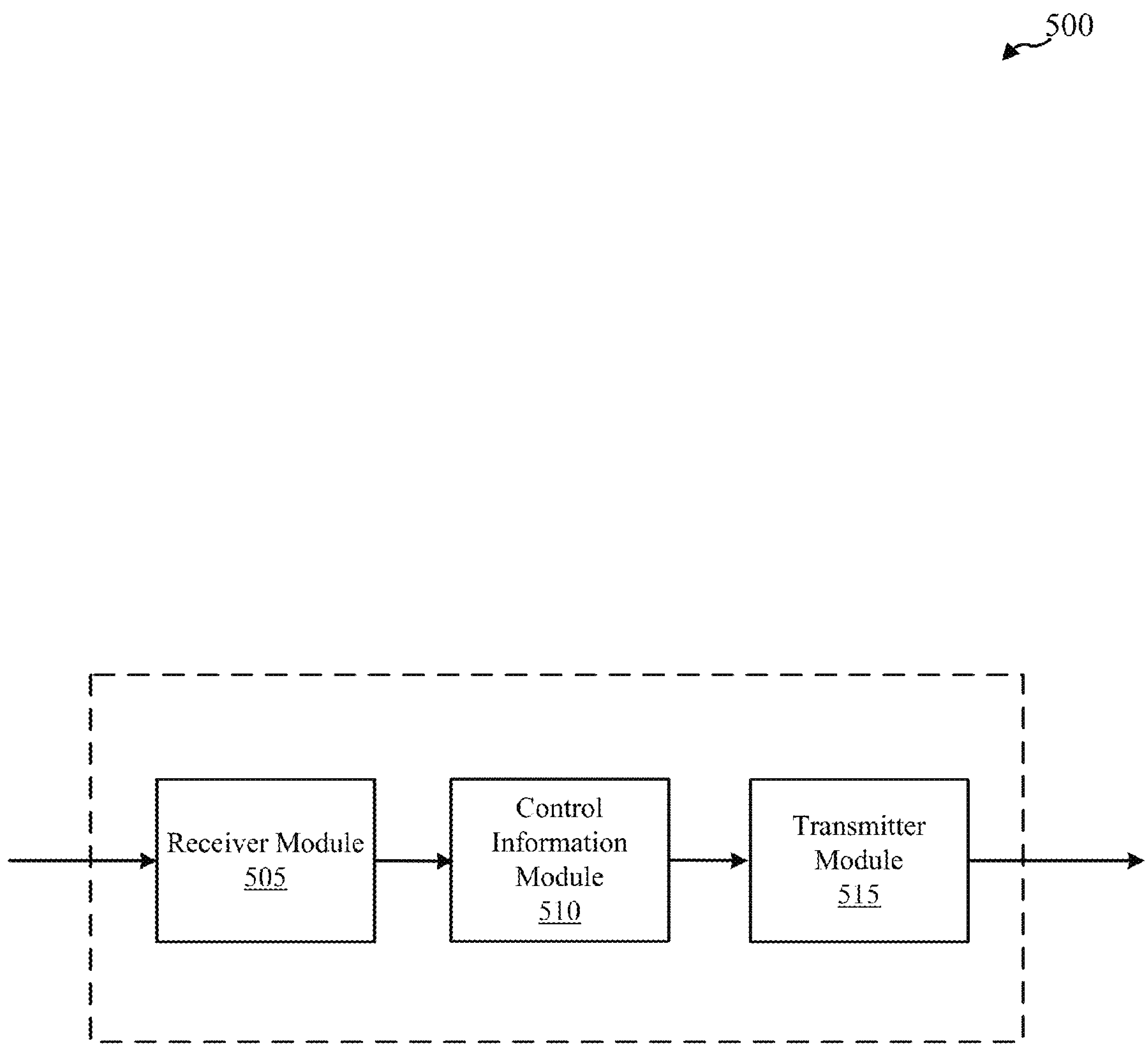

500
Receiver Module
505
Control
Information
Module
510
Transmitter
Module
515

FIG. 5A

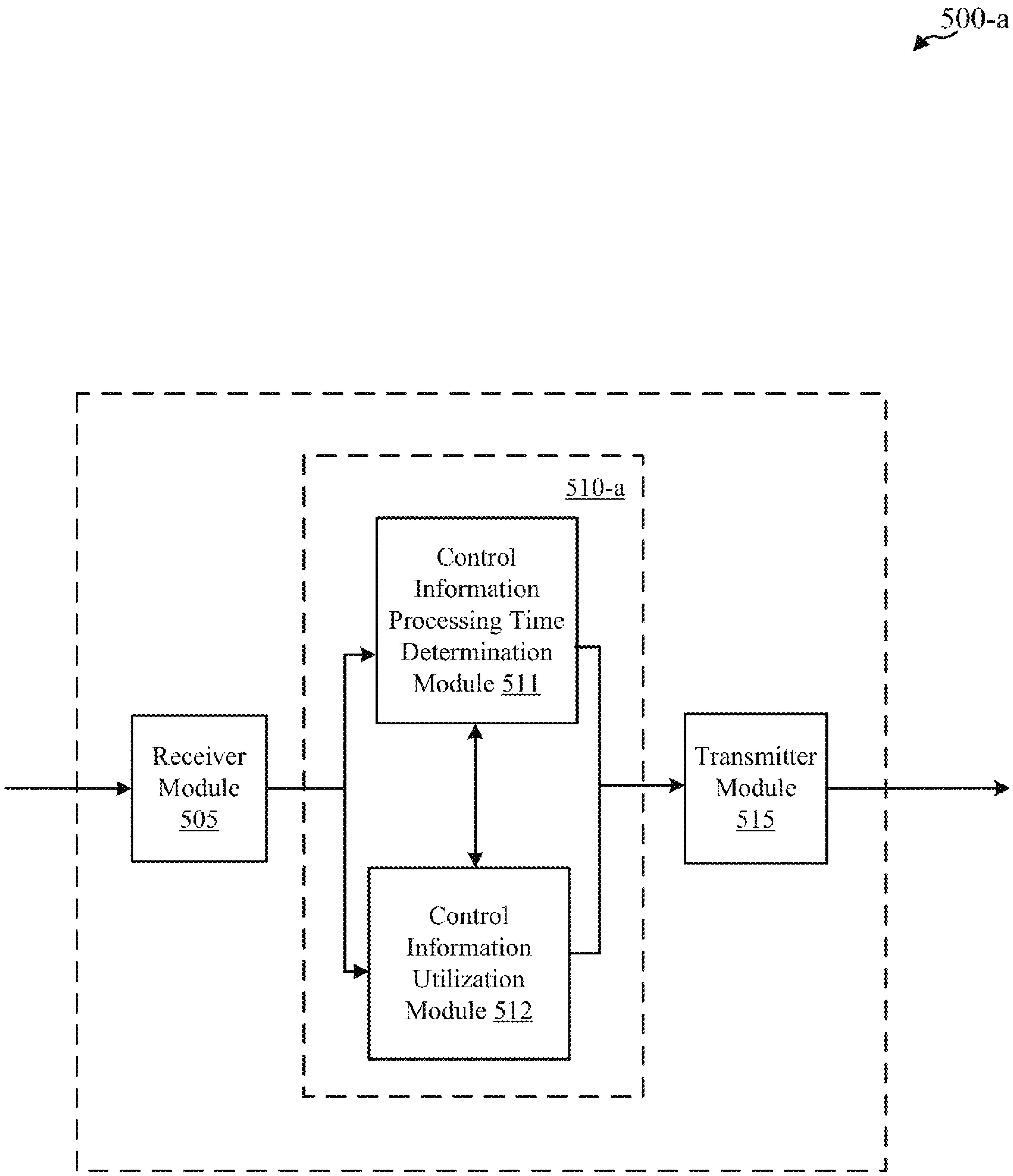

500-a
510-a
Control Information Processing Time Determination Module 511
Receiver Module 505
Transmitter Module 515
Control Information Utilization Module 512

FIG. 5B

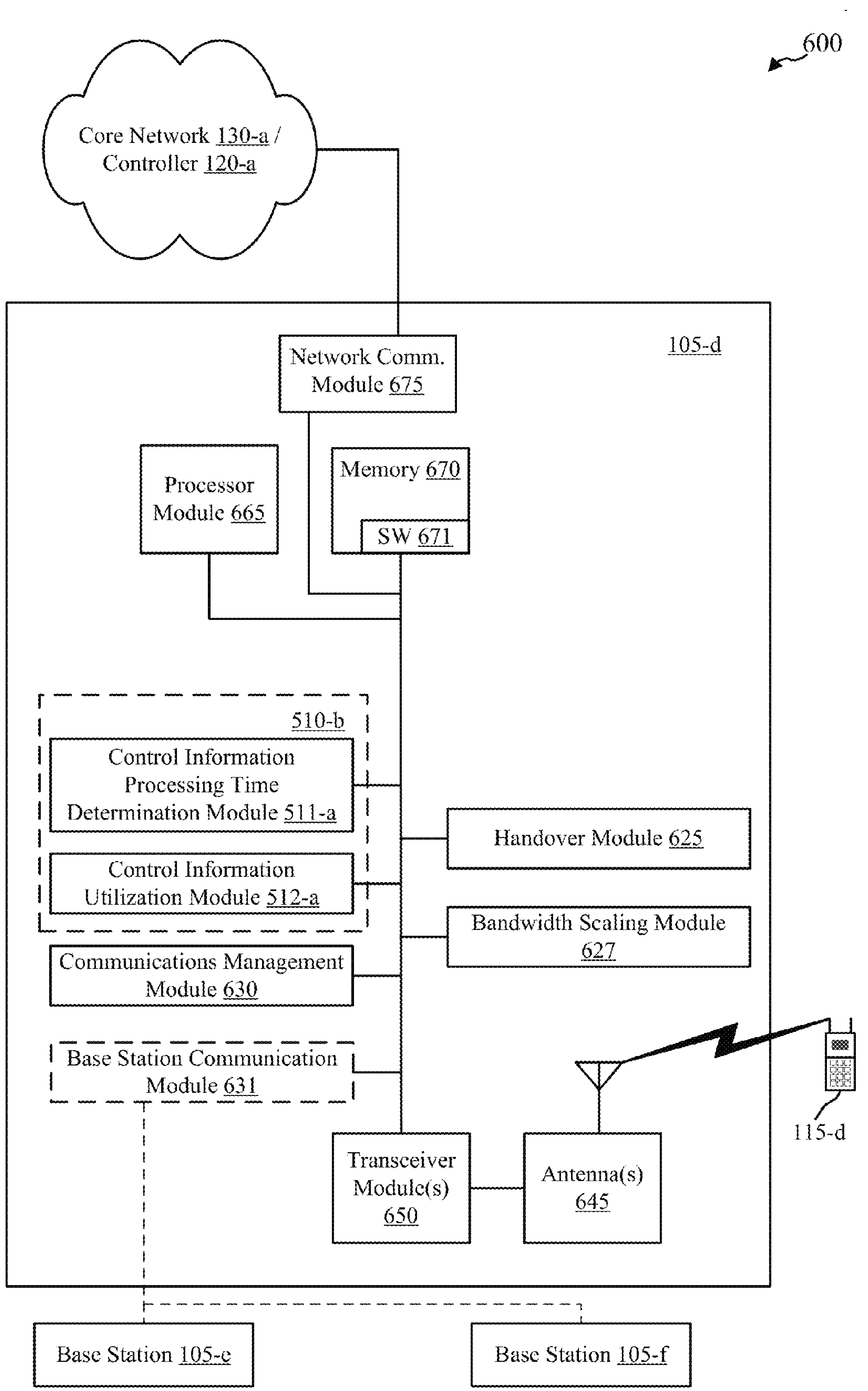

600
Core Network 130-a / Controller 120-a
105-d
Network Comm. Module 675
Processor Module 665
Memory 670
SW 671
510-b
Control Information Processing Time Determination Module 511-a
Control Information Utilization Module 512-a
Handover Module 625
Bandwidth Scaling Module 627
Communications Management Module 630
Base Station Communication Module 631
Transceiver Module(s) 650
Antenna(s) 645
115-d
Base Station 105-e
Base Station 105-f

FIG. 6

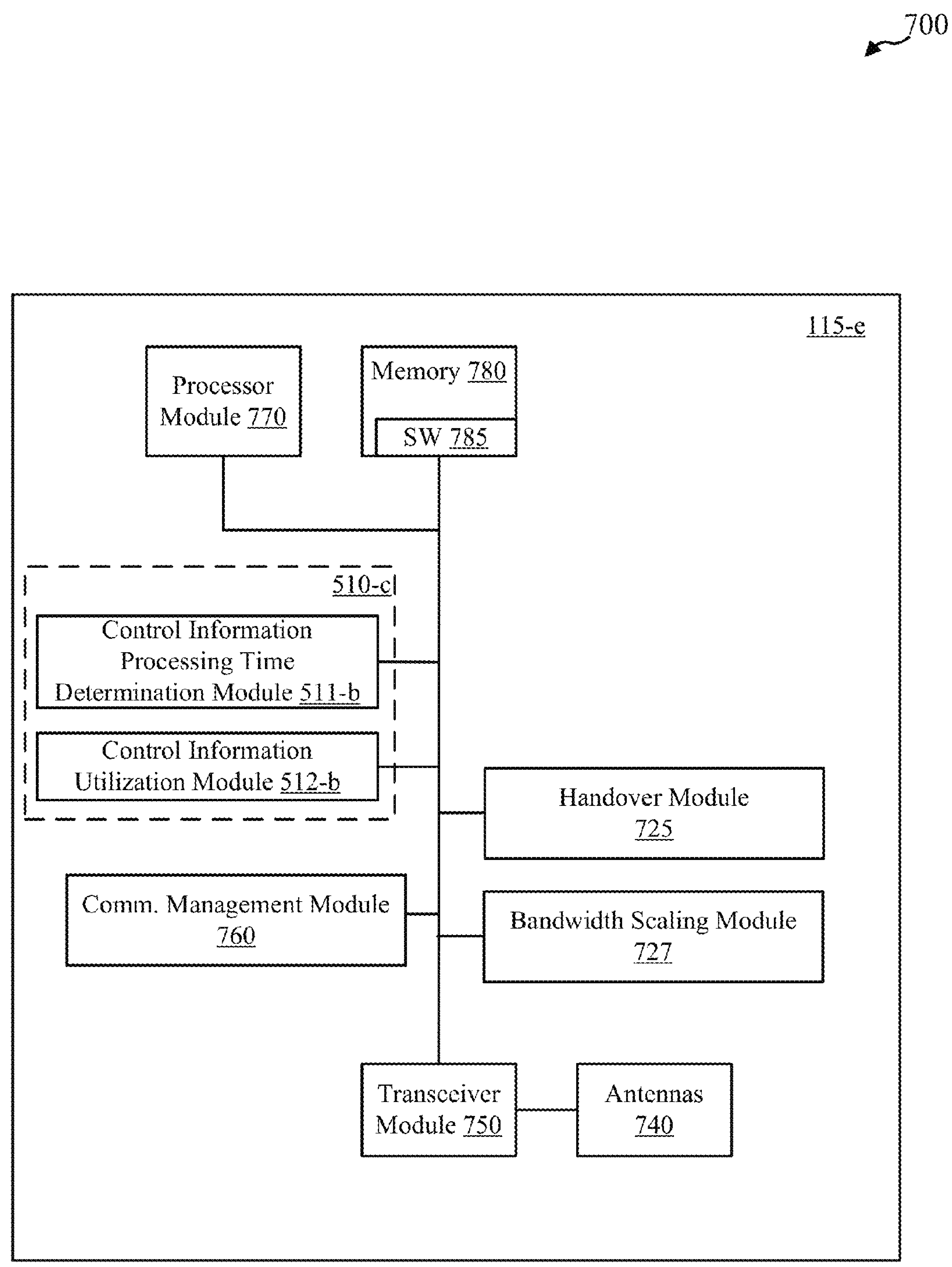

700
115-e
Processor Module 770
Memory 780
SW 785
510-c
Control Information Processing Time Determination Module 511-b
Control Information Utilization Module 512-b
Handover Module 725
Comm. Management Module 760
Bandwidth Scaling Module 727
Transceiver Module 750
Antennas 740

FIG. 7

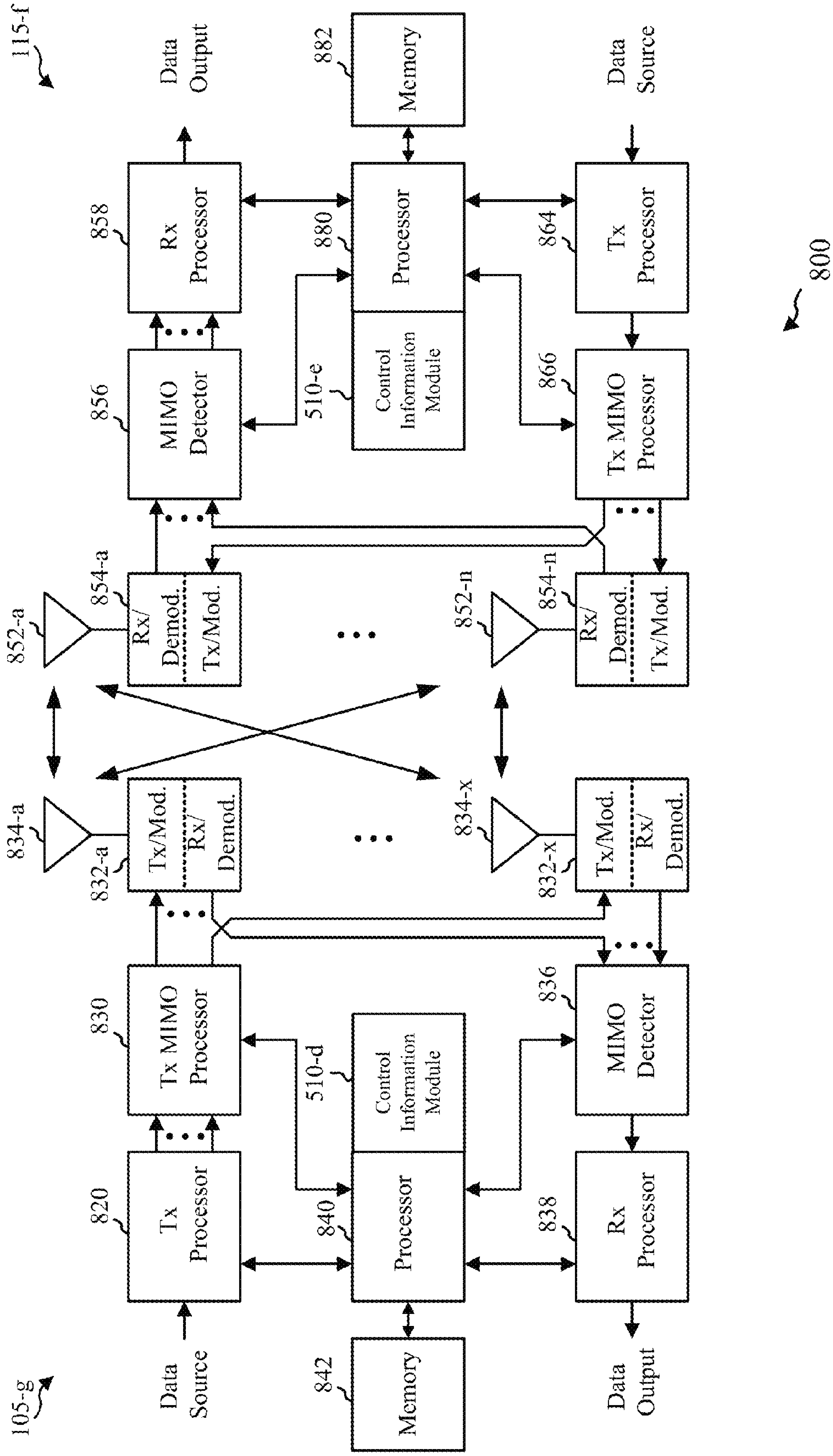

115-f
Data Output
882
Memory
Data Source
858
Rx Processor
880
Processor
864
Tx Processor
800
856
MIMO Detector
510-e
Control Information Module
866
Tx MIMO Processor
852-a
854-a
Rx/ Demod.
Tx/Mod.
852-n
854-n
Rx/ Demod.
Tx/Mod.
834-a
832-a
Tx/Mod.
Rx/ Demod.
834-x
832-x
Tx/Mod.
Rx/ Demod.
830
Tx MIMO Processor
510-d
Control Information Module
836
MIMO Detector
820
Tx Processor
840
Processor
838
Rx Processor
105-g
Data Source
842
Memory
Data Output

FIG. 8

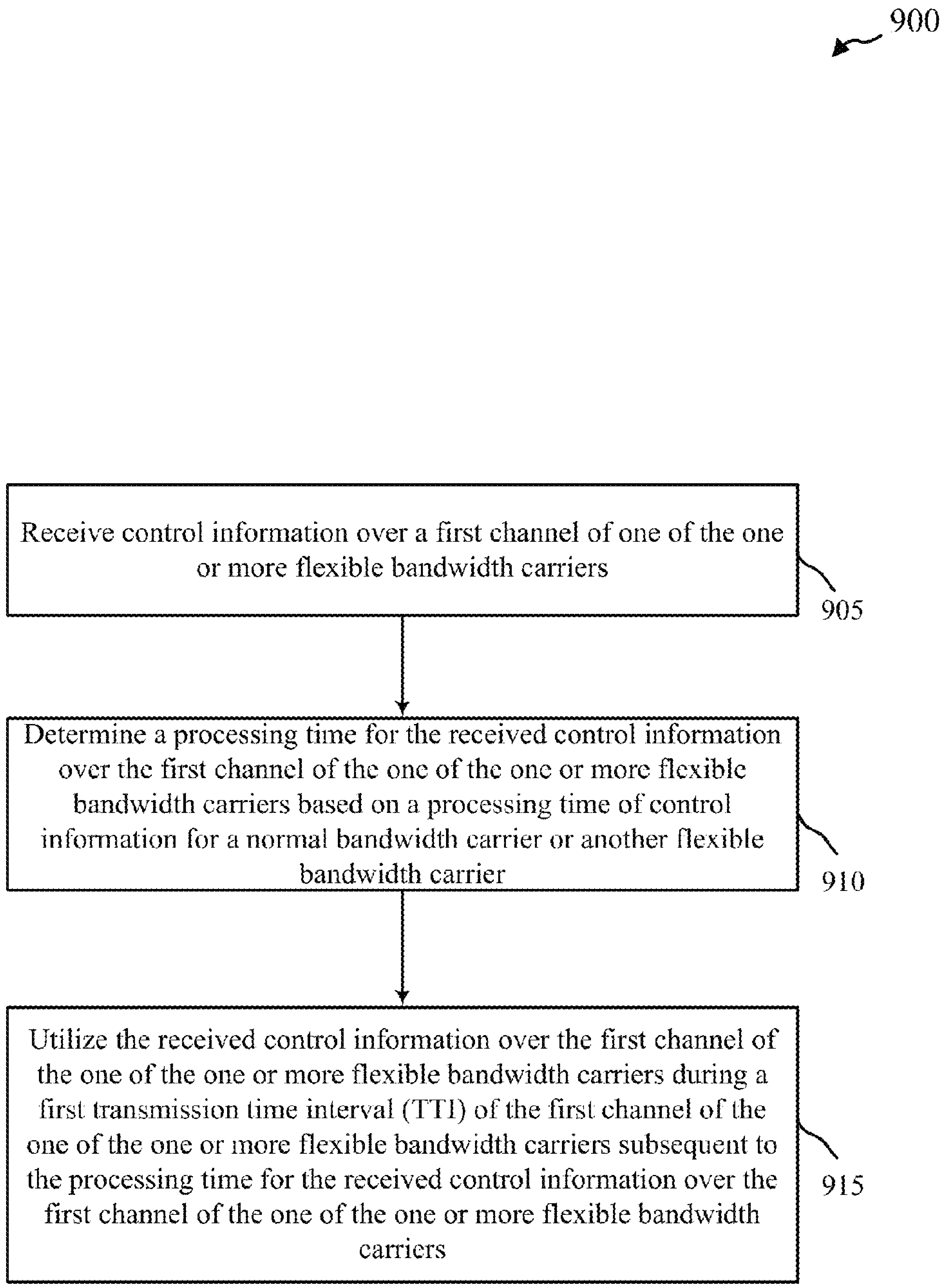

900
Receive control information over a first channel of one of the one or more flexible bandwidth carriers
905
Determine a processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers based on a processing time of control information for a normal bandwidth carrier or another flexible bandwidth carrier
910
Utilize the received control information over the first channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the first channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers
915

FIG. 9A

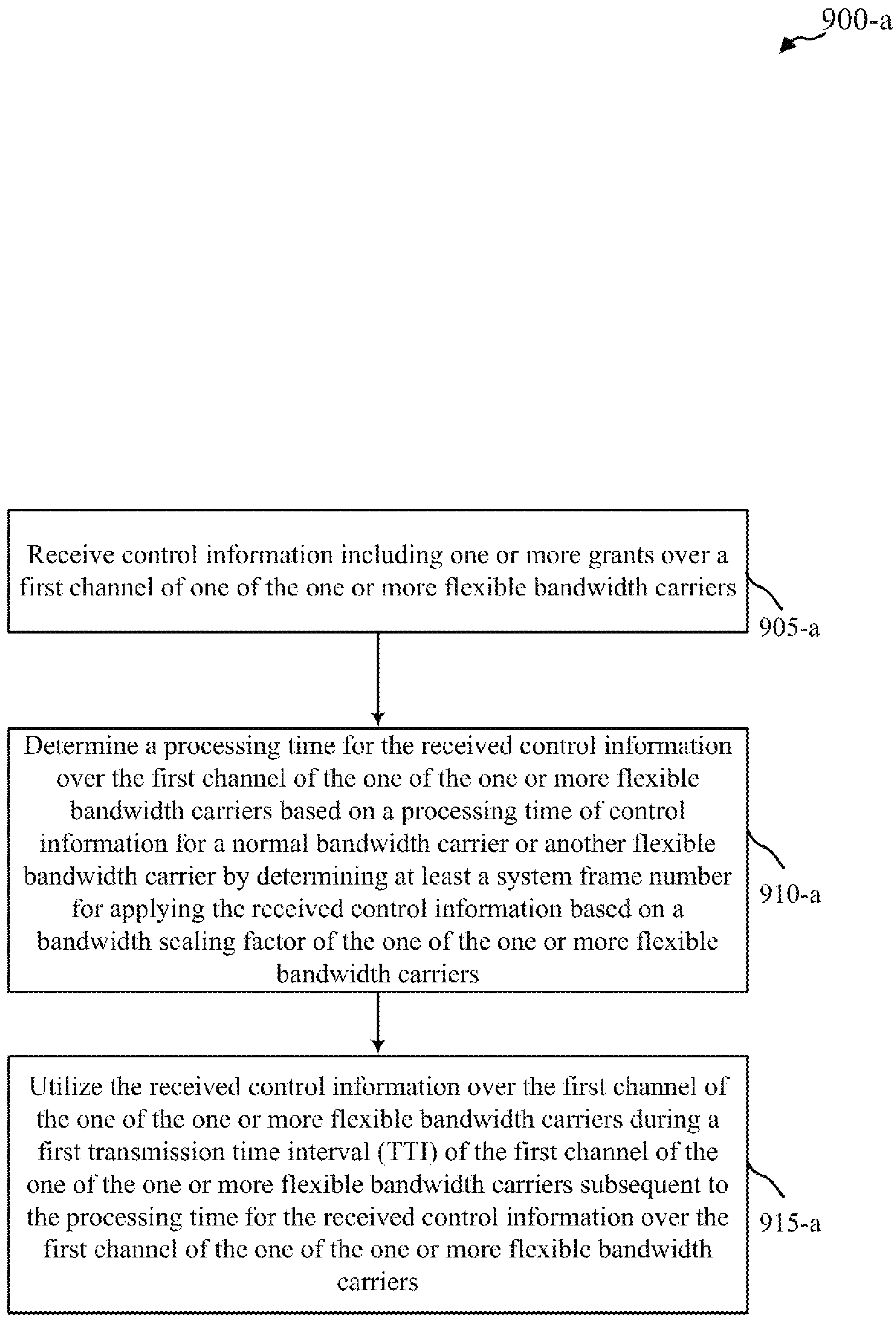

900-a
Receive control information including one or more grants over a first channel of one of the one or more flexible bandwidth carriers
905-a
Determine a processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers based on a processing time of control information for a normal bandwidth carrier or another flexible bandwidth carrier by determining at least a system frame number for applying the received control information based on a bandwidth scaling factor of the one of the one or more flexible bandwidth carriers
910-a
Utilize the received control information over the first channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the first channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers
915-a

FIG. 9B

GRANT PROCESSING FOR FLEXIBLE BANDWIDTH CARRIER SYSTEMS

BACKGROUND

Wireless communications systems are widely deployed to provide various types of communication content such as voice, video, packet data, messaging, broadcast, and so on. These systems may be multiple-access systems capable of supporting communication with multiple users by sharing the available system resources (e.g., time, frequency, and power). Examples of such multiple-access systems include code-division multiple access (CDMA) systems, time-division multiple access (TDMA) systems, frequency-division multiple access (FDMA) systems, 3GPP Long Term Evolution (LTE) systems, and orthogonal frequency-division multiple access (OFDMA) systems.

Service providers are typically allocated blocks of frequency spectrum for exclusive use in certain geographic regions. These blocks of frequencies are generally assigned by regulators regardless of the multiple access technology being used. In most cases, these blocks are not integer multiples of channel bandwidths, hence there may be unutilized parts of the spectrum. As the use of wireless devices has increased, the demand for and value of this spectrum has generally surged, as well. Nonetheless, in some cases, wireless communications systems may not utilize portions of the allocated spectrum because the portions are not big enough to fit a standard or normal waveform. The developers of the LTE standard, for example, recognized the problem and decided to support many different system bandwidths (e.g., 1.4, 3, 5, 10, 15 and 20 MHz). This may provide one partial solution to the problem.

Flexible bandwidth systems, also referred to herein as scalable bandwidth systems, may provide for better utilization of bandwidth resources. However, some flexible bandwidth systems may face timing issues due to time dilation when they include multiple carriers that may utilize different bandwidths.

SUMMARY

Methods, systems, and devices are provided for control information processing and utilization, such as for optimizing timing relations, in a wireless communications system that utilizes one or more flexible bandwidth carriers. For example, tools and techniques are provided that may help optimize, such as by aligning, the processing time of control information for a flexible or scalable bandwidth carrier to conform to the processing time for a system that may utilize a normal bandwidth carrier or another flexible bandwidth carrier.

Optimizing and/or aligning the processing time in a flexible bandwidth carrier system may include receiving control information over a first channel of one or more flexible bandwidth carriers, determining a processing time for the received control information over the first channel of the one or more flexible bandwidth carriers based on a processing time of control information for a normal bandwidth carrier or another flexible bandwidth carrier, and utilizing the received control information over the first channel of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the first channel of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one or more flexible bandwidth carriers. These tools and techniques may also be utilized with multicarrier systems that may utilize one or more flexible bandwidth carriers and one or more normal bandwidth carriers, and/or systems that may utilize multiple different flexible bandwidth carriers having different bandwidth scaling factors.

Flexible bandwidth carriers for wireless communications systems may utilize portions of spectrum that may not be big enough to fit a normal waveform utilizing flexible bandwidth waveforms. A flexible bandwidth system that utilizes a flexible bandwidth carrier may be generated with respect to a normal bandwidth system through dilating, or scaling down, the time or the chip rate of the flexible bandwidth system with respect to the normal bandwidth system. Some embodiments may increase the bandwidth of a waveform through expanding, or scaling up, the time or the chip rate of the flexible bandwidth system.

In wireless communications systems that may utilize one or more flexible bandwidth carriers, dilated control information processing times and utilization for a flexible bandwidth carrier may cause an increase in required system resources, such as increased grant processing time and consequently grant delays and a decrease in overall system efficiency relative to a system that utilizes normal bandwidth carriers or other flexible bandwidth carriers. In general, certain time periods may be defined for the application of different grants. Simply dilating these time periods for a flexible or scalable bandwidth carrier relative to a normal bandwidth carrier or another flexible bandwidth carrier may result in an increased time between when a grant is provided to a user equipment and when the user equipment actually utilizes it. For example, with dilation, a grant may be applied in a frame later than if the processing time was not dilated. In other words, dilatation may cause unwanted delay in the application of a grant. These problems may be addressed by aligning the processing time for control information for at least two carriers in a multicarrier system, for example, by configuring a control information processing time on one channel, such as a flexible or scalable bandwidth carrier, to align with a control information processing time for a normal bandwidth carrier or another flexible bandwidth carrier.

Methods for control information processing time and utilization alignment may be particularly useful in a multicarrier High-Speed Uplink Packet Access (HSUPA) network that may utilize a primary serving Uplink High Speed-Dedicated Physical Control Channel (HS-DPCCH cell) with a normal chip rate, such as 3.84 Mcps (e.g., N=1) and a secondary serving HS-DPCCH cell(s) that may utilize a time dilated chip rate=3.84/2 Mcps (e.g., N=2) or 3.84/4 Mcps (e.g., N=4) or vice versa. Tools and techniques provided may support alignment of control information processing time and utilization between carriers having different chip rates, such as between the primary serving HS-DPCCH cell (which may have N=1) and secondary serving HS-DPCCH cell(s) (which may utilize a flexible bandwidth carrier, such as with N=2 or N=4), vice versa, and/or between a primary serving HS-DPCCH cell (which may have N=2) and a secondary serving HS-DPCCH cell (which may have N=4).

Some embodiments include a method of control information processing and utilization for a wireless communications system that utilizes one or more flexible bandwidth carriers. The method may include: receiving control information over a first channel of one of the one or more flexible bandwidth carriers; determining a processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers based on a processing time of control information for a normal bandwidth carrier or another flexible bandwidth carrier; and/or utilizing the received control information over the first channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the first channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers.

In some embodiments, the method may further include: receiving the control information for the normal bandwidth carrier or the other flexible bandwidth carrier over a channel of the normal bandwidth carrier or the other flexible bandwidth carrier; and/or utilizing the received control information for the normal bandwidth carrier or the other flexible bandwidth carrier during a first transmission time interval (TTI) of the channel of the normal bandwidth carrier or the other flexible bandwidth carrier subsequent to the processing time for the received control information over the channel of the normal bandwidth carrier or the other flexible bandwidth carrier.

In yet other embodiments, the method may include: receiving control information over a second channel of one of the one or more flexible bandwidth carriers; determining a processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers based on a processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier and the determined processing time for the received control information over the channel of the one or more flexible bandwidth carriers; and/or utilizing the received control information over the second channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the second channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers.

In some embodiments, determining the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may include determining at least a system frame number for applying the received control information based on a bandwidth scaling factor of the first channel of one of the one or more flexible bandwidth carriers.

In some cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may equal the processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier. In other cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be less than a dilated processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers.

In some embodiments, the control information over the first channel of one of the one or more flexible bandwidth carriers may include one or more grants. In some embodiments, the first channel of the one of the one or more flexible bandwidth carriers may include at least an Enhanced Absolute Grant Channel (E-AGCH) or an Enhanced Relative Grant Channel (E-RGCH). In some cases, the one of the one or more flexible bandwidth carriers of the first channel may include a bandwidth scaling factor equal to 2 or 4.

Some embodiments may include a system for control information processing and utilization in a wireless communications system that utilizes one or more flexible bandwidth carriers. The system may include: means for receiving control information over a first channel of one of the one or more flexible bandwidth carriers; means for determining a processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers based on a processing time of control information for a normal bandwidth carrier or another flexible bandwidth carrier; and/or means for utilizing the received control information over the first channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the first channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers.\

The system, in some cases, may also include: means for receiving the control information for the normal bandwidth carrier or the other flexible bandwidth carrier over a channel of the normal bandwidth carrier or the other flexible bandwidth carrier; and/or means for utilizing the received control information for the normal bandwidth carrier or the other flexible bandwidth carrier during a first transmission time interval (TTI) of the channel of the normal bandwidth carrier or the other flexible bandwidth carrier subsequent to the processing time for the received control information over the channel of the normal bandwidth carrier or the other flexible bandwidth carrier.

In some embodiments, the system may further include: means for receiving control information over a second channel of one of the one or more flexible bandwidth carriers; means for determining a processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers based on a processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier and the determined processing time for the received control information over the channel of the one or more flexible bandwidth carriers; and/or means for utilizing the received control information over the second channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the second channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers.

The means for determining the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may include means for determining at least a system frame number for applying the received control information based on a bandwidth scaling factor of the first channel of one of the one or more flexible bandwidth carriers.

In some cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may equal the processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier. In other cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be less than a dilated processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers.

In some embodiments, the control information over the first channel of one of the one or more flexible bandwidth carriers may include one or more grants. In some embodiments, the first channel of the one of the one or more flexible bandwidth carriers may include at least an Enhanced Absolute Grant Channel (E-AGCH) or an Enhanced Relative Grant Channel (E-RGCH). In some cases, one of the one or more flexible bandwidth carriers of the first channel may include a bandwidth scaling factor equal to 2 or 4.

Some embodiments may include a computer program product for control information processing and utilization in a wireless communications system that utilizes one or more flexible bandwidth carriers that may include a non-transitory computer-readable medium. The non-transitory computer readable medium may include: code for receiving control information over a first channel of one of the one or more flexible bandwidth carriers; code for determining a processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers based on a processing time of control information for a normal bandwidth carrier or another flexible bandwidth carrier; and/or code for utilizing the received control information over the first channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the first channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers.

In some embodiments, the non-transitory computer-readable medium may further include: code for receiving the control information for the normal bandwidth carrier or the other flexible bandwidth carrier over a channel of the normal bandwidth carrier or the other flexible bandwidth carrier; and/or code for utilizing the received control information for the normal bandwidth carrier or the other flexible bandwidth carrier during a first transmission time interval (TTI) of the channel of the normal bandwidth carrier or the other flexible bandwidth carrier subsequent to the processing time for the received control information over the channel of the normal bandwidth carrier or the other flexible bandwidth carrier.

In other embodiments, the non-transitory computer-readable medium may further include: code for receiving control information over a second channel of one of the one or more flexible bandwidth carriers; code for determining a processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers based on a processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier and the determined processing time for the received control information over the channel of the one or more flexible bandwidth carriers; and/or code for utilizing the received control information over the second channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the second channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers.

The code for determining the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may include code for determining at least a system frame number for applying the received control information based on a bandwidth scaling factor of the first channel of one of the one or more flexible bandwidth carriers.

In some cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may equal the processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier. In other cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be less than a dilated processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers.

In some embodiments of the computer program product, the control information over the first channel of one of the one or more flexible bandwidth carriers may include one or more grants. In some embodiments of the computer program product, the first channel of the one of the one or more flexible bandwidth carriers may include at least an Enhanced Absolute Grant Channel (E-AGCH) or an Enhanced Relative Grant Channel (E-RGCH). In some embodiments of the computer program product, the one of the one or more flexible bandwidth carriers of the first channel may include a bandwidth scaling factor equal to 2 or 4.

Some embodiments may include a wireless communications device configured for control information processing and utilization in a wireless communications system that utilizes one or more flexible bandwidth carriers. The wireless communications device may include at least one processor configured to: receive control information over a first channel of one of the one or more flexible bandwidth carriers; determine a processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers based on a processing time of control information for a normal bandwidth carrier or another flexible bandwidth carrier; and/or utilize the received control information over the first channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the first channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers.

In some embodiments, the at least one processor may be further configured to: receive the control information for the normal bandwidth carrier or the other flexible bandwidth carrier over a channel of the normal bandwidth carrier or the other flexible bandwidth carrier; and/or utilize the received control information for the normal bandwidth carrier or the other flexible bandwidth carrier during a first transmission time interval (TTI) of the channel of the normal bandwidth carrier or the other flexible bandwidth carrier subsequent to the processing time for the received control information over the channel of the normal bandwidth carrier or the other flexible bandwidth carrier.

In some embodiments, the at least one processor may be configured to: receive control information over a second channel of one of the one or more flexible bandwidth carriers; determine a processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers based on a processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier and the determined processing time for the received control information over the channel of the one or more flexible bandwidth carriers; and/or utilize the received control information over the second channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the second channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers.

The at least one processor configured to determine the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be further configured to determine at least a system frame number for applying the received control information based on a bandwidth scaling factor of the first channel of one of the one or more flexible bandwidth carriers.

In some cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may equal the processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier. In other cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be less than a dilated processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers.

In some embodiments, the control information over the first channel of one of the one or more flexible bandwidth carriers may include one or more grants. In some embodiments, the first channel of the one of the one or more flexible bandwidth carriers may include at least an Enhanced Absolute Grant Channel (E-AGCH) or an Enhanced Relative Grant Channel (E-RGCH). In some cases, one of the one or more flexible bandwidth carriers of the first channel may include a bandwidth scaling factor equal to 2 or 4.

The foregoing has outlined rather broadly the features and technical advantages of examples according to the disclosure in order that the detailed description that follows may be better understood. Additional features and advantages will be described hereinafter. The conception and specific examples disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present disclosure. Such equivalent constructions do not depart from the spirit and scope of the appended claims. Features which are believed to be characteristic of the concepts disclosed herein, both as to their organization and method of operation, together with associated advantages will be better understood from the following description when considered in connection with the accompanying figures. Each of the figures is provided for the purpose of illustration and description only, and not as a definition of the limits of the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

A further understanding of the nature and advantages of the different embodiments may be realized by reference to the following drawings. In the appended figures, similar components or features may have the same reference label. Further, various components of the same type may be distinguished by following the reference label by a dash and a second label that distinguishes among the similar components. If only the first reference label is used in the specification, the description is applicable to any one of the similar components having the same first reference label irrespective of the second reference label.

FIG. **1** shows a block diagram of a wireless communications system in accordance with various embodiments;

FIG. **2**A shows an example of a wireless communications system where a flexible bandwidth waveform fits into a portion of spectrum not broad enough to fit a normal waveform in accordance with various embodiments;

FIG. **2**B shows an example of a wireless communications system where a flexible bandwidth waveform fits into a portion of spectrum near an edge of a band in accordance with various embodiments;

FIG. **3** shows a block diagram of a wireless communications system in accordance with various embodiments;

FIG. **4**A shows a control information timing diagram of two carriers having different bandwidth scaling factors in accordance with various embodiments;

FIG. **4**B shows another control information timing diagram of two carriers having different bandwidth scaling factors in accordance with various embodiments;

FIG. **4**C shows another control information timing diagram of two carriers having different bandwidth scaling factors in accordance with various embodiments;

FIG. **5**A shows a block diagram of a device configured for control information processing and utilization in a multicarrier system that utilizes one or more flexible bandwidth carriers in accordance with various embodiments;

FIG. **5**B shows a block diagram of another device configured for control information processing and utilization in a multicarrier system that utilizes one or more flexible bandwidth carriers in accordance with various embodiments;

FIG. **6** shows a block diagram of a communications system configured in accordance with various embodiments;

FIG. **7** shows a block diagram of a user equipment configured in accordance with various embodiments;

FIG. **8** shows a block diagram of a wireless communications system that includes a base station and a user equipment in accordance with various embodiments;

FIG. **9**A shows a flow diagram of a method of control information processing and utilization in a multicarrier system that utilizes one or more flexible bandwidth carriers in accordance with various embodiments; and

FIG. **9**B shows a flow diagram of another method of control information processing and utilization in a multicarrier system that utilizes one or more flexible bandwidth carriers in accordance with various embodiments.

DETAILED DESCRIPTION

Methods, systems, and devices are provided for control information processing and utilization, such as for optimizing timing relations, in a wireless communications system that utilizes one or more flexible bandwidth carriers. For example, tools and techniques are provided that may help align the processing time of control information for a flexible or scalable bandwidth carrier to conform to the processing time for a system that may utilize a normal bandwidth carrier or another flexible bandwidth carrier.

Aligning the processing time in a flexible bandwidth carrier system may include receiving control information over a first channel of one of the one or more flexible bandwidth carriers, determining a processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers based on a processing time of control information for a normal bandwidth carrier or another flexible bandwidth carrier, and utilizing the received control information over the first channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the first channel of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers. These tools and techniques may also be utilized with multicarrier systems that may utilize one or more flexible bandwidth carriers and one or more normal bandwidth carriers, and/or systems that may utilize multiple different flexible bandwidth carriers having different bandwidth scaling factors.

Flexible bandwidth carriers for wireless communications systems may utilize portions of spectrum that may not be big enough to fit a normal waveform utilizing flexible bandwidth waveforms. A flexible bandwidth system that utilizes a flexible bandwidth carrier may be generated with respect to a normal bandwidth system through dilating, or scaling down, the time or the chip rate of the flexible bandwidth system with respect to the normal bandwidth system. Some embodiments may increase the bandwidth of a waveform through expanding, or scaling up, the time or the chip rate of the flexible bandwidth system.

In wireless communications systems that may utilize one or more flexible bandwidth carriers, dilated control information processing times and utilization for a flexible bandwidth carrier may cause an increase in required system resources, such as increased grant processing time and consequently grant delays and a decrease in overall system efficiency. In general, certain time periods may be defined for the application of different grants. Simply dilating these time periods for a flexible or scalable bandwidth carrier relative to a normal bandwidth carrier or another flexible bandwidth carrier may result in an increased time between when a grant is provided to a user equipment and when the user equipment actually utilizes it. For example, with dilation, a grant may be applied in a frame later than if the processing time was not dilated. In other words, dilation may cause unwanted delay in the application of a grant. These problems may be addressed by aligning the processing time for control information for at least two carriers in a multicarrier system, for example, by configuring a control information processing time on one channel, such as a flexible or scalable bandwidth carrier, to align with a control information processing for a normal bandwidth carrier or another flexible bandwidth carrier.

Methods for control information processing time and utilization alignment may be particularly useful in a multicarrier High-Speed Uplink Packet Access (HSUPA) network that may utilize a primary serving Uplink High Speed-Dedicated Physical Control Channel (HS-DPCCH cell) with a normal chip rate, such as 3.84 Mcps (e.g., N=1) and a secondary serving HS-DPCCH cell(s) that may utilize a time dilated chip rate=3.84/2 Mcps (e.g., N=2) or 3.84/4 Mcps (e.g., N=4) or vice versa. Tools and techniques provided may support alignment of control information processing time and utilization between carriers having different chip rates, such as between the primary serving HS-DPCCH cell (which may be N=1) and secondary serving HS-DPCCH cell(s) (which may utilize a flexible bandwidth carrier, such as with N=2 or N=4), vice versa, and/or between a primary serving HS-DPCCH cell (which may have N=2) and a secondary serving HS-DPCCH cell (which may have N=4).

In some embodiments, methods for control information processing and utilization may also include receiving the control information for the normal bandwidth carrier or the other flexible bandwidth carrier over a channel of the normal bandwidth carrier or the other flexible bandwidth carrier, and utilizing the received control information for the normal bandwidth carrier or the other flexible bandwidth carrier during a first transmission time interval (TTI) of the channel of the normal bandwidth carrier or the other flexible bandwidth carrier subsequent to the processing time for the received control information over the channel of the normal bandwidth carrier or the other flexible bandwidth carrier.

In other embodiments, the methods for control information processing and utilization may include receiving control information over a second channel of one of the one or more flexible bandwidth carriers. These methods may further include determining a processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers based on a processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier and the determined processing time for the received control information over the channel of the one or more flexible bandwidth carriers. In some cases, these methods may include utilizing the received control information over the second channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the second channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers.

In some embodiments, determining the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may include determining at least a system frame number for applying the received control information based on a bandwidth scaling factor of the first channel of one of the one or more flexible bandwidth carriers.

In some cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may equal the processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier. In some embodiments, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be less than a dilated processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers.

In some cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be undilated with respect to the processing time for a normal bandwidth carrier or the other flexible bandwidth carrier. In other words, this may equate to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers, when adjusted, being undilated in relation to other signaling of the flexible bandwidth carrier. In some cases, the processing time across one or more flexible bandwidth carriers and the processing time across a normal bandwidth carrier or the other flexible bandwidth carrier may be constant or near constant. In other cases, all or a portion of the processing time for the one or more flexible bandwidth carriers may align, i.e. be adjusted so as to be undilated/the same length, with respect to the normal bandwidth carrier or the other flexible bandwidth carrier.

In some embodiments, the control information over the first channel of one of the one or more flexible bandwidth carriers may include one or more grants. In some cases, the first channel of the one of the one or more flexible bandwidth carriers may include one of an Enhanced Absolute Grant Channel (E-AGCH) or Enhanced Relative Grant Channel (E-RGCH). The one of the one or more flexible bandwidth carriers may utilize a bandwidth scaling factor equal to 2 or 4.

Techniques described herein may be used for various wireless communications systems such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, Peer-to-Peer, and other systems. The terms “system” and “network” are often used interchangeably. A CDMA system may implement a radio technology such as CDMA2000, Universal Terrestrial Radio Access (UTRA), etc. CDMA2000 covers IS-2000, IS-95, and IS-856 standards. IS-2000 Releases 0 and A are commonly referred to as CDMA2000 1×, 1×, etc. IS-856 (TIA-856) is commonly referred to as CDMA2000 1×EV-DO, High Rate Packet Data (HRPD), etc. UTRA includes Wideband CDMA (WCDMA) and other variants of CDMA. A TDMA system may implement a radio technology such as Global System for Mobile Communications (GSM). An OFDMA or OFDM system may implement a radio technology such as Ultra Mobile Broadband (UMB), Evolved UTRA (E-UTRA), IEEE 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, Flash-OFDM, etc. UTRA and E-UTRA are part of Universal

Mobile Telecommunication System (UMTS). Some systems may utilize high speed packet access (HSPA). 3GPP Long Term Evolution (LTE) and LTE-Advanced (LTE-A) are new releases of UMTS that use E-UTRA. UTRA, E-UTRA, UMTS, LTE, LTE-A, and GSM are described in documents from an organization named "3rd Generation Partnership Project" (3GPP). CDMA2000 and UMB are described in documents from an organization named "3rd Generation Partnership Project 2" (3GPP2). The techniques described herein may be used for the systems and radio technologies mentioned above, as well as other systems and radio technologies.

Thus, the following description provides examples, and is not limiting of the scope, applicability, or configuration set forth in the claims. Changes may be made in the function and arrangement of elements discussed without departing from the spirit and scope of the disclosure. Various embodiments may omit, substitute, or add various procedures or components as appropriate. For instance, the methods described may be performed in an order different from that described, and various steps may be added, omitted, or combined. Also, features described with respect to certain embodiments may be combined in other embodiments.

Referring first to FIG. **1**, a block diagram illustrates an example of a wireless communications system **100** in accordance with various embodiments. The system **100** includes base stations **105**, user equipment (also referred to herein as a UE) **115**, a base station controller **120**, and a core network **130** (the controller **120** may be integrated into the core network **130** in some embodiments; in some embodiments, controller **120** may be integrated into base stations **105**). The system **100** may support operation on multiple carriers (waveform signals of different frequencies). Multi-carrier transmitters can transmit modulated signals simultaneously on the multiple carriers. Each modulated signal may be a Code Division Multiple Access (CDMA) signal, Time Division Multiple Access (TDMA) signal, Frequency Division Multiple Access (FDMA) signal, Orthogonal FDMA (OFDMA) signal, Single-Carrier FDMA (SC-FDMA) signal, etc. Each modulated signal may be sent on a different carrier and may carry control information (e.g., pilot signals), overhead information, data, etc. The system **100** may be a multi-carrier LTE network capable of efficiently allocating network resources.

The user equipment **115** may be any type of mobile station, user equipment, access terminal, subscriber unit, or user equipment. The user equipment **115** may include cellular phones and wireless communications devices, but may also include personal digital assistants (PDAs), smartphones, other handheld devices, netbooks, notebook computers, etc. Thus, the term user equipment should be interpreted broadly hereinafter, including the claims, to include any type of wireless or mobile communications device.

Throughout this application, some user equipment may be referred to as flexible bandwidth capable user equipment, flexible bandwidth compatible user equipment, and/or flexible bandwidth user equipment. This may generally mean that the user equipment is flexible capable or compatible. In general, these devices may also be capable of normal functionality with respect to one or more normal radio access technologies (RATs). The use of the term flexible as meaning flexible capable or flexible compatible may generally be applicable to other aspects of system **100**, such as for controller **120** and/or base stations **105**, or a radio access network.

The base stations **105** may wirelessly communicate with the user equipment **115** via a base station antenna. The base stations **105** may be configured to communicate with the user equipment **115** under the control of the controller **120** via multiple carriers. Each of the base station **105** sites can provide communication coverage for a respective geographic area. In some embodiments, base stations **105** may be referred to as a NodeB, eNodeB, Home NodeB, and/or Home eNodeB. The coverage area for each base station **105** here is identified as **110**-*a*, **110**-*b*, or **110**-*c*. The coverage area for a base station may be divided into sectors (not shown, but making up only a portion of the coverage area). The system **100** may include base stations **105** of different types (e.g., macro, micro, femto, and/or pico base stations).

The different aspects of system **100**, such as the user equipment **115**, the base stations **105**, the core network **130**, and/or the controller **120** may be configured to utilize flexible bandwidth and waveforms in accordance with various embodiments. System **100**, for example, shows transmissions **125** between user equipment **115** and base stations **105**. The transmissions **125** may include uplink and/or reverse link transmission, from a user equipment **115** to a base station **105**, and/or downlink and/or forward link transmissions, from a base station **105** to a user equipment **115**. The transmissions **125** may include flexible/scalable and/or normal waveforms. Normal waveforms may also be referred to as legacy and/or normal waveforms.

The different aspects of system **100**, such as the user equipment **115**, the base stations **105**, the core network **130**, and/or the controller **120** may be configured to utilize flexible bandwidth or scalable waveforms and/or normal waveforms in accordance with various embodiments. For example, different aspects of system **100** may utilize portions of spectrum that may not be big enough to fit a normal waveform. Devices such as the user equipment **115**, the base stations **105**, the core network **130**, and/or the controller **120** may be configured to adapt the chip rates, spreading factor, and/or scaling factors to generate and/or utilize flexible bandwidth and/or waveforms. Some aspects of system **100** may form a flexible subsystem (such as certain user equipment **115** and/or base stations **105**) that may be generated with respect to a normal subsystem (that may be implemented using other user equipment **115** and/or base stations **105**) through dilating, or scaling down, the time of the flexible subsystem with respect to the time of the normal subsystem.

In some embodiments, different aspects of system **100**, such as the user equipment **115**, may be configured to receive control information over a first channel of one of the one or more flexible bandwidth carriers. In some cases, the user equipment **115** may be configured to determine a processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers based on a processing time of control information for a normal bandwidth carrier or another flexible bandwidth carrier. The user equipment **115** may be further configured to utilize the received control information over the first channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the first channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers. At least the first carrier or the second carrier may include at least one of the one or more flexible bandwidth carriers.

In alternative embodiments, different aspects of system **100**, such as the base stations **105**, the core network **130**, and/or the controller **120** may be configured to perform some or all of the above functionality with or in place of the user equipment **115**.

FIG. **2**A shows an example of a wireless communications system **200**-*a* with a base station **105**-*a* and a user equipment

115-*a* in accordance with various embodiments, where a flexible bandwidth waveform **210**-*a* fits into a portion of spectrum not broad enough to fit a normal waveform **220**-*a*. System **200**-*a* may be an example of system **100** of FIG. **1**. In some embodiments, the flexible bandwidth waveform **210**-*a* may overlap with the normal waveform **220**-*a* that either the base **105**-*a* and/or the user equipment **115**-*a* may transmit. In some cases, the normal waveform **220**-*a* may completely overlap the flexible bandwidth waveform **210**-*a*. Some embodiments may also utilize multiple flexible bandwidth waveforms **210**. In some embodiments, another base station and/or user equipment (not shown) may transmit the normal waveform **220**-*a* and/or the flexible bandwidth waveform **210**-*a*.

FIG. **2**B shows an example of a wireless communications system **200**-*b* with a base station **105**-*b* and user equipment **115**-*b*, where a flexible bandwidth waveform **210**-*b* fits into a portion of spectrum near an edge of a band, which may be a guard band, where normal waveform **220**-*b* may not fit. System **200**-*b* may be an example of system **100** of FIG. **1**. User equipment **115**-*a*/**115**-*b* and/or base stations **105**-*a*/**105**-*b* may be configured to dynamically adjust the bandwidth of the flexible bandwidth waveforms **210**-*a*/**210**-*b* in accordance with various embodiments.

In some embodiments, different aspects of systems **200**-*a* and/or **200**-*b*, such as the user equipment **115**-*a* and/or **115**-*b*, may be configured to receive control information over a first channel of one of the one or more flexible bandwidth carriers. Different aspects of systems **200**-*a* and/or **200**-*b*, such as the user equipment **115**-*a* and/or **1150**-*b* and/or the base stations **105**-*a* and/or **105**-*b* may be configured to determine a processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers based on a processing time of control information for a normal bandwidth carrier or another flexible bandwidth carrier. Different aspects of systems **200**-*a* and/or **200**-*b*, such as the user equipment **115**-*a* and/or **1150**-*b* and/or the base stations **105**-*a* and/or **105**-*b* may be further configured to utilize the received control information over the first channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the first channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers. At least the first carrier or the second carrier may include at least one of the one or more flexible bandwidth carriers.

In alternative embodiments, different aspects of systems **200**-*a* and/or **200**-*b*, such as the base stations **105**-*a* and/or **105**-*b* may be configured to perform some or all of the functionality described above either with or in place of the user equipment **115**-*a*, **115**-*b*.

In general, a first waveform or carrier bandwidth and a second waveform or carrier bandwidth may partially overlap when they overlap by at least 1%, 2%, and/or 5%. In some embodiments, partial overlap may occur when the overlap is at least 10%. In some embodiments, the partial overlap may be less than 99%, 98%, and/or 95%. In some embodiments, the overlap may be less than 90%. In some cases, a flexible bandwidth waveform or carrier bandwidth may be contained completely within another waveform or carrier bandwidth. This overlap may still reflect partial overlap, as the two waveforms or carrier bandwidths do not completely coincide. In general, partial overlap can mean that the two or more waveforms or carrier bandwidths do not completely coincide (i.e., the carrier bandwidths are not the same).

Some embodiments may utilize different definitions of overlap based on power spectrum density (PSD). For example, one definition of overlap based on PSD is shown in the following overlap equation for a first carrier:

$$\text{overlap} = 100\% * \frac{\int_0^\infty PSD_1(f) * PSD_2(f)}{\int_0^\infty PSD_1(f) * PSD_1(f)}.$$

In this equation, $PSD_1(f)$ is the PSD for a first waveform or carrier bandwidth and $PSD_2(f)$ is the PSD for a second waveform or carrier bandwidth. When the two waveforms or carrier bandwidths coincide, then the overlap equation may equal 100%. When the first waveform or carrier bandwidth and the second waveform or carrier bandwidth at least partially overlap, then the overlap equation may not equal 100%. For example, the Overlap Equation may result in a partial overlap of greater than or equal to 1%, 2%, 5%, and/or 10% in some embodiments. The overlap equation may result in a partial overlap of less than or equal to 99%, 98%, 95%, and/or 90% in some embodiments. One may note that in the case in which the first waveform or carrier bandwidth is a normal waveform or carrier bandwidth and the second waveform or a carrier waveform is a flexible bandwidth waveform or carrier bandwidth that is contained within the normal bandwidth or carrier bandwidth, then the overlap equation may represent the ratio of the flexible bandwidth compared to the normal bandwidth, written as a percentage. Furthermore, the overlap equation may depend on which carrier bandwidth's perspective the overlap equation is formulated with respect to. Some embodiments may utilize other definitions of overlap. In some cases, another overlap may be defined utilizing a square root operation such as the following:

$$\text{overlap} = 100\% * \sqrt{\frac{\int_0^\infty PSD_1(f) * PSD_2(f)}{\int_0^\infty PSD_1(f) * PSD_1(f)}}.$$

Other embodiments may utilize other overlap equations that may account for multiple overlapping carriers.

FIG. **3** shows a wireless communications system **300** with a base station **105**-*c* and user equipment **115**-*c* in accordance with various embodiments. Different aspects of system **300**, such as the user equipment **115**-*c* and/or the base stations **105**-*c*, may be configured for control information processing and utilization in system **300** that may utilize multiple carriers including one or more flexible bandwidth carriers.

Transmissions **305**-*a* and/or **305**-*b* between the user equipment **115**-*c* and the base station **105**-*a* may utilize normal and/or flexible bandwidth waveforms that may be generated to occupy less (or more) bandwidth than a normal waveform. For example, at a band edge, there may not be enough available spectrum to place a normal waveform. For a flexible bandwidth waveform, as time gets dilated, the frequency occupied by a waveform goes down, thus making it possible to fit a flexible bandwidth waveform into spectrum that may not be broad enough to fit a normal waveform. In some embodiments, the flexible bandwidth waveform may be scaled utilizing a scaling factor N with respect to a normal waveform. Scaling factor N may take on numerous different values including, but not limited to, integer values such as 1, 2, 3, 4, 8, etc. N, however, does not have to be an integer. In some cases, transmissions **305**-*a* may be with respect to a primary serving cell and transmission **305**-*b* may be with respect to a secondary serving cell. In other cases, transmissions **305**-*a* and **305**-*b* may between a single antenna of a user equipment **115**-*c* and the same or different antennas of the base station **105**-*a*.

Different aspects of system **300**, such as the user equipment **115**-*c*, may be configured for receiving control information over a first channel of one of the one or more flexible bandwidth carriers. The user equipment **115**-*c* may be configured for determining a processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers based on a processing time of control information for a normal bandwidth carrier or another flexible bandwidth carrier. The user equipment **115**-*c* may also be configured for utilizing the received control information over the first channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the first channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers. At least the first carrier or the second carrier may include at least one of the one or more flexible bandwidth carriers.

In some embodiments, the base stations **105**-*c* may also either in conjunction with or in place of the user equipment **115**-*c*, perform some or all of the functionality described in reference to FIG. **3**.

In some embodiments, the user equipment **115**-*c* may be configured for receiving the control information for the normal bandwidth carrier or the other flexible bandwidth carrier over a channel of the normal bandwidth carrier or the other flexible bandwidth carrier. The user equipment **115**-*c* may utilize the received control information for the normal bandwidth carrier or the other flexible bandwidth carrier during a first transmission time interval (TTI) of the channel of the normal bandwidth carrier or the other flexible bandwidth carrier subsequent to the processing time for the received control information over the channel of the normal bandwidth carrier or the other flexible bandwidth carrier.

In some embodiments, the user equipment **115**-*c* may be configured for receiving control information over a second channel of one of the one or more flexible bandwidth carriers. The user equipment **115**-*c* may determine a processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers based on a processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier and the determined processing time for the received control information over the channel of the one or more flexible bandwidth carriers. The user equipment **115**-*c* may also utilize the received control information over the second channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the second channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers.

In some embodiments, the user equipment **115**-*c* may be configured for determining at least a system frame number for applying the received control information based on a bandwidth scaling factor of the first channel of one of the one or more flexible bandwidth carriers, as part of determining the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers. In some cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may equal the processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier. In other cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be less than a dilated processing time, which may be less than a theoretical processing time, for the received control information over the first channel of the one of the one or more flexible bandwidth carriers. In some cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be undilated with respect to the processing time for a normal bandwidth carrier or another flexible bandwidth carrier.

In some embodiments, the control information over the first channel of one of the one or more flexible bandwidth carriers may include one or more grants, such as for the user equipment **115**-*c* to apply. In some cases, the first channel of the one of the one or more flexible bandwidth carriers may include one of an Enhanced Absolute Grant Channel (E-AGCH) or Enhanced Relative Grant Channel (E-RGCH). In some cases, the one of the one or more flexible bandwidth carriers may utilize a bandwidth scaling factor equal to 2 or 4.

System **300** may be an example of a multicarrier HSPA/HSPA+ network, such as a multicarrier High Speed Downlink Packet Access (HSDPA) network that may utilize a primary serving High Speed Downlink Shared Channel (HS-DSCH cell) with a normal chip rate, such as 3.84 Mcps (e.g., N=1) and a secondary serving HS-DSCH cell(s) that may utilize a time dilated chip rate=3.84/2 Mcps (e.g., N=2) or 3.84/4 Mcps (e.g., N=4) or vice versa. Tools and techniques provided may support alignment of control information processing time and utilization between carriers having different chip rates, such as between the primary serving HS-DPCCH cell (which may be N=1) and secondary serving HS-DPCCH cell(s) (which may utilize a flexible bandwidth carrier, such as with N=2 or N=4), vice versa, and/or between a primary serving HS-DPCCH cell (which may have N=2) and a secondary serving HS-DPCCH cell (which may have N=4). In some cases, this may be accomplished by allotting a time period for control information processing that is greater than a minimum required processing time, such as for a normal bandwidth carrier or another flexible bandwidth carrier. In some cases, the determined control information processing time for the flexible bandwidth carrier may be equal to an un-dilated processing time for a normal bandwidth carrier. Subsequent to a determined processing time, the control information, which may include one or more grants, may be applied during the first TTI following the end of the determined and/or minimum required processing time.

Some embodiments may utilize additional terminology. A new unit D may be utilized. The unit D is dilated. The unit is unitless and has the value of N. One can talk about time in the flexible system in terms of "dilated time". For example, a slot of say 10 ms in normal time may be represented as 10 Dms in flexible time (note: even in normal time, this will hold true since N=1 in normal time: D has a value of 1, so 10 Dms=10 ms). In time scaling, one can replace most "seconds" with "dilated-seconds." Note frequency in Hertz is 1/s.

As discussed above, a flexible bandwidth or scalable bandwidth waveform may be a waveform that occupies less bandwidth than a normal waveform. Thus, in a flexible bandwidth system, the same number of symbols and bits may be transmitted over a longer duration compared to normal bandwidth system. This may result in time stretching, whereby slot duration, frame duration, etc., may increase by a scaling factor N. Scaling factor N may represent the ratio of the normal bandwidth to flexible bandwidth (BW). Thus, data rate in a flexible bandwidth system may equal (Normal Rater 1/N), and delay may equal (Normal Delay×N). In general, a flexible systems channel BW=channel BW of normal systems/N. Delay×BW may remain unchanged. Furthermore, in some embodiments, a flexible bandwidth waveform may be a waveform that occupies more bandwidth than a normal waveform. Scaling factor N may also be referred to as a bandwidth scaling factor.

Throughout this specification, the term normal system, subsystem, and/or waveform may be utilized to refer to systems, subsystems, and/or waveforms that involve embodiments that may utilize a scaling factor that may be equal to one (e.g., N=1) or a normal or standard chip rate. These normal systems, subsystems, and/or waveforms may also be referred to as standard and/or legacy systems, subsystems, and/or waveforms. Furthermore, flexible systems, subsystems, and/or waveforms may be utilized to refer to systems, subsystems, and/or waveforms that involve embodiments that may utilize a scaling factor that may be not equal to one (e.g., N=2, 4, 8, ½, ¼, etc.). For N>1, or if a chip rate is decreased, the bandwidth of a waveform may decrease. Some embodiments may utilize scaling factors or chip rates that increase the bandwidth. For example, if N<1, or if the chip rate is increased, then a waveform may be expanded to cover bandwidth larger than a normal waveform. Some embodiments may utilize a chip rate divisor (Dcr) to change the chip rate in some embodiments. Flexible systems, subsystems, and/or waveforms may also be referred to as scalable systems, subsystems, and/or waveforms in some cases. Flexible systems, subsystems, and/or waveforms may also be referred to as fractional systems, subsystems, and/or waveforms in some cases. Fractional systems, subsystems, and/or waveforms may or may not change bandwidth, for example. A fractional system, subsystem, or waveform may be flexible because it may offer more possibilities than a normal or standard system, subsystem, or waveform (e.g., N=1 system). Furthermore, the use of the term flexible may also be utilized to mean flexible bandwidth capable.

Turning next to FIGS. **4A-4C**, control information processing and utilization timing diagrams illustrate multiple configuration **400**, including configurations **400**-*a*, **400**-*b*, and **400**-*c* that each include control information processing and utilization functionality in a multicarrier system that utilizes one or more flexible bandwidth carriers in accordance with various embodiments. The control information processing and utilization timing diagrams may be examples of control information methods, such as control information processing and utilization, implemented by various wireless entities, including all or part of: the base stations **105** of FIG. **1**, FIG. **2**A, FIG. **2**B, and FIG. **3**; the user equipment **115** of FIG. **1**, FIG. **2**A, FIG. **2**B, FIG. **3**; and/or the controller **120**/core network **130** of FIG. **1**. The common aspects between FIGS. **4A-4C** will be described generally, and the particulars of each FIG. will then be described separately.

In some embodiments, configurations **400** may be implemented in a wireless communication system utilizing High-Speed Uplink Packet Access (HSUPA), particularly in a Scalable Universal Mobile Telecommunications System (S-UMTS). Multiple carriers may be utilized in a S-UMTS HSUPA configured system with some carriers having different bandwidth scaling factors than other carriers. For example, a normal bandwidth carrier **405** may having a bandwidth scaling factor of N=1. In addition, other carriers used in the S-UMTS HSUPA system, such as carriers **435**, **445** may have different bandwidth scaling factors, such as N=2 or N=4.

Each carrier **405**, **435**, **445** may include multiple channels for communicating and processing various signaling, such as signaling including control information. The multiple channels may include a Primary Common Control Physical Channel (P-CCPCH) **410**, an Absolute Grant Channel (E-AGCH) **415**, a Downlink Dedicated Physical Channel (DL-DPCH) **420**, and an Enhanced Dedicated Physical Data Channel (E-DPDCH) **425**, for example. The E-AGCH **415** may receive Enhanced Dedicated Channel (E-DCH) control data, such as one or more grants, in multiple E-AGCH frames, such as in E-AGCH frame **417**. The control information communicated in E-AGCH frame **417** may be processed during a required processing time **430**, **432**, **434** and utilized in a subsequent E-DPDCH frame, such as E-DPDCH frame **428** or E-DPDCH frame **429**. The time between the full receipt of the E-AGCH frame **417** and the utilization of the control information communicated in the E-AGCH frame **417** may be defined as a utilization time **431**.

The timing of each frame across the P-CCPCH **410**, E-AGCH **415**, DL-DPCH **420**, and the E-DPDCH **425** may be relative to a system frame number (SFN) in a higher layer channel, such as the P-CCPCH **410**. The length of the SFN may define and/or relate to a Transmission Time Interval (TTI) for the corresponding E-DCH for each carrier. The P-CCPCH **410** may be defined by multiple frames and/or SFNs, such as P-CCPCH SFN i **411**, P-CCPCH SFN i+1 **412**, and P-CCPCH SFN i+2 **413**. The E-AGCH frame **417** may begin a delay **416** after the beginning of a P-CCPCH SFN i **411**, which may be equal to 2 slots. A DL DPCH frame **422**, which may be used to carry other relevant downlink information, for example, may begin a time τ_{DPCH} **421**, which may be equal to 70*256 chips for N=1, N=2, and/or N=4 carriers, after the beginning of the P-CCPCH SFN i **411**. A first E-DPDCH frame **427** may begin a time **426** after the beginning of the E-DPDCH frame **422**. In some cases, time **426** may be equal to 1024 chips.

From these relationships, the required processing time **432**, **434** for flexible bandwidth carriers **435**, **445** having bandwidth scaling factors of N=2 and N=4 may be determined based on the require processing time **430** for the normal bandwidth carrier **405** having N=1. In some embodiments, the required processing time **432**, **434** may be the minimum required processing time for the control information communicated over the E-AGCH **415**, such as in the E-AGCH frame **417**. In some cases, the required processing time **432**, **434** may be undilated relative to the timing of flexible bandwidth carriers **435** and **445**. By undilating the required processing time **432**, **434** for the flexible bandwidth carriers **435** and **445**, the processed control information may be utilized and applied in the following TTI, which may correspond to the next P-CCPCH SFN frame, such as P-CCPCH SFN i+1 **412** via an E-DPDCH frame, such an E-DPDCH frame **428**.

The TTI length of the E-DCH may determine how the required processing time **430**, **432**, **434** and the corresponding control information utilization times **431**, **433**, **435** may be determined for carriers having different bandwidth scaling factors, such as N=1, N=2, and/or N=4. The following are given only as examples. The claimed subject matter is not so limited however, and may include other TTI lengths.

In some embodiments, the SFN's of one or cells **405**, **410** may increment by 1, 2, or 4, or any other value. In some cases, the SFN's may be relative to an N=1 cell, such that each SFN for a normal bandwidth carrier increments by one. For a N=2 carrier, in order to align with an N=1 carrier, each SFN on the N=2 carrier may increment by two. For a N=4 carrier, in order to align with an N=1 carrier, each SFN on the N=4 carrier may increment by four. In other cases, the SFN's may be relative to an N=2 cell, such that each SFN increments by two, or relative to a N=4 cell, such that each SNF increments by 4. In other embodiments, SFN's for an N=1 cell, or a n N=2 or 4 cell, may only utilize even or odd numbers.

In some cases, a SFN for a carrier, such as the normal carrier **405**, may not completely align or be numbered the same as another carrier, such as flexible bandwidth carrier **410**, or vice versa. However, for ease of understanding, FIGS. **4A-4C** show CFN's for multiple carriers as aligned. It should be appreciated that the claimed subject matter is not so limited.

The UE **115** may receive E-DCH control data over the E-AGCH **415**, with the TTI of the corresponding E-DCH equal to 10 ms, for example. The UE **115** may first take into account E-DCH control data received in the E-AGCH frame **417** associated with P-CCPCH SFN i **411** over the P-CCPCH **410** in the higher layer procedures which may correspond to E-DCH transmission in the E-DPDCH frame associated a next P-CCPCH SFN i+1+s, which may be E-DPDCH frame **428** beginning in P-CCPCH SFN i+1 **412** or E-DPDCH frame **429** beginning in P-CCPCH SFN i+2 **413**. The value s of P-CCPCH SFN i+1+s may be defined by the following:

$$s = \left\lceil \frac{80/N + 20 - (\tau_{DPCH,n}/256)}{150} \right\rceil; \quad \text{where } N = 1, 2 \text{ or } 4 \tag{1}$$

Equation (1) may be used to determine in which P-CCPCH SFN, and hence in which E-DPCH frame, the control information contained in E-AGCH frame **417** will be utilized, over multiple carriers having different bandwidth scaling factors, such as carrier **405** with N=1, carrier **435** with N=2, or carrier **445** with N=4. Based on the determined P-CCPCH SFN for multiple flexible carriers having different bandwidth scaling factors, the processing times **430**, **432**, **434** and hence the utilization times **431**, **433**, **435** of the multiple flexible bandwidth carriers may be aligned across the multiple different flexible bandwidth carriers to increase control information processing and utilization efficiency.

In other embodiments, the UE **115** may receive E-DCH control data over the E-AGCH **415**, with the TTI of the corresponding E-DCH equal to 2 ms, for example. The UE **115** may first take into account E-DCH control data received in subframe j of the E-AGCH frame **417** associated with P-CCPCH SFN i **411** over the P-CCPCH **410** in the higher layer procedures which may correspond to E-DCH transmission in sub-frame t of the E-DPDCH frame associated a next P-CCPCH SFN i+s, such as E-DPDCH frame **428** beginning in P-CCPCH SFN i+1 **412** or E-DPDCH frame **429** beginning in P-CCPCH SFN i+2 **413**. The value s of P-CCPCH SFN i+s may be defined by the following:

$$s = \left\lfloor \frac{\left\lceil \frac{30j + 50/N + 50 - (\tau_{DPCH,n}/256)}{30} \right\rceil}{5} \right\rfloor; \quad \text{where } N = 1, 2 \text{ or } 4 \tag{2}$$

And the subframe t of the E-DPDCH frame in which the control information may be utilized may be determined by the following:

$$t = \left\lceil \frac{30j + 50/N + 50 - (\tau_{DPCH,n}/256) - 150s}{30} \right\rceil; \quad \text{where } N = 1, 2 \text{ or } 4 \tag{3}$$

Equation (2) may be used to determine in which P-CCPCH SFN, and hence in which E-DPDCH frame, the control information contained in E-AGCH frame **417** will be utilized, over multiple carriers having different bandwidth scaling factors, such as carrier **405** with N=1, carrier **435** with N=2, or carrier **445** with N=4. Equation (3) may be used to determine more particularly in which subframe t of the determined E-DPDCH frame, the control information will be utilized. Based on the determined P-CCPCH SFN, E-DPDCH frame, and subframe t of that E-DPDCH frame for multiple flexible carriers having different bandwidth scaling factors, the processing times **430**, **432**, **434** and hence the utilization times **431**, **433**, **435** of the multiple flexible bandwidth carriers may be aligned across the multiple different flexible bandwidth carriers to increase control information processing and utilization efficiency.

In some embodiments, a UE **115** which does not belong to the serving E-DCH radio link set may receive control information which may include one or more grants, over a Relative Grant Channel (E-RGCH) (not shown in FIGS. **4A-4C**, as the timing relations depicted in FIGS. **4A-4C** are generally applicable to an E-RGCH replacing the E-AGCH **415**). Just as descried above with respect to control information received over the E-AGCH **415**, different TTIs associated with the E-DCH may change the timing relations and the required control information processing times of carriers having different bandwidth scaling factors for the E-RGCH.

In some embodiments, the UE **115** may receive E-DCH control data over the E-RGCH, with the TTI of the corresponding E-DCH equal to 10 ms, for example. The UE **115** may first take into account E-DCH control data received in an E-RGCH frame associated with P-CCPCH SFN i **411** over the P-CCPCH **410** in the higher layer procedures which may correspond to E-DCH transmission in the E-DPDCH frame associated a next P-CCPCH SFN i+1+s, which may be E-DPDCH frame **428** beginning in P-CCPCH SFN i+1 **412** or E-DPDCH frame **429** beginning in P-CCPCH SFN i+2 **413**. The value s of P-CCPCH SFN i+1+s may be defined by the following:

$$s = \left\lceil \frac{140/N + 20 - (\tau_{DPCH,n}/256)}{150} \right\rceil; \quad \text{where } N = 1, 2 \text{ or } 4 \tag{4}$$

Equation (4) may be used to determine in which P-CCPCH SFN, and hence in which E-DPCH frame, the control information contained in the E-RGCH frame will be utilized, over multiple carriers having different bandwidth scaling factors, such as carrier **405** with N=1, carrier **435** with N=2, or carrier **445** with N=4. Based on the determined P-CCPCH SFN for multiple flexible carriers having different bandwidth scaling factors, the processing times **430**, **432**, **434** and hence the utilization times **431**, **433**, **435** of the multiple flexible bandwidth carriers may be aligned across the multiple different flexible bandwidth carriers to increase control information processing and utilization efficiency.

In other embodiments, the UE **115** may receive E-DCH control data over the E-RGCH, with the TTI of the corresponding E-DCH equal to 2 ms, for example. The UE **115** may first take into account E-DCH control data received in an E-RGCH frame associated with P-CCPCH SFN i **411** over the P-CCPCH **410** in the higher layer procedures which may correspond to E-DCH transmission in sub-frame t of the E-DPDCH frame associated a next P-CCPCH SFN i+s, such as E-DPDCH frame **428** beginning in P-CCPCH SFN i+1 **412** or E-DPDCH frame **429** beginning in P-CCPCH SFN i+2 **413**. The value s of P-CCPCH SFN i+s may be defined by the following:

$$s = \left\lfloor \frac{\left\lceil \frac{140/N + 20 - (\tau_{DPCH,n}/256)}{30} \right\rceil}{5} \right\rfloor; \quad (5)$$

where $N = 1, 2$ or 4

And the subframe t of the E-DPDCH frame in which the control information may be utilized may be determined by the following:

$$t = \left\lceil \frac{140/N + 20 - (\tau_{DPCH,n}/256) - 150s}{30} \right\rceil; \quad (6)$$

where $N = 1, 2$ or 4

Equation (5) may be used to determine in which P-CCPCH SFN, and hence in which E-DPDCH frame, the control information contained in the E-RGCH frame will be utilized, over multiple carriers having different bandwidth scaling factors, such as carrier **405** with N=1, carrier **435** with N=2, or carrier **445** with N=4. Equation (6) may be used to determine more particularly in which subframe t of the determined E-DPDCH frame, the control information will be utilized. Based on the determined P-CCPCH SFN, E-DPDCH frame, and subframe t of that E-DPDCH frame for multiple flexible carriers having different bandwidth scaling factors, the processing times **430**, **432**, **434** and hence the utilization times **431**, **433**, **435** of the multiple flexible bandwidth carriers may be aligned across the multiple different flexible bandwidth carriers to increase control information processing and utilization efficiency.

With specific reference to FIG. **4**A, a control information processing and utilization timing diagram **400**-*a* depicts a normal bandwidth carrier (N=1) **405** and a flexible bandwidth carrier (N=2) **435**. All of the relationship described above with respect to the various channels including timing relations apply to both carrier **405** and **435**, with the only difference being that in time, every frame and time period for carrier **435** is twice as long as for carrier **405**, such that each frame length of each of the P-CCPCH **410**-*b*, the E-AGCH **415**-*b*, the DL DPCH **420**-*b*, and the E-DPDCH **425**-*b* is twice as long as each frame of the P-CCPCH **410**-*a*, the E-AGCH **415**-*a*, the DL DPCH **420**-*a*, and the E-DPDCH **425**-*a* over carrier **405**. For example, frames **411**-*b*, **412**-*b*, **413**-*b*, **417**-*b*, **422**-*b*, **427**-*b*, **428**-*b*, and **429**-*b* associated with carrier **435** may be twice as long in time than frames **411**-*a*, **412**-*a*, **413**-*a*, **417**-*a*, **422**-*a*, **427**-*a*, **428**-*a*, and **429**-*a* associated with carrier **405**. Furthermore, delay times **416**-*b*, **421**-*b*, and **426**-*b* of carrier **435** may also be twice as long as delay times **416**-*a*, **421**-*a*, and **426**-*a* of carrier **405**. Thus the timing relationships between the various frames across the various channels of carrier **435** are the same as for carrier **405**, except scaled by a factor of 2.

In some embodiments, an E-AGCH frame **417**-*a* received over E-AGCH **415**-*a* in carrier **405** having N=1, may carry control information, such as one or more grants, that may be utilized over the E-DPDCH **425**-*a*. In order to utilize this control information communicated in E-AGCH frame **417**-*a*, the control information may be processed, such as during required processing time **430**-*a*. The processed control information may then be utilized over the E-DPDCH **425**-*a* in a next E-DPDCH frame, such as E-DPDCH frame **429**-*a*, after a utilization time **431**-*a*. Utilization time **431**-*a* may be determined based on the required processing time **430**-*a*. E-DPDCH frame **429**-*a* may begin in P-CCPCH SFN i+2 **413**-*a*, which may be determined by Equation (1) or Equations (2) and (3) above, depending on which TTI value is implemented across the E-DCH. In some cases, if the control information is communicated via an E-RGCH, Equation (4) or Equations (5) and (6) may also be used to determine the relative staring P-CCPCH SFN across the P-CCPCH **410**-*a*.

As carrier **405** is not dilated, i.e. N=1, the required processing time **430**-*a* may be used as the minimum required processing time for other carriers having different flexible bandwidths, such as carrier **435** having N=2. Because carrier **435** is dilated by a factor of 2 with respect to carrier **405**, a dilated processing time **432** of control information communicated in an E-AGCH frame **417**-*b* and subsequent to communication of the E-AGCCH frame **417**-*b*, may be twice as long as the required processing time **430**-*a* for a normal bandwidth carrier, which is shown right next to the dilated processing time **432**, as required processing time **430**-*b*. Because the dilated processing time **432** for carrier **435** is twice as long, the E-DPDCH frame **428**-*b* may not be utilized to apply the control information communicated in E-AGCH frame **417**-*b*. Rather, the E-DPDCH frame **429**-*b* may be used as the dilated processing time **432** ends in the middle of E-DPDCH frame **428**-*b*, thus increasing the dilated utilization time **433**. However, by configuring the dilated processing time **432** and thus the subsequent dilated utilization time **433** to correspond to the required processing time **430**-*b* and the subsequent utilization time **431**-*b*, for example by undilating these values, the dilated utilization time **433** may be decreased to the utilization time **431**-*b*. This may further be accomplished by determining the P-CCPCH SFN on the P-CCPCH **410**-*b* over which the control information may be utilized via Equations (1) or (2) and (3), depending on what value of TTI is used across the E-DCH. By undilating the dilated processing time **433** for carrier **435**, the control information, which may include one or more grants, may be applied 1 frame earlier across the E-DPDCH **425**-*b*, than if the dilated processing time **432** remained dilated. Further advantages may also be realized by decreasing the required processing time over flexible bandwidth carriers (dilated) to correlate with the required processing time over a normal bandwidth carrier (undilated), such as increases in overall system efficiency due to decreased control information delays, such as grant processing and utilization.

With specific reference to FIG. **4**B, a control information processing and utilization timing diagram **400**-*b* depicts a normal bandwidth carrier (N=1) **405**-*a* and a flexible bandwidth carrier (N=4) **445**. All of the relationships described above with respect to the various channels including timing relations may apply to both carrier **405**-*a* and **445**, with the only difference being that in time, every frame and time period for carrier **445** is 4 times as long as for carrier **405**-*a*, such that each frame length of each of the P-CCPCH **410**-*d*, the E-AGCH **415**-*d*, the DL DPCH **420**-*d*, and the E-DPDCH **425**-*d* is four times as long as each frame of the P-CCPCH **410**-*c*, the E-AGCH **415**-*c*, the DL DPCH **420**-*c*, and the E-DPDCH **425**-*c* over carrier **405**-*a*. For example, frames **411**-*d*, **412**-*d*, **413**-*d*, **417**-*d*, **422**-*d*, **427**-*d*, **428**-*d*, and **429**-*d* associated with carrier **445** may be four times as long in time than frames **411**-*c*, **412**-*c*, **413**-*c*, **417**-*c*, **422**-*c*, **427**-*c*, **428**-*c*, and **429**-*c* associated with carrier **405**-*a*. Furthermore, delay times **416**-*d*, **421**-*d*, and **426**-*d* of carrier **445** may also be four times as long as delay times **416**-*c*, **421**-*c*, and **426**-*c* of carrier **405**-*a*. Thus the timing relationships between the various frames across the various channels of carrier **445** are the same as for carrier **405**-*a*, except scaled by a factor of 4.

For example, an E-AGCH frame **417**-*c* received over E-AGCH **415**-*c* in carrier **405**-*a* having N=1, may carry control information, such as one or more grants, that may be utilized over the E-DPDCH **425**-*c*. In order to utilize this control information communicated in E-AGCH frame **417**-*c*, the control information may be processed, such as during required processing time **430**-*c*. The processed control information may then be utilized over the E-DPDCH **425**-*c* in a next E-DPDCH frame, such as E-DPDCH frame **429**-*c*, after a utilization time **431**-*c*. Utilization time **431**-*c* may be determined based on the required processing time **430**-*c*. E-DPDCH frame **429**-*c* may correspond to P-CCPCH SFN i+2 **413**-*c*, which may be determined by Equation (1) or Equations (2) and (3) above, depending on which TTI value is implemented across the E-DCH. In some cases, if the control information is communicated via an E-RGCH, Equation (4) or Equations (5) and (6) may be also used.

As carrier **405**-*a* is not dilated, i.e. N=1, the required processing time **430**-*c* may be used as the minimum required processing time for other carriers having different flexible bandwidths, such as carrier **445** having N=4. Because carrier **445** is dilated by a factor of 4 with respect to carrier **405**-*a*, a dilated processing time **434** of control information communicated in an E-AGCH frame **417**-*d* may be 4 times as long as the required processing time **430**-*c* for a normal bandwidth carrier, which is shown right next to the dilated processing time **434**, as required processing time **430**-*d*. Because the dilated processing time **434** for carrier **445** is 4 times as long, the E-DPDCH frame **428**-*d* may not be utilized to apply the control information communicated in E-AGCH frame **417**-*d*. Rather, the E-DPDCH frame **429**-*d* may be used as the dilated processing time **434** ends in the middle of E-DPDCH frame **428**-*d*, thus increasing the dilated utilization time **435**. However, by configuring the dilated processing time **434** and thus the subsequent dilated utilization time **435** to correspond to the required processing time **430**-*d* and the subsequent utilization time **431**-*d*, by for example by undilating these values, the dilated utilization time **435** may be decreased to the utilization time **431**-*d*. This may further be accomplished by determining the SFN on the P-CCPCH **425**-*d* over which the control information may be utilized via Equation (1) or Equations (2) and (3), depending on what value of TTI is used across the E-DCH. By undilating the dilated processing time **435** for carrier **445**, the control information, which may include one or more grants, may be applied 1 frame earlier across the E-DPDCH **425**-*d* than if the dilated processing time **434** remained dilated. Further advantages may also be realized by decreasing the required processing time over a flexible bandwidth carrier to correlate with the required processing time over a normal bandwidth carrier, such as increases in overall system efficiency.

With specific reference to FIG. **4**C, a control information processing and utilization timing diagram **400**-*c* depicts a first flexible bandwidth carrier (N=2) **435**-*a*, and a second flexible bandwidth carrier (N=4) **445**-*a*. All of the relationship described above with respect to the various channels including timing relations may apply to carriers **435**-*a* and **445**-*a*, with the only difference being that in time, every frame and time period for carrier **445**-*a* is 2 times as long as for carrier **435**-*a*, such that each frame length of each of the P-CCPCH **410**-*f*, the E-AGCH **415**-*f*, the DL DPCH **420**-*f*, and the E-DPDCH **425**-*f* is 2 times as long as each frame of the P-CCPCH **410**-*e*, the E-AGCH **415**-*e*, the DL DPCH **420**-*e*, and the E-DPDCH **425**-*e* over carrier **435**-*a*. For example, frames **411**-*f*, **412**-*f*, **413**-*f*, **417**-*f*, **422**-*f*, **427**-*f*, **428**-*f*, and **429**-*f* associated with carrier **445**-*a* may be 2 times as long in time than frames **411**-*e*, **412**-*e*, **413**-*e*, **417**-*e*, **422**-*e*, **427**-*e*, **428**-*e*, and **429**-*e* associated with carrier **435**-*a*. Furthermore, delay times **416**-*f*, **421**-*f*, and **426**-*f* of carrier **445**-*a* may also be 2 times as long as delay times **416**-*e*, **421**-*e*, and **426**-*e* of carrier **435**-*a*. Thus the timing relationships between the various frames across the various channels of carrier **445**-*a* are the same as for carrier **435**-*a*, except scaled by a factor of 2 with respect to carrier **435**-*a*.

In some embodiments, in addition to aligning a required processing time **430** of a normal bandwidth carrier, such as carrier **405**, with a dilated processing time of a flexible bandwidth carrier, the dilated processing times of two different flexible bandwidth carriers may be aligned/configured based on a required processing time (undilated) of a normal bandwidth carrier. For example, a dilated processing time **432**-*a* of a flexible bandwidth carrier **435**-*a* having N=2, may be aligned with the dilated processing time **434**-*a* of another flexible bandwidth carrier **445**-*a* having N=4, based on a required processing time **430**-*e*, **430**-*f* (undilated), of a normal bandwidth carrier having N=1, such as carrier **405** (not shown).

In particular, an E-AGCH frame **417**-*e* received over E-AGCH **415**-*e* of carrier **435**-*a* having N=2, may carry control information, such as one or more grants, that may be utilized over the E-DPDCH **425**-*e*. In order to utilize this control information communicated in E-AGCH frame **417**-*e*, the control information may be processed, such as during a dilated processing time **432**-*a*. The processed control information may then be utilized over the E-DPDCH **425**-*e* in the next E-DPDCH frame, such as E-DPDCH frame **429**-*e*, after a utilization time **433**-*a*. Utilization time **433**-*a* may be determined based on the required processing time **432**-*a*. E-DPDCH frame **429**-*e* may correspond to P-CCPCH SFN i+2 **413**-*e*, which may be determined by Equation (1) or Equations (2) and (3) above, depending on which TTI value is implemented across the E-DCH. In some cases, if the control information is communicated via an E-RGCH, Equation (4) or Equations (5) and (6) may be used.

The required processing time **430**-*e*, corresponding to a normal bandwidth carrier such as carrier **405**, may be used as the minimum required processing time for other carriers having different flexible bandwidths, such as carrier **435**-*a* having N=2 and carrier **445**-*a* having N=4. Because carrier **435**-*a* is dilated by a factor of 2, a dilated processing time **432**-*a* of control information communicated in an E-AGCH frame **417**-*e* may be twice as long as the required processing time **430**-*e* for a normal bandwidth carrier, which is shown right next to the dilated processing time **432**-*a*. Because the dilated processing time **432**-*a* for carrier **435**-*a* is twice as long, the E-DPDCH frame **428**-*e* beginning in PCCPCH SFN i+1 **413**-*e* may not be utilized to apply the control information communicated in E-AGCH frame **417**-*e*. Rather, the E-DPDCH frame **429**-*e* beginning in PCCPCH SFN i+2 **413**-*e* may be used as the dilated processing time **432**-*a* ends in the middle of E-DPDCH frame **428**-*b*, thus increasing the dilated utilization time **433**-*a*.

Furthermore, carrier **445**-*a* is dilated by a factor of 4 resulting in a dilated processing time **434**-*a* of control information communicated in an E-AGCH frame **417**-*f* being 4 times as long as the required processing time **430**-*f* for a normal bandwidth carrier, which is shown next to the dilated processing time **434**-*a*. Because the dilated processing time **434**-*a* for carrier **445**-*a* is 4 times as long, the E-DPDCH frame **428**-*e* beginning in PCCPCH SFN i+1 **413**-*f* may not be utilized to apply the control information communicated in E-AGCH frame **417**-*f*. Rather, the E-DPDCH frame beginning in

PCCPCH SFN i+1 **413**-*f* **429**-*f* may be used as the dilated processing time **434**-*a* ends in the middle of E-DPDCH frame **428**-*e*, thus increasing the dilated utilization time **435**-*a*.

In some embodiments, by configuring the dilated processing times **432**-*a*, **434**-*a* and thus the subsequent dilated utilization times **433**-*a*, **435**-*a* to correspond to the required processing time **430**-*e*, **430**-*f* and the subsequent utilization time **431**-*e*, **431**-*f*, for example by undilating these values, the dilated utilization time **433**-*a*, **435**-*a* may be decreased to the utilization times **431**-*e*, **431**-*f*. Configuring the dilated processing time **434**-*a* of carrier **445**-*a* to match the required processing time **430**-*e*, **430**-*f* of a normal bandwidth carrier, may also be done in conjunction with configuring the dilated processing time **432**-*a* of carrier **435**-*a* to match the same required processing time **430**-*e*, **430**-*f* of a normal bandwidth carrier to realize control information processing and utilization synchronization and/or efficiency increases across multiple different flexible bandwidth carriers. This may further be accomplished by determining the SFN on the P-CCPCH **410**-*e*, **410**-*f* over which the control information may be utilized via Equation (1) or Equations (2) and (3), depending on what value of TTI is used across the E-DCH. By undilating the dilated processing time **432**-*a*, **434**-*a* for carriers **435**-*a* and **445**-*a*, the control information, which may include one or more grants, may be applied 1 frame earlier across the E-DPDCH **425**-*c*, **425**-*d*, such as in E-DPDCH **428**-*e*, **428**-*f* beginning in P-CCPCH SFN i+1 **412**-*e*, **412**-*f*, than if the required processing time **432**-*a*, **434**-*a* remained dilated.

In other embodiments, the dilated processing time, such as time **432**-*a* of carrier **435**-*a* having N=2, may be used as the baseline to adjust a dilated processing time **434**-*a* of carrier **445**-*a* having N=4. This may result in the utilization time **435**-*a* of carrier **445**-*a* being reduced such that an E-DPDCH frame **428**-*f* beginning in P-CCPCH SFN i+1 **412**-*f* may be used to apply the control information received in the E-AGCH frame **417**-*f* instead of in the E-DPDCH frame **429**-*f* beginning in P-CCPCH SFN i+2 **413**-*f*, thus reducing control information application delay. In some cases this may equate to the dilated utilization time **435**-*a* over carrier **445**-*a* being reduced to the dilated utilization time **433**-*a* over carrier **435**-*a*.

Turning next to FIG. **5**A, a block diagram illustrates a device **500** that includes control information processing and utilization functionality in a multicarrier system that utilizes one or more flexible bandwidth carriers in accordance with various embodiments. The device **500** may be an example of the user equipment (UE) **115** of FIG. **1**, FIG. **2**A, FIG. **2**B, and/or FIG. **3**, configured to implement aspects of timing diagrams **400**-*a*, **400**-*b*, and/or **400**-*c*, of FIGS. **4**A, **4**B, and/or **4**C. In alternative embodiments, device **500** may be an example of aspects of: the base stations **105** of FIG. **1**, FIG. **2**A, FIG. **2**B, and/or FIG. **3**, and/or the controller **120**/core network **130** of FIG. **1**. The device **500** may include a receiver module **505**, a control information module **510**, and a transmitter module **515**. Each of these components may be in communication with each other.

These components of the device **500** may, individually or collectively, be implemented with one or more application-specific integrated circuits (ASICs) adapted to perform some or all of the applicable functions in hardware. Alternatively, the functions may be performed by one or more other processing units (or cores), on one or more integrated circuits. In other embodiments, other types of integrated circuits may be used (e.g., Structured/Platform ASICs, Field Programmable Gate Arrays (FPGAs), and other Semi-Custom ICs), which may be programmed in any manner known in the art. The functions of each unit may also be implemented, in whole or in part, with instructions embodied in a memory, formatted to be executed by one or more general or application-specific processors.

The receiver module **505** may receive information such as packet, data, and/or signaling information regarding what device **500** has received. The receiver module **505** may receive control information over a first channel of one of the one or more flexible bandwidth carriers. The received control information may be utilized by the device **500** for different purposes. The transmitter module **515** may transmit information such as packets, data, or signaling information regarding what device **500** has processed. The transmitted information may be utilized by various network entities for different purposes, as described below.

The control information module **510** may be configured to perform a method of control information processing and utilization, such as for optimizing timing relations between multiple carriers, in a multicarrier system that utilizes one or more flexible bandwidth carriers. For example, the control information module **510** may, upon communication of the received control information over a first channel of one of the one or more flexible bandwidth carriers from the receiver module **505**, determine a processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers based on a processing time of control information for a normal bandwidth carrier or another flexible bandwidth carrier. The control information module **510** may further utilize the received control information over the first channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the first channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers. At least the first carrier or the second carrier may include at least one of the one or more flexible bandwidth carriers.

In some cases, the control information module **510** may, upon determining or obtaining the processing time for the received control information, instruct, via transmitter module **515**, another network device, such as a UE **115** or base station (s) **105**, to utilize the received control information over the first channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the first channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers.

In some embodiments, the receiver module **505** may further be configured to receive the control information for the normal bandwidth carrier or the other flexible bandwidth carrier over a channel of the normal bandwidth carrier or the other flexible bandwidth carrier and communicate this control information to the control information module **510**. The control information module **510** may then utilize the received control information for the normal bandwidth carrier or the other flexible bandwidth carrier during a first transmission time interval (TTI) of the channel of the normal bandwidth carrier or the other flexible bandwidth carrier subsequent to the processing time for the received control information over the channel of the normal bandwidth carrier or the other flexible bandwidth carrier. In some cases, another network entity, such as a UE **115** or base station(s) **105** may be instructed to utilize the received control information for the normal bandwidth carrier or the other flexible bandwidth carrier as described above, via transmitter module **515**.

In some embodiments, the receiver module **505** may further be configured to receive control information over a second channel of one of the one or more flexible bandwidth carriers and communicate this control information to the control information module **510**. The control information module **510** may then determine a processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers based on a processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier and the determined processing time for the received control information over the channel of the one or more flexible bandwidth carriers. The control information module **510** may further utilize the received control information over the second channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the second channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers. In some cases, another network entity, such as a UE **115** or base station(s) **105** may be instructed to utilize the received control information for the second channel of the one of the one or more flexible bandwidth carriers as described above, via transmitter module **515**.

In some embodiments, the control information module **510** may determine the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers, at least in part, by determining a system frame number for applying the received control information based on a bandwidth scaling factor of the first channel of one of the one or more flexible bandwidth carriers.

In some cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may equal the processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier. In some embodiments, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be less than a dilated processing time, such as a theoretical dilated processing time, for the received control information over the first channel of the one of the one or more flexible bandwidth carriers.

In some cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be undilated with respect to the processing time for control information over a normal bandwidth carrier or another flexible bandwidth carrier. In other words, this may equate to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers, when adjusted, being un-dilated in relation to other signaling over the flexible bandwidth carrier.

In some embodiments, the control information over the first channel of one of the one or more flexible bandwidth carriers may include one or more grants. In some cases, the first channel of the one of the one or more flexible bandwidth carriers may include one of an Enhanced Absolute Grant Channel (E-AGCH) or Enhanced Relative Grant Channel (E-RGCH).

In some embodiments, the first carrier may be a normal bandwidth carrier and the second carrier may include be a flexible bandwidth carrier. In some embodiments, the first carrier may be a flexible bandwidth carrier and the second carrier may be a flexible bandwidth carrier different from the first carrier. In some cases, the flexible bandwidth of the first carrier may be greater than the flexible bandwidth of the second carrier. In some cases, the flexible bandwidth of the first carrier may be less than the flexible bandwidth of the second carrier.

In some embodiments, the first carrier may have a bandwidth scaling factor equal to 1 and the second carrier may have a bandwidth scaling factor equal to 2 or 4. In other embodiments, the first carrier may have a bandwidth scaling factor equal to 2 or 4, and the second carrier may have a bandwidth scaling factor equal to 4 or 2.

Turning next to FIG. **5**B, a block diagram illustrates a device **500**-*a* that includes control information processing and utilization functionality in a multicarrier system that utilizes one or more flexible bandwidth carriers in accordance with various embodiments. The device **500**-*a* may be an example of aspects of the user equipment **115** of FIG. **1**, FIG. **2**A, FIG. **2**B, and/or FIG. **3**, and/or aspects of the controller **120**/core network **130** of FIG. **1**, configured to implement the timing diagrams **400**-*a*, **400**-*b*, and/or **400**-*c* of FIGS. **4**A, **4**B, and/or **4**C. In alternative embodiments, the device **500**-*a* may be an example of: the base stations **105** of FIG. **1**, FIG. **2**A, FIG. **2**B, and/or FIG. **3**.

The device **500**-*a* may include a receiver module **505**, a control information processing time determination module **511**, a control information utilization module **512**, and a transmitter module **515**. Each of these components may be in communication with each other. In some embodiments, the control information module **510**-*a*, which may incorporate some or all aspects of the control information module **510** of FIG. **5**A, may include the control information processing time determination module **511** and the control information utilization module **512**. Device **500**-*a*, which may be a UE **115**, may include some or all aspects of, or may implement some or all of the functionality of, device **500** as described above in reference to FIG. **5**A.

The components of the device **500**-*a* may, individually or collectively, be implemented with one or more application-specific integrated circuits (ASICs) adapted to perform some or all of the applicable functions in hardware. Alternatively, the functions may be performed by one or more other processing units (or cores), on one or more integrated circuits. In other embodiments, other types of integrated circuits may be used (e.g., Structured/Platform ASICs, Field Programmable Gate Arrays (FPGAs), and other Semi-Custom ICs), which may be programmed in any manner known in the art. The functions of each unit may also be implemented, in whole or in part, with instructions embodied in a memory, formatted to be executed by one or more general or application-specific processors.

The receiver module **505** may receive information such as packet, data, and/or signaling information regarding what device **500**-*a* has received. The receiver module **505** may receive control information over a first channel of one of the one or more flexible bandwidth carriers. The received control information may be utilized by the device **500**-*a* for different purposes. The transmitter module **515** may transmit information such as packets, data, or signaling information regarding what device **500**-*a* has processed. The transmitted information may be utilized by various network entities for different purposes as described herein.

The control information processing time determination module **511** may be configured to, upon communication of the received control information over a first channel of one of the one or more flexible bandwidth carriers from the receiver module **505**, determine a processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers based on a processing time of control information for a normal bandwidth carrier or another flexible bandwidth carrier. The control information processing time determination module **511** may then communication the determined processing time to the control information utilization module **512**. The control information utilization module **512** may utilize the received control information over the first channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the first channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers. The transmitter module **515** may be configured to communicate some or all of the determined information, including control information processing time(s), to help coordinate control information processing and utilization across multiple carriers utilized by various network entities, such as by UE(s) **115** and base stations(s) **105**. In some cases, at least the first carrier or the second carrier may include at least one of the one or more flexible bandwidth carriers.

In some embodiments, the receiver module **505** may further be configured to receive the control information for the normal bandwidth carrier or the other flexible bandwidth carrier over a channel of the normal bandwidth carrier or the other flexible bandwidth carrier and communication this control information to the control information module **510**. The control information utilization module **512** may then utilize the received control information for the normal bandwidth carrier or the other flexible bandwidth carrier during a first transmission time interval (TTI) of the channel of the normal bandwidth carrier or the other flexible bandwidth carrier subsequent to the processing time for the received control information over the channel of the normal bandwidth carrier or the other flexible bandwidth carrier.

In some embodiments, the receiver module **505** may further be configured to receive control information over a second channel of one of the one or more flexible bandwidth carriers and communication this control information to the control information processing time determination module **511**. The control information processing time determination module **511** may then determine a processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers based on a processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier and the determined processing time for the received control information over the channel of the one or more flexible bandwidth carriers. The control information processing time determination module **511** may communicate the processing time for the received control information over the second channel to the control information utilization module **512**. The control information utilization module **512** may then utilize the received control information over the second channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the second channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers.

In some embodiments, the control information processing time determination module **511** may determine the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers, at least in part, by determining a system frame number for applying the received control information based on a bandwidth scaling factor of the first channel of one of the one or more flexible bandwidth carriers.

In some cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may equal the processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier. In some embodiments, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be less than a dilated processing time, such as a theoretical dilated processing time, for the received control information over the first channel of the one of the one or more flexible bandwidth carriers.

In some cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be undilated with respect to the processing time for control information over a normal bandwidth carrier or another flexible bandwidth carrier. In other words, this may equate to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers, when adjusted, being un-dilated, or scaled by a factor of 2 or 4, in relation to other signaling over the flexible bandwidth carrier.

In some embodiments, the control information over the first channel of one of the one or more flexible bandwidth carriers may include one or more grants. In some cases, the first channel of the one of the one or more flexible bandwidth carriers may include one of an Enhanced Absolute Grant Channel (E-AGCH) or Enhanced Relative Grant Channel (E-RGCH). In some cases, the one of the one or more flexible bandwidth carriers may utilize a bandwidth scaling factor equal to 2 or 4.

In some embodiments, the control information processing time determination module **511** and/or the control information utilization module **512** may be located at a UE **115**. The receiver module **505** and/or the transmitter module **515** may also be located at the UE **115**. In other embodiments, the receiver module **505**, the control information processing time determination module **511**, the control information utilization module **512**, and/or the transmitter module **15** may be located at different network entities, such as base station (s) **105**, and may coordinate via the backhaul, air interfaces, etc.

FIG. **6** shows a block diagram of a communications system **600** that may be configured for control information processing and utilization in a multicarrier system that utilizes one or more flexible bandwidth carriers in accordance with various embodiments. This system **600** may include aspects of the system **100** depicted in FIG. **1**, systems **200**-*a* and **200**-*b* of FIGS. **2**A and **2**B, system **300** of FIG. **3**, and/or systems **400**-*a*, **400**-*b*, and/or **400**-*c* of FIGS. **4**A, **4**B, and/or **4**C, and/or devices **500** and **500**-*a* of FIGS. **5**A and/or **5**B. The base station **105**-*d* may include aspects of a controller **120**-*a* and/or a core network **130**-*a* in some cases. The base station **105**-*d* may include antennas **645**, a transceiver module **650**, memory **670**, and a processor module **665**, which each may be in communication, directly or indirectly, with each other (e.g., over one or more buses). The transceiver module **650** may be configured to communicate bi-directionally, via the antennas **645**, with the user equipment **115**-*d*, which may be a multi-mode user equipment. The transceiver module **650** (and/or other components of the base station **105**-*d*) may also be configured to communicate bi-directionally with one or more networks. In some cases, the base station **105**-*d* may communicate with the network **130**-*a* through network communications module **675**. Base station **105**-*d* may be an example of an eNodeB base station, a Home eNodeB base station, a NodeB base station, a Radio Network Controller (RNC), and/or a Home NodeB base station.

Base station **105**-*d* may also communicate with other base stations **105**, such as base station **105**-*e* and base station **105**-*f* Each of the base stations **105** may communicate with user equipment **115**-*d* using different wireless communications technologies, such as different Radio Access Technologies. In some cases, base station **105**-*d* may communicate with other base stations such as **105**-*e* and/or **105**-*f* utilizing base station communication module **631**. In some embodiments, base station communication module **631** may provide an X2 interface within an LTE wireless communication technology to provide communication between some of the base stations **105**. In some embodiments, base station **105**-*d* may communicate with other base stations through controller **120**-*a* and/or network **130**-*a*.

The memory **670** may include random access memory (RAM) and read-only memory (ROM). The memory **670** may also store computer-readable, computer-executable software code **671** containing instructions that are configured to, when executed, cause the processor module **665** to perform various functions described herein (e.g., call processing, database management, message routing, etc.). Alternatively, the software **671** may not be directly executable by the processor module **665** but be configured to cause the computer, e.g., when compiled and executed, to perform functions described herein.

The processor module **665** may include an intelligent hardware device, e.g., a central processing unit (CPU) such as those made by Intel® Corporation or AMD®, a microcontroller, an application-specific integrated circuit (ASIC), etc. The processor module **665** may include a speech encoder (not shown) configured to receive audio via a microphone, convert the audio into packets (e.g., 20 ms in length) representative of the received audio, provide the audio packets, and/or provide indications of whether a user is speaking.

The transceiver module **650** may include a modem configured to modulate the packets and provide the modulated packets to the antennas **645** for transmission, and to demodulate packets received from the antennas **645**. While some examples of the base station **105**-*d* may include a single antenna **645**, the base station **105**-*d* preferably includes multiple antennas **645** for multiple links which may support carrier aggregation. For example, one or more links may be used to support macro communications with user equipment **115**-*d*.

According to the architecture of FIG. **6**, the base station **105**-*d* may further include a communications management module **630**. By way of example, the communications management module **630** may be a component of the base station **105**-*d* in communication with some or all of the other components of the base station **105**-*d* via a bus. Alternatively, functionality of the communications management module **630** may be implemented as a component of the transceiver module **650**, as a computer program product, and/or as one or more controller elements of the processor module **665**.

The components for base station **105**-*d* may be configured to implement aspects discussed above with respect to device **500** of FIG. **5**A and/or device **500**-*a* of FIG. **5**B and/or configurations of systems **400**-*a*, **400**-*b*, and/or **400**-*c* of FIGS. **4**A, **4**B, and/or **4**C and may not be repeated here for the sake of brevity. The control information processing time determination module **511**-*a* may be an example of the control information processing time determination module **511** of FIG. **5**B. The control information utilization module **512**-*a* may be an example of the control information processing time determination module **512** of FIG. **5**B. Furthermore, control information module **510**-*b*, which may include the control information processing time determination module **511**-*a* and the control information utilization module **512**-*a*, may be an example of the control information module **510** of FIG. **5**A and/or the control information module **510**-*a* of FIG. **5**B.

The base station **105**-*d* may also include a spectrum identification module (not shown). The spectrum identification module may be utilized to identify spectrum available for flexible bandwidth waveforms. In some embodiments, a handover module **625** may be utilized to perform handover procedures of the user equipment **115**-*d* from one base station **105** to another. For example, the handover module **625** may perform a handover procedure of the user equipment **115**-*d* from base station **105**-*d* to another where normal waveforms are utilized between the user equipment **115**-*d* and one of the base stations and flexible bandwidth waveforms are utilized between the user equipment and another base station. A bandwidth scaling module **627** may be utilized to scale and/or alter chip rates and/or time to generate flexible bandwidth waveforms.

In some embodiments, the transceiver module **650** in conjunction with antennas **645**, along with other possible components of base station **105**-*d*, may transmit and/or receive information regarding flexible bandwidth waveforms and/or scaling factors from the base station **105**-*d* to the user equipment **115**-*d*, to other base stations **105**-*e*/**105**-*f*, or core network **130**-*a*. In some embodiments, the transceiver module **650** in conjunction with antennas **645**, along with other possible components of base station **105**-*d*, may transmit and/or receive information to or from the user equipment **115**-*d*, to or from other base stations **105**-*e*/**105**-*f*, or core network **130**-*a*, such as flexible bandwidth waveforms and/or scaling factors, such that these devices or systems may utilize flexible bandwidth waveforms.

FIG. **7** is a block diagram **700** of a user equipment **115**-*e* configured in accordance with various embodiments. The user equipment **115**-*e* may have any of various configurations, such as personal computers (e.g., laptop computers, netbook computers, tablet computers, etc.), cellular telephones, PDAs, digital video recorders (DVRs), internet appliances, gaming consoles, e-readers, etc. The user equipment **115**-*e* may have an internal power supply (not shown), such as a small battery, to facilitate mobile operation. In some embodiments, the user equipment **115**-*e* may implement aspects of the system **100** depicted in FIG. **1**, systems **200**-*a* and **200**-*b* of FIGS. **2**A and **2**B, system **300** of FIG. **3**, systems **400**-*a*, **400**-*b*, and/or **400**-*c* of FIGS. **4**A, **4**B, and/or **4**C, and/or system **600** of FIG. **6**; and/or devices **500** and **500**-*a* of FIGS. **5**A and/or **5**B. The user equipment **115**-*e* may be a multi-mode user equipment. The user equipment **115**-*e* may further be referred to as a wireless communications device in some cases.

The user equipment **115**-*e* may include antennas **740**, a transceiver module **750**, memory **780**, and a processor module **770**, which each may be in communication, directly or indirectly, with each other (e.g., via one or more buses). The transceiver module **750** is configured to communicate bi-directionally, via the antennas **740** and/or one or more wired or wireless links, with one or more networks, as described above. For example, the transceiver module **750** may be configured to communicate bi-directionally with base stations **105** of FIG. **1**, FIGS. **2**A and **2**B, FIG. **3**, and/or FIG. **6**, and/or with devices **500** and **500**-*a* of FIGS. **5**A and **5**B. The transceiver module **750** may include a modem configured to modulate the packets and provide the modulated packets to the antennas **740** for transmission, and to demodulate packets received from the antennas **740**. While the user equipment

115-*e* may include a single antenna, the user equipment **115**-*e* will typically include multiple antennas **740** for multiple links.

The memory **780** may include random access memory (RAM) and read-only memory (ROM). The memory **780** may store computer-readable, computer-executable software code **785** containing instructions that are configured to, when executed, cause the processor module **770** to perform various functions described herein (e.g., call processing, database management, message routing, etc.). Alternatively, the software **785** may not be directly executable by the processor module **770** but may be configured to cause the computer (e.g., when compiled and executed) to perform functions described herein.

The processor module **770** may include an intelligent hardware device, e.g., a central processing unit (CPU) such as those made by Intel® Corporation or AMD®, a microcontroller, an application-specific integrated circuit (ASIC), etc. The processor module **770** may include a speech encoder (not shown) configured to receive audio via a microphone, convert the audio into packets (e.g., 20 ms in length) representative of the received audio, provide the audio packets to the transceiver module **750**, and provide indications of whether a user is speaking. Alternatively, an encoder may only provide packets to the transceiver module **750**, with the provision or withholding/suppression of the packet itself providing the indication of whether a user is speaking. The processor module **770** may also include a speech decoder that may perform a reverse functionality as the speech encoder.

According to the architecture of FIG. **7**, the user equipment **115**-*e* may further include a communications management module **760**. The communications management module **760** may manage communications with other user equipments **115**. By way of example, the communications management module **760** may be a component of the user equipment **115**-*e* in communication with some or all of the other components of the user equipment **115**-*e* via a bus. Alternatively, functionality of the communications management module **760** may be implemented as a component of the transceiver module **750**, as a computer program product, and/or as one or more controller elements of the processor module **770**.

The components for user equipment **115**-*e* may be configured to implement aspects discussed above with respect to device **500** of FIG. **5**A and/or device **500**-*a* of FIG. **5**B, system **600** of FIG. **6**, and/or configurations of systems **400**-*a*, **400**-*b*, and/or **400**-*c* of FIGS. **4**A, **4**B, and/or **4**C, and may not be repeated here for the sake of brevity. The control information processing time determination module **511**-*b* may be an example of the control information processing time determination module **511** of FIG. **5**B. The control information utilization module **512**-*b* may be an example of the control information utilization module **512** of FIG. **5**B. Furthermore, control information module **510**-*c*, which may include control information processing time determination module **511**-*b* and the control information utilization module **512**-*b*, may be an example of the control information module **510** of FIG. **5**A and/or the control information module **510**-*a* of FIG. **5**B.

The user equipment **115**-*e* may also include a spectrum identification module (not shown). The spectrum identification module may be utilized to identify spectrum available for flexible bandwidth waveforms. In some embodiments, a handover module **725** may be utilized to perform handover procedures of the user equipment **115**-*e* from one base station to another. For example, the handover module **725** may perform a handover procedure of the user equipment **115**-*e* from one base station to another where normal waveforms are utilized between the user equipment **115**-*e* and one of the base stations and flexible bandwidth waveforms are utilized between the user equipment and another base station. A bandwidth scaling module **727** may be utilized to scale and/or alter chip rates and/or time to generate/decode flexible bandwidth waveforms.

In some embodiments, the transceiver module **750**, in conjunction with antennas **740**, along with other possible components of user equipment **115**-*e*, may transmit information regarding flexible bandwidth waveforms and/or scaling factors from the user equipment **115**-*e* to base stations or a core network. In some embodiments, the transceiver module **750**, in conjunction with antennas **740**, along with other possible components of user equipment **115**-*e*, may transmit/receive information, such flexible bandwidth waveforms and/or scaling factors, to/from base stations or a core network such that these devices or systems may utilize flexible bandwidth waveforms.

FIG. **8** is a block diagram of a system **800** including a base station **105**-*g* and a user equipment **115**-*f* in accordance with various embodiments. The system **800** may be an example of the system **100** of FIG. **1**, systems **200**-*a* and **200**-*b* of FIGS. **2**A and **2**B, system **300** of FIG. **3**, system **600** of FIG. **6**, system **700** of FIG. **7**, and/or devices **500** and **500**-*a* of FIGS. **5**A and **5**B. The base station **105**-*g* may be equipped with antennas **834**-*a* through **834**-*x*, and the user equipment **115**-*f* may be equipped with antennas **852**-*a* through **852**-*n*. At the base station **105**-*g*, a transmit processor **820** may receive data from a data source. System **800** may be configured to implement different aspects of the systems as shown in FIGS. **4**A, **4**B, and/or **4**C, and/or the associated descriptions.

The transmit processor **820** may process the data. The transmit processor **820** may also generate reference symbols, and a cell-specific reference signal. A transmit (TX) MIMO processor **830** may perform spatial processing (e.g., precoding) on data symbols, control symbols, and/or reference symbols, if applicable, and may provide output symbol streams to the transmit modulators **832**-*a* through **832**-*x*. Each modulator **832** may process a respective output symbol stream (e.g., for OFDM, etc.) to obtain an output sample stream. Each modulator **832** may further process (e.g., convert to analog, amplify, filter, and upconvert) the output sample stream to obtain a downlink (DL) signal. In one example, DL signals from modulators **832**-*a* through **832**-*x* may be transmitted via the antennas **834**-*a* through **834**-*x*, respectively. The transmit processor **820** may receive information from a processor **840**. The processor **840** may be coupled with a memory **842**. The processor **840** may be configured to generate flexible bandwidth waveforms through altering a chip rate and/or utilizing a scaling factor. In some embodiments, the processor module **840** may be configured for dynamically adapting flexible bandwidth in accordance with various embodiments. The processor **840** may dynamically adjust one or more scale factors of the flexible bandwidth signal associated with transmissions between base station **105**-*g* and user equipment **115**-*f*. These adjustments may be made based on information such as traffic patterns, interference measurements, etc.

For example, within system **800**, the processor **840** may further include a control information module **510**-*d* configured to, upon receiving control information over a first channel of one of the one or more flexible bandwidth carriers, for example via the antennas **834**-*a* through **834**-*x*, determine a processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers based on a processing time of control information for a normal bandwidth carrier or another flexible bandwidth carrier. The control information module **510**-*d* may further be configured to utilize the received control information over the first channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the first channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers. At least the first carrier or the second carrier may include at least one of the one or more flexible bandwidth carriers. The control information module **510**-*d* may be an example of or may incorporate aspects of the control information module **510**, **510**-*a*, **510**-*b*, and **510**-*c* of FIGS. **5**A, **5**B, **6**, and/or **7**.

At the user equipment **115**-*f*, the user equipment antennas **852**-*a* through **852**-*n* may receive the DL signals from the base station **105**-*g* and may provide the received signals to the demodulators **854**-*a* through **854**-*n*, respectively. Each demodulator **854** may condition (e.g., filter, amplify, downconvert, and digitize) a respective received signal to obtain input samples. Each demodulator **854** may further process the input samples (e.g., for OFDM, etc.) to obtain received symbols. A MIMO detector **856** may obtain received symbols from all the demodulators **854**-*a* through **854**-*n*, perform MIMO detection on the received symbols, if applicable, and provide detected symbols. A receive processor **858** may process (e.g., demodulate, deinterleave, and decode) the detected symbols, providing decoded data for the user equipment **115**-*f* to a data output, and provide decoded control information to a processor **880**, or memory **882**.

On the uplink (UL) or reverse link, at the user equipment **115**-*f*, a transmit processor **864** may receive and process data from a data source. The transmitter processor **864** may also generate reference symbols for a reference signal. The symbols from the transmit processor **864** may be precoded by a transmit MIMO processor **866**, if applicable, further processed by the demodulators **854**-*a* through **854**-*n* (e.g., for SC-FDMA, etc.), and be transmitted to the base station **105**-*g* in accordance with the transmission parameters received from the base station **105**-*g*. The transmit processor **864** may also be configured to generate flexible bandwidth waveforms through altering a chip rate and/or utilizing a scaling factor; this may be done dynamically in some cases. The transmit processor **864** may receive information from processor **880**. The processor **880** may provide for different alignment and/or offsetting procedures. The processor **880** may also utilize scaling and/or chip rate information to perform measurements on the other subsystems, perform handoffs to the other subsystems, perform reselection, etc. The processor **880** may invert the effects of time stretching associated with the use of flexible bandwidth through parameter scaling. At the base station **105**-*g*, the UL signals from the user equipment **115**-*f* may be received by the antennas **834**, processed by the demodulators **832**, detected by a MIMO detector **836**, if applicable, and further processed by a receive processor **838**. The receive processor **838** may provide decoded data to a data output and to the processor **840**. In some embodiments, the processor **840** may be implemented as part of a general processor, the transmit processor **830**, and/or the receiver processor **838**.

In some embodiments, the processor module **880** may be configured for dynamically adapting flexible bandwidth in accordance with various embodiments. The processor **880** may dynamically adjust one or more scale factors of the flexible bandwidth signal associated with transmissions between base station **105**-*g* and user equipment **115**-*f*. These adjustments may be made based on information such as traffic patterns, interference measurements, etc.

For example, within system **800**, the processor **880** may further include a control information module **510**-*e* configured to, upon receiving control information over a first channel of one of the one or more flexible bandwidth carriers, for example via the antennas **852**-*a* through **852**-*n*, determine a processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers based on a processing time of control information for a normal bandwidth carrier or another flexible bandwidth carrier. The control information module **510**-*e* may further be configured to utilize the received control information over the first channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the first channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers. At least the first carrier or the second carrier may include at least one of the one or more flexible bandwidth carriers. The control information module **510**-*e* may be an example of or may incorporate aspects of the control information module **510**, **510**-*a*, **510**-*b*, and **510**-*c* of FIGS. **5**A, **5**B, **6**, and/or **7**. Furthermore, the control information module **510**-*e* may coordinate and/or share functionality with the control information module **510**-*d*.

Turning to FIG. **9**A, a flow diagram of a method **900** for control information processing and utilization in a multicarrier system that utilizes one or more flexible bandwidth carriers is provided in accordance with various embodiments. Method **900** may be implemented utilizing various wireless communications devices and/or systems including, but not limited to: system **100** of FIG. **1**, systems **200**-*a* and **200**-*b* of FIGS. **2**A and **2**B, system **300** of FIG. **3**, systems **400**-*a*, **400**-*b*, and/or **400**-*c* of FIGS. **4**A, **4**B, and/or **4**C, system **600** of FIG. **6**, system **700** of FIG. **7**, and/or system **800** of FIG. **8**; the base stations **105** of FIG. **1**, FIG. **2**A, FIG. **2**B, FIG. **3**, FIG. **6**, and/or FIG. **8**; the user equipment **115** of FIG. **1**, FIG. **2**A, FIG. **2**B, FIG. **3**, FIG. **6**, FIG. **7**, and/or FIG. **8**; the controller **120**/core network **130** of FIGS. **1** and/or **6**; and/or devices **500** and **500**-*a* of FIGS. **5**A and **5**B.

At block **905**, control information may be received over a first channel of one of the one or more flexible bandwidth carriers, such as at a UE **115**.

At block **910**, a processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be determined based on a processing time of control information for a normal bandwidth carrier or another flexible bandwidth carrier.

At block **915**, the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be utilized during a first transmission time interval (TTI) of the first channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers.

In some embodiments, the method **900** may also include receiving the control information for the normal bandwidth carrier or the other flexible bandwidth carrier over a channel of the normal bandwidth carrier or the other flexible bandwidth carrier, and utilizing the received control information for the normal bandwidth carrier or the other flexible bandwidth carrier during a first transmission time interval (TTI) of the channel of the normal bandwidth carrier or the other flexible bandwidth carrier subsequent to the processing time for the received control information over the channel of the normal bandwidth carrier or the other flexible bandwidth carrier.

In further embodiments, the method **900** may include receiving control information over a second channel of one of the one or more flexible bandwidth carriers. Method **900** may further include determining a processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers based on a processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier and the determined processing time for the received control information over the channel of the one or more flexible bandwidth carriers. In some cases, method **900** may further include utilizing the received control information over the second channel of the one of the one or more flexible bandwidth carriers during a first transmission time interval (TTI) of the second channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the second channel of the one of the one or more flexible bandwidth carriers.

In some embodiments, determining the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may include determining at least a system frame number for applying the received control information based on a bandwidth scaling factor of the first channel of one of the one or more flexible bandwidth carriers.

In some cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may equal the processing time of the control information for the normal bandwidth carrier or the other flexible bandwidth carrier. In some embodiments, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be less than a dilated processing time, which may be less than a theoretical processing time, for the received control information over the first channel of the one of the one or more flexible bandwidth carriers.

In some cases, the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be undilated with respect to the processing time for a normal bandwidth carrier or another flexible bandwidth carrier. In other words, this may equate to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers, when adjusted, being undilated in relation to other signaling of the flexible bandwidth carrier.

In some embodiments, the control information over the first channel of one of the one or more flexible bandwidth carriers may include one or more grants. In some cases, the first channel of the one of the one or more flexible bandwidth carriers may include one of an Enhanced Absolute Grant Channel (E-AGCH) or Enhanced Relative Grant Channel (E-RGCH). The one of the one or more flexible bandwidth carriers may utilize a bandwidth scaling factor equal to 2 or 4.

Turning to FIG. **9**B, a flow diagram of a method **900**-*a* for control information processing and utilization in a multicarrier system that utilizes one or more flexible bandwidth carriers is provided in accordance with various embodiments. Method **900**-*a* may be implemented utilizing various wireless communications devices and/or systems including, but not limited to: system **100** of FIG. **1**, systems **200**-*a* and **200**-*b* of FIGS. **2**A and **2**B, system **300** of FIG. **3**, systems **400**-*a*, **400**-*b*, and/or **400**-*c*, of FIGS. **4**A, **4**B, and/or **4**C, system **600** of FIG. **6**, system **700** of FIG. **7**, and/or system **800** of FIG. **8**; the base stations **105** of FIG. **1**, FIG. **2**A, FIG. **2**B, FIG. **3**, FIG. **6**, and/or FIG. **8**; the user equipment **115** of FIG. **1**, FIG. **2**A, FIG. **2**B, FIG. **3**, FIG. **6**, FIG. **7**, and/or FIG. **8**; the controller **120**/core network **130** of FIGS. **1** and/or **6**; and/or devices **500** and **500**-*a* of FIGS. **5**A and **5**B. Method **900**-*a* may be an example of method **900** of FIG. **9**A.

At block **905**-*a*, control information including one or more grants may be received over a first channel of one of the one or more flexible bandwidth carriers, such as at a UE **115**.

At block **910**-*a*, a processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be determined based on a processing time of control information for a normal bandwidth carrier or another flexible bandwidth carrier by determining at least a system frame number for applying the received control information based on a bandwidth scaling factor of the one of the one or more flexible bandwidth carriers.

At block **915**-*a*, the received control information over the first channel of the one of the one or more flexible bandwidth carriers may be utilized during a first transmission time interval (TTI) of the first channel of the one of the one or more flexible bandwidth carriers subsequent to the processing time for the received control information over the first channel of the one of the one or more flexible bandwidth carriers. At least one of the carriers may include a flexible bandwidth carrier.

The detailed description set forth above in connection with the appended drawings describes exemplary embodiments and does not represent the only embodiments that may be implemented or that are within the scope of the claims. The term "exemplary" used throughout this description means "serving as an example, instance, or illustration," and not "preferred" or "advantageous over other embodiments." The detailed description includes specific details for the purpose of providing an understanding of the described techniques. These techniques, however, may be practiced without these specific details. In some instances, well-known structures and devices are shown in block diagram form in order to avoid obscuring the concepts of the described embodiments.

Information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

The various illustrative blocks and modules described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, multiple microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

The functions described herein may be implemented in hardware, software executed by a processor, firmware, or any combination thereof. If implemented in software executed by a processor, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Other examples and implementations are within the scope and spirit of the disclosure and appended claims. For example, due to the nature of software, functions described above can be implemented using software executed by a processor, hardware, firmware, hardwiring, or combinations of any of these. Features implementing functions may also be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations. Also, as used herein, including in the claims, "or" as used in a list of items prefaced by "at least one of" indicates a disjunctive list such that, for example, a list of "at least one of A, B, or C" means A or B or C or AB or AC or BC or ABC (i.e., A and B and C).

Computer-readable media includes both computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A storage medium may be any available medium that can be accessed by a general purpose or special purpose computer. By way of example, and not limitation, computer-readable media can comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code means in the form of instructions or data structures and that can be accessed by a general-purpose or special-purpose computer, or a general-purpose or special-purpose processor. Also, any connection is properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of medium. Disk and disc, as used herein, include compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk and blu-ray disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above are also included within the scope of computer-readable media.

The previous description of the disclosure is provided to enable a person skilled in the art to make or use the disclosure. Various modifications to the disclosure will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other variations without departing from the spirit or scope of the disclosure. Throughout this disclosure the term "example" or "exemplary" indicates an example or instance and does not imply or require any preference for the noted example. Thus, the disclosure is not to be limited to the examples and designs described herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

What is claimed is:

1. A method of control information processing and utilization for a wireless communications system that utilizes one or more flexible bandwidth carriers, the method comprising:

receiving control information over a first channel of one of the one or more flexible bandwidth carriers;

decreasing a dilated processing time attributed to the received control information over the first channel to correspond to a required processing time, wherein the required processing time is less than the dilated processing time attributed to the received control information over the first channel; and

determining a first transmission time interval (TTI) of the first channel to use in response to the received control information over the first channel based at least in part on the decreased dilated processing time for the received control information over the first channel.

2. The method of claim **1**, further comprising:

receiving control information for a normal bandwidth carrier over a channel of the normal bandwidth carrier; and

utilizing the received control information for the normal bandwidth carrier during a first transmission time interval (TTI) of the channel of the normal bandwidth carrier, the first TTI of the channel of the normal bandwidth carrier being determined based at least in part on a processing time of the control information for the normal bandwidth carrier.

3. The method of claim **1**, further comprising:

receiving control information over a second channel of one of the one or more flexible bandwidth carriers;

decreasing a dilated processing time attributed to the received control information over the second channel; and

utilizing the received control information over the second channel during a first transmission time interval (TTI) of the second channel, the first TTI of the second channel being determined based at least in part on the decreased dilated processing time for the received control information over the second channel.

4. The method of claim **1**, wherein determining the first TTI of the first channel comprises determining at least a system frame number for applying the received control information based at least in part on a bandwidth scaling factor of the first channel.

5. The method of claim **1**, wherein the required processing time equals a processing time of control information for a normal bandwidth carrier.

6. The method of claim **1**, wherein the control information over the first channel comprises one or more grants.

7. The method of claim **1**, wherein the first channel comprises at least an Enhanced Absolute Grant Channel (E-AGCH) or an Enhanced Relative Grant Channel (E-RGCH).

8. The method of claim **1**, wherein the one of the one or more flexible bandwidth carriers of the first channel comprises a bandwidth scaling factor equal to 2 or 4.

9. A system for control information processing and utilization in a wireless communications system that utilizes one or more flexible bandwidth carriers, the system comprising:

means for receiving control information over a first channel of one of the one or more flexible bandwidth carriers;

means for decreasing a dilated processing time attributed to the received control information over the first channel to correspond to a required processing time, wherein the required processing time is less than the dilated processing time attributed to the received control information over the first channel; and

means for determining a first transmission time interval (TTI) of the first channel to use in response to the received control information over the first channel based at least in part on the decreased dilated processing time for the received control information over the first channel.

10. The system of claim **9**, further comprising:

means for receiving control information for a normal bandwidth carrier over a channel of the normal bandwidth carrier; and

means for utilizing the received control information for the normal bandwidth carrier during a first transmission time interval (TTI) of the channel of the normal bandwidth carrier, the first TTI of the channel of the normal bandwidth carrier being determined based at least in part on a processing time of the control information for the normal bandwidth carrier.

11. The system of claim **9**, further comprising:

means for receiving control information over a second channel of one of the one or more flexible bandwidth carriers;

means for decreasing a dilated processing time attributed to the received control information over the second channel; and

means for utilizing the received control information over the second channel during a first transmission time interval (TTI) of the second channel, the first TTI of the second channel being determined based at least in part on the decreased dilated processing time for the received control information over the second channel.

12. The system of claim **9**, wherein the means for determining the first TTI of the first channel comprises means for determining at least a system frame number for applying the received control information based at least in part on a bandwidth scaling factor of the first channel.

13. The system of claim **9**, wherein the required processing time equals a processing time of control information for a normal bandwidth carrier.

14. The system of claim **9**, wherein the control information over the first channel comprises one or more grants.

15. The system of claim **9**, wherein the first channel comprises at least an Enhanced Absolute Grant Channel (E-AGCH) or an Enhanced Relative Grant Channel (E-RGCH).

16. The system of claim **9**, wherein the one of the one or more flexible bandwidth carriers of the first channel comprises a bandwidth scaling factor equal to 2 or 4.

17. A computer program product for control information processing and utilization in a wireless communications system that utilizes one or more flexible bandwidth carriers comprising:

a non-transitory computer-readable medium comprising:

code for receiving control information over a first channel of one of the one or more flexible bandwidth carriers;

code for decreasing a dilated processing time attributed to the received control information over the first channel to correspond to a required processing time, wherein the required processing time is less than the dilated processing time attributed to the received control information over the first channel; and

code for determining a first transmission time interval (TTI) of the first channel to use in response to the received control information over the first channel based at least in part on the decreased dilated processing time for the received control information over the first channel.

18. The computer program product of claim **17**, wherein the non-transitory computer-readable medium further comprises:

code for receiving control information for a normal bandwidth carrier over a channel of the normal bandwidth carrier; and

code for utilizing the received control information for the normal bandwidth carrier during a first transmission time interval (TTI) of the channel of the normal bandwidth carrier, the first TTI of the channel of the normal bandwidth carrier being determined based at least in part on a processing time of the control information for the normal bandwidth carrier.

19. The computer program product of claim **17**, wherein the non-transitory computer-readable medium further comprises:

code for receiving control information over a second channel of one of the one or more flexible bandwidth carriers;

code for decreasing a dilated processing time attributed to the received control information over the second channel; and

code for utilizing the received control information over the second channel during a first transmission time interval (TTI) of the second channel, the first TTI of the second channel being determined based at least in part on the decreased dilated processing time for the received control information over the second channel.

20. The computer program product of claim **17**, wherein the code for determining the first TTI of the first channel comprises code for determining at least a system frame number for applying the received control information based at least in part on a bandwidth scaling factor of the first channel.

21. The computer program product of claim **17**, wherein the required processing time equals a processing time of control information for a normal bandwidth carrier.

22. The computer program product of claim **17**, wherein the control information over the first channel comprises one or more grants.

23. The computer program product of claim **17**, wherein the first channel comprises at least an Enhanced Absolute Grant Channel (E-AGCH) or an Enhanced Relative Grant Channel (E-RGCH).

24. The computer program product of claim **17**, wherein the one of the one or more flexible bandwidth carriers of the first channel comprises a bandwidth scaling factor equal to 2 or 4.

25. A wireless communications device configured for control information processing and utilization in a wireless communications system that utilizes one or more flexible bandwidth carriers comprising:

at least one processor configured to:

receive control information over a first channel of one of the one or more flexible bandwidth carriers;

decrease a dilated processing time attributed to the received control information over the first channel to correspond to a required processing time, wherein the required processing time is less than the dilated processing time attributed to the received control information over the first channel; and

determine a first transmission time interval (TTI) of the first channel to use in response to the received control information over the first channel based at least in part on the decreased dilated processing time for the received control information over the first channel.

26. The wireless communications device of claim **25**, wherein the at least one processor is further configured to:

receive control information for a normal bandwidth carrier over a channel of the normal bandwidth carrier; and

utilize the received control information for the normal bandwidth carrier during a first transmission time interval (TTI) of the channel of the normal bandwidth carrier, the first TTI of the channel of the normal bandwidth carrier being determined based at least in part on a processing time of the control information for the normal bandwidth carrier.

27. The wireless communications device of claim **25**, wherein the at least one processor is further configured to:

receive control information over a second channel of one of the one or more flexible bandwidth carriers;

decrease a dilated processing time attributed to the received control information over the second channel; and

utilize the received control information over the second channel during a first transmission time interval (TTI) of the second channel, the first TTI of the second channel being determined based at least in part on the decreased dilated processing time for the received control information over the second channel.

28. The wireless communications device of claim **25**, wherein the at least one processor configured to determine the first TTI of the first channel is further configured to determine at least a system frame number for applying the received control information based at least in part on a bandwidth scaling factor of the first channel.

29. The wireless communications device of claim **25**, wherein the required processing time equals a processing time of control information for a normal bandwidth carrier.

30. The wireless communications device of claim **25**, wherein the control information over the first channel comprises one or more grants.

31. The wireless communications device of claim **25**, wherein the first channel comprises at least an Enhanced Absolute Grant Channel (E-AGCH) or an Enhanced Relative Grant Channel (E-RGCH).

32. The wireless communications device of claim **25**, wherein the one of the one or more flexible bandwidth carriers of the first channel comprises a bandwidth scaling factor equal to 2 or 4.

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