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(54) **DISCONTINUOUS RECEPTION FOR MULTICARRIER SYSTEMS WITH FLEXIBLE BANDWIDTH CARRIER**

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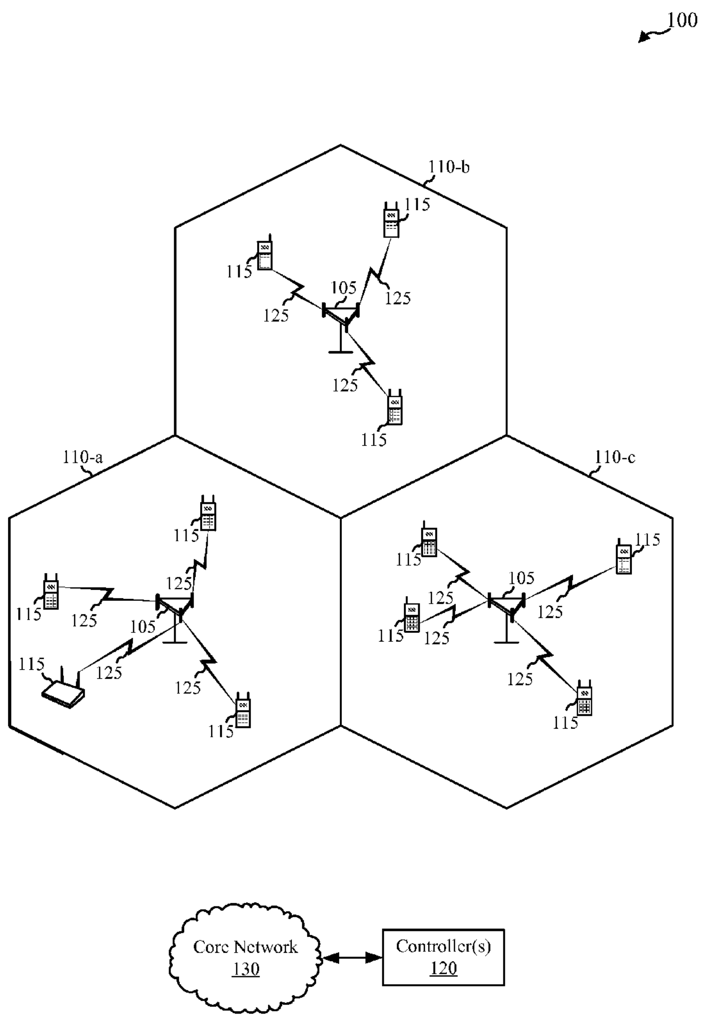
CPC ***H04W 52/02*** (2013.01)
USPC **370/311**

(57) **ABSTRACT**

Methods, systems, and devices are provided for discontinuous reception (DRX) alignment for multicarrier systems that may utilize one or more flexible bandwidth carriers. Tools and techniques are provided that may help ensure signaling alignment, such as with respect to DRX cycles, in multicarrier systems that may utilize one or more flexible bandwidth carriers and/or systems that may utilize multiple different flexible bandwidth carriers. Some methods may include identifying a DRX cycle for a first cell and/or adjusting a boundary for a DRX cycle for a second cell such that the boundary for the DRX cycle for the second cell coincides with a boundary for the DRX cycle for the first cell, where at least the first cell or the second cell comprises at least one of the one or more flexible bandwidth carriers.



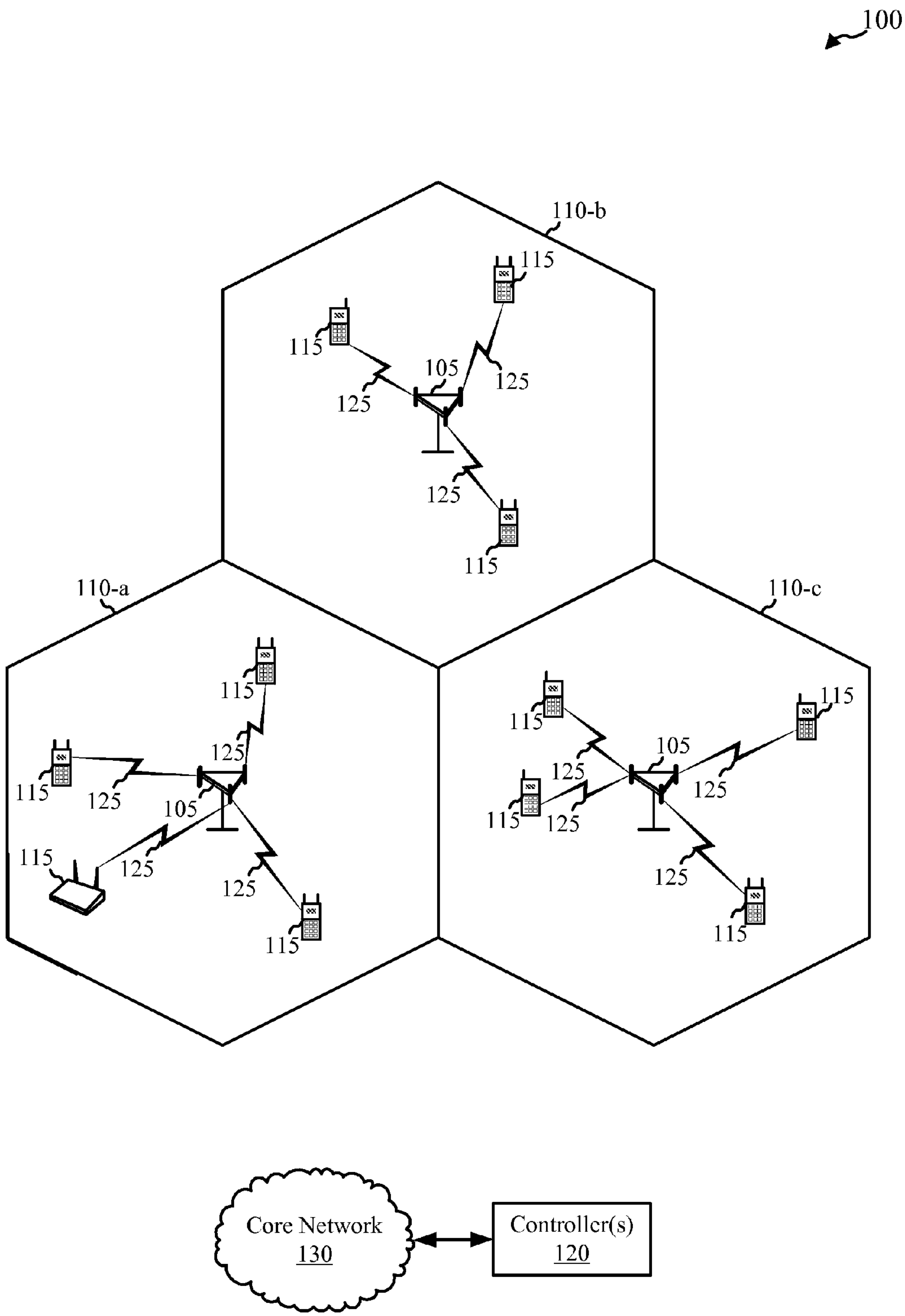

100
110-b
115
115
105
125
125
125
115
110-a
110-c
115
125
115
125
105
115
125
125
115
115
105
115
125
125
115
125
125
115
125
115
Core Network
130
Controller(s)
120

FIG. 1

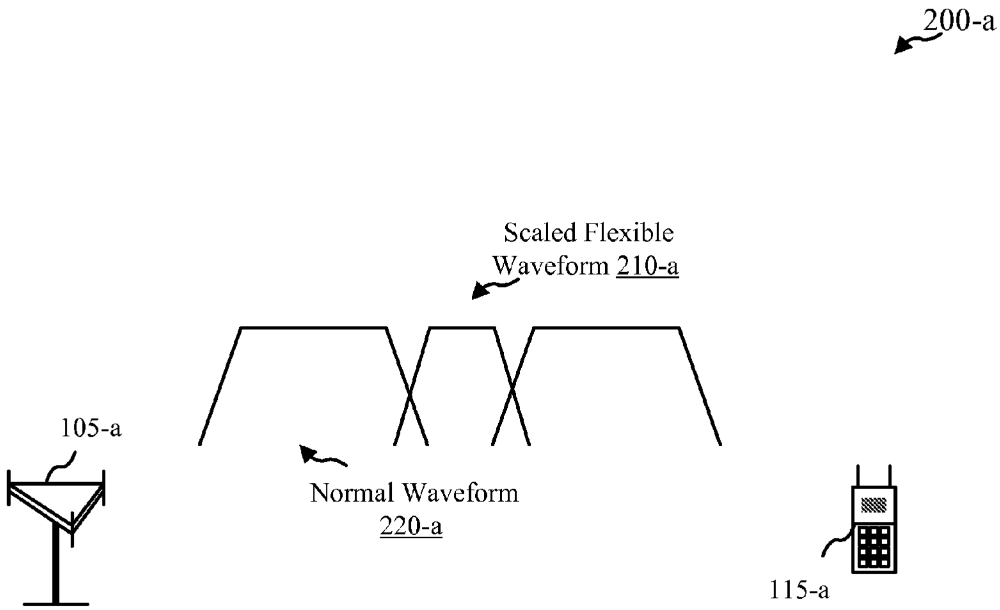

200-a
Scaled Flexible
Waveform 210-a
105-a
Normal Waveform
220-a
115-a

FIG. 2A

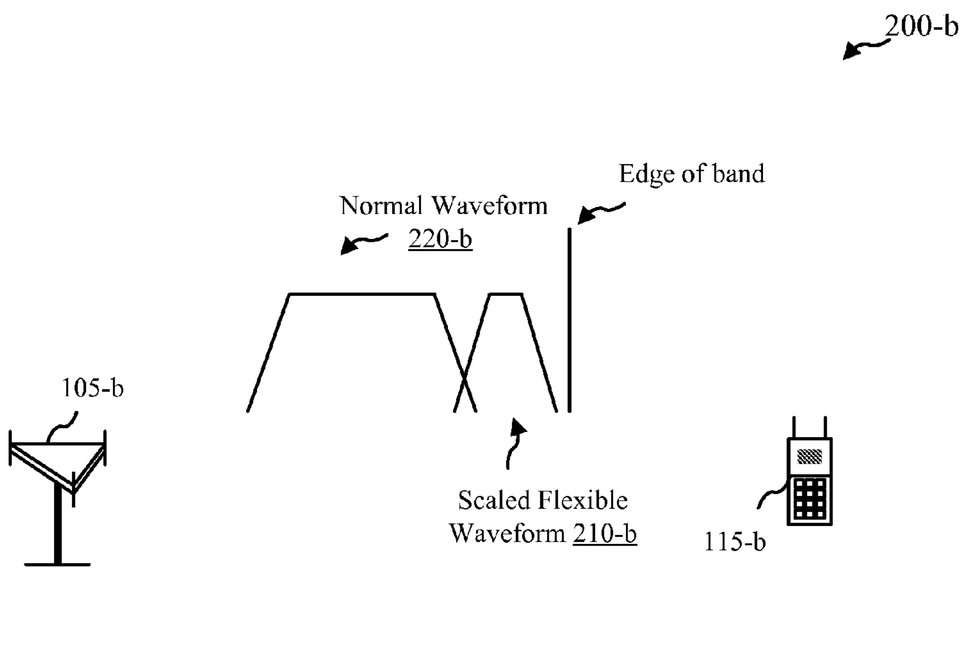

200-b
Edge of band
Normal Waveform
220-b
105-b
Scaled Flexible
Waveform 210-b
115-b

FIG. 2B

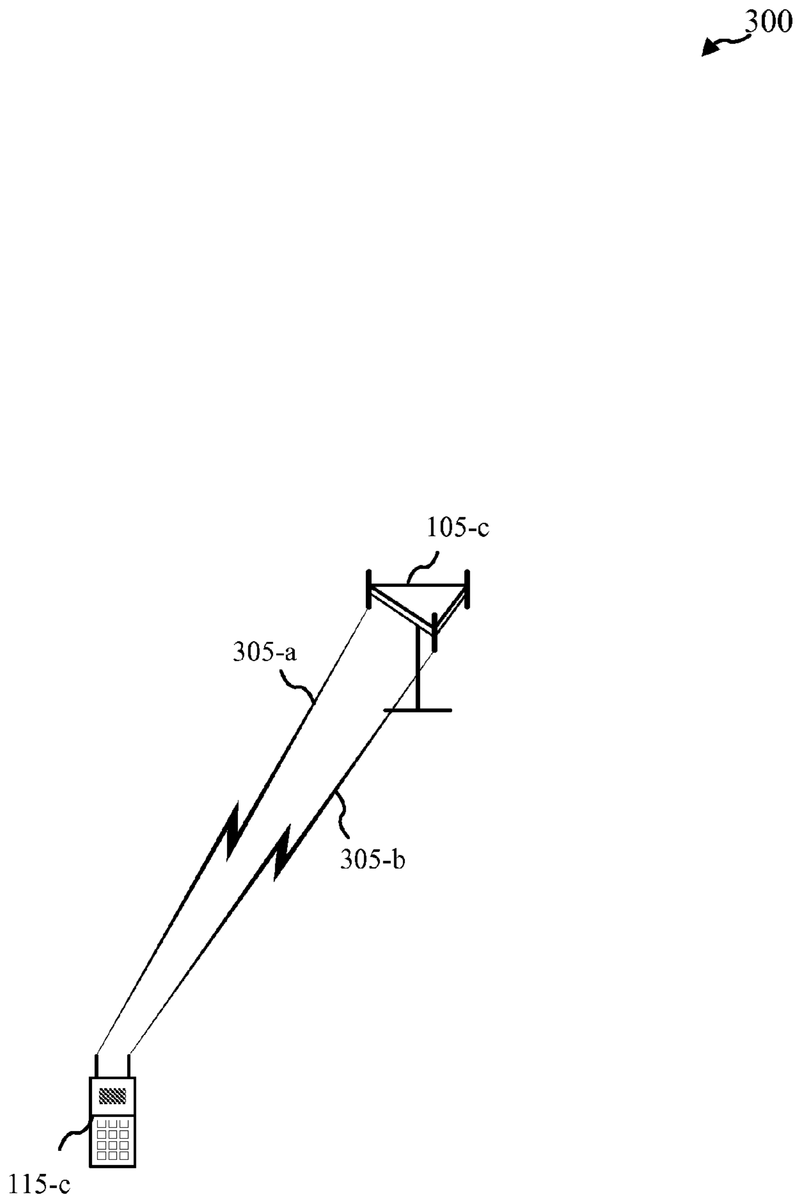


FIG. 3

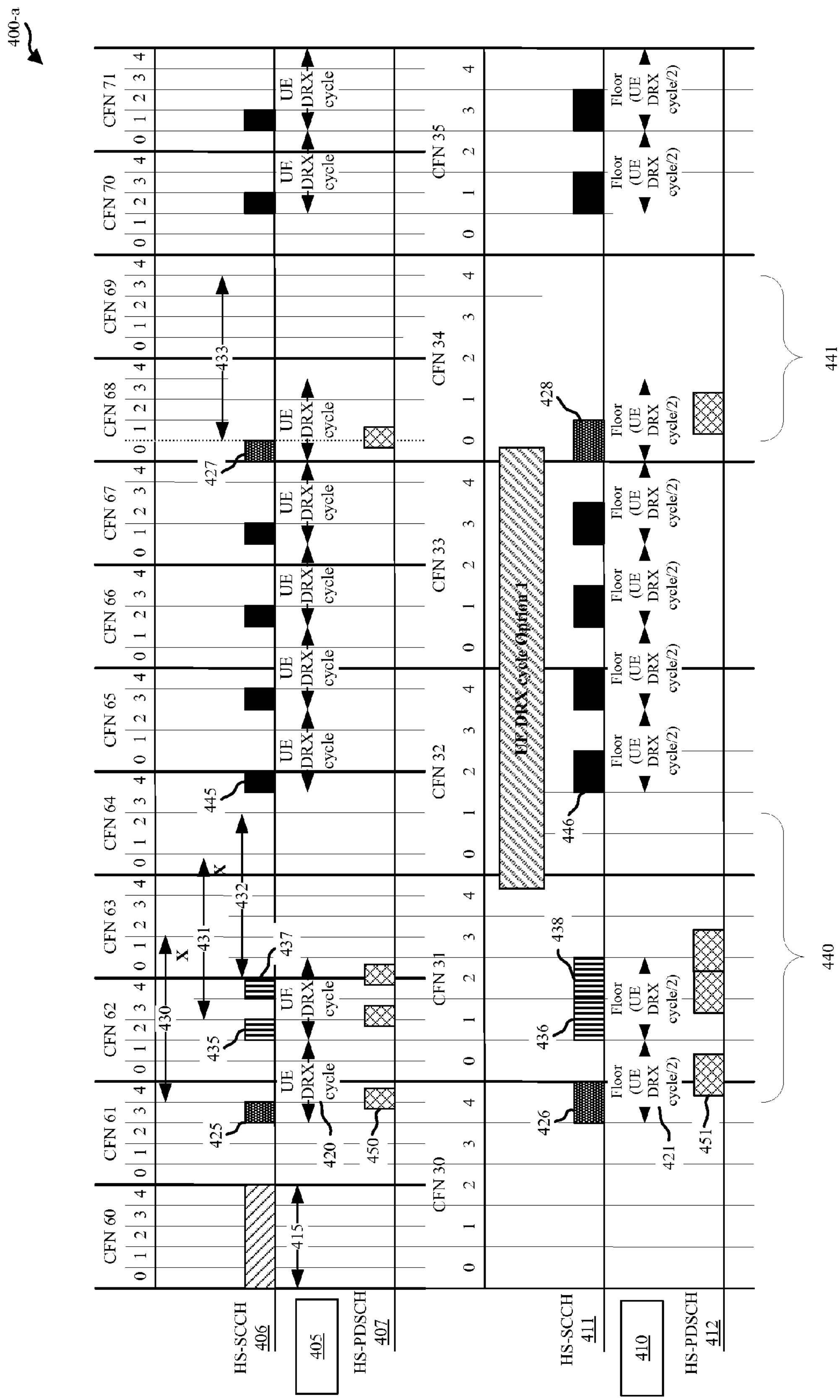

400-a
HS-SCCH 406
405
HS-PDSCH 407
HS-SCCH 411
410
HS-PDSCH 412
CFN 60
CFN 61
CFN 62
CFN 63
CFN 64
CFN 65
CFN 66
CFN 67
CFN 68
CFN 69
CFN 70
CFN 71
CFN 30
CFN 31
CFN 32
CFN 33
CFN 34
CFN 35
UE DRX cycle
Floor (UE DRX cycle/2)
UL DRX cycle Option 1
X
415
420
421
425
426
427
428
430
431
432
433
435
436
437
438
440
441
445
446
450
451

FIG. 4A

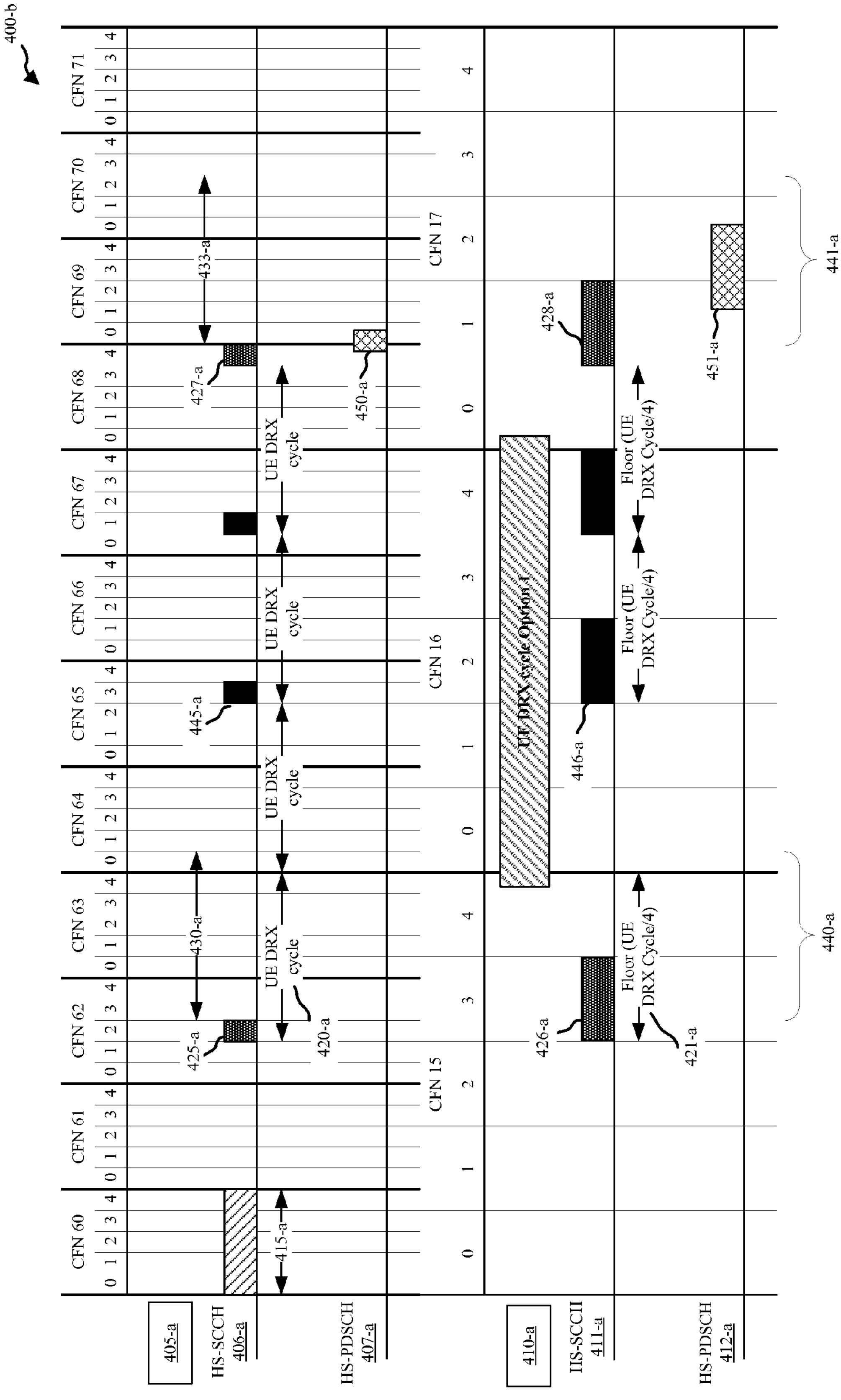

400-b
405-a
HS-SCCH 406-a
HS-PDSCH 407-a
410-a
HS-SCCH 411-a
HS-PDSCH 412-a
CFN 60
CFN 61
CFN 62
CFN 63
CFN 64
CFN 65
CFN 66
CFN 67
CFN 68
CFN 69
CFN 70
CFN 71
CFN 15
CFN 16
CFN 17
415-a
420-a
421-a
425-a
426-a
427-a
428-a
430-a
433-a
440-a
441-a
445-a
446-a
450-a
451-a
UE DRX cycle
Floor (UE DRX Cycle/4)
FE DRX cycle Option 1

FIG. 4B

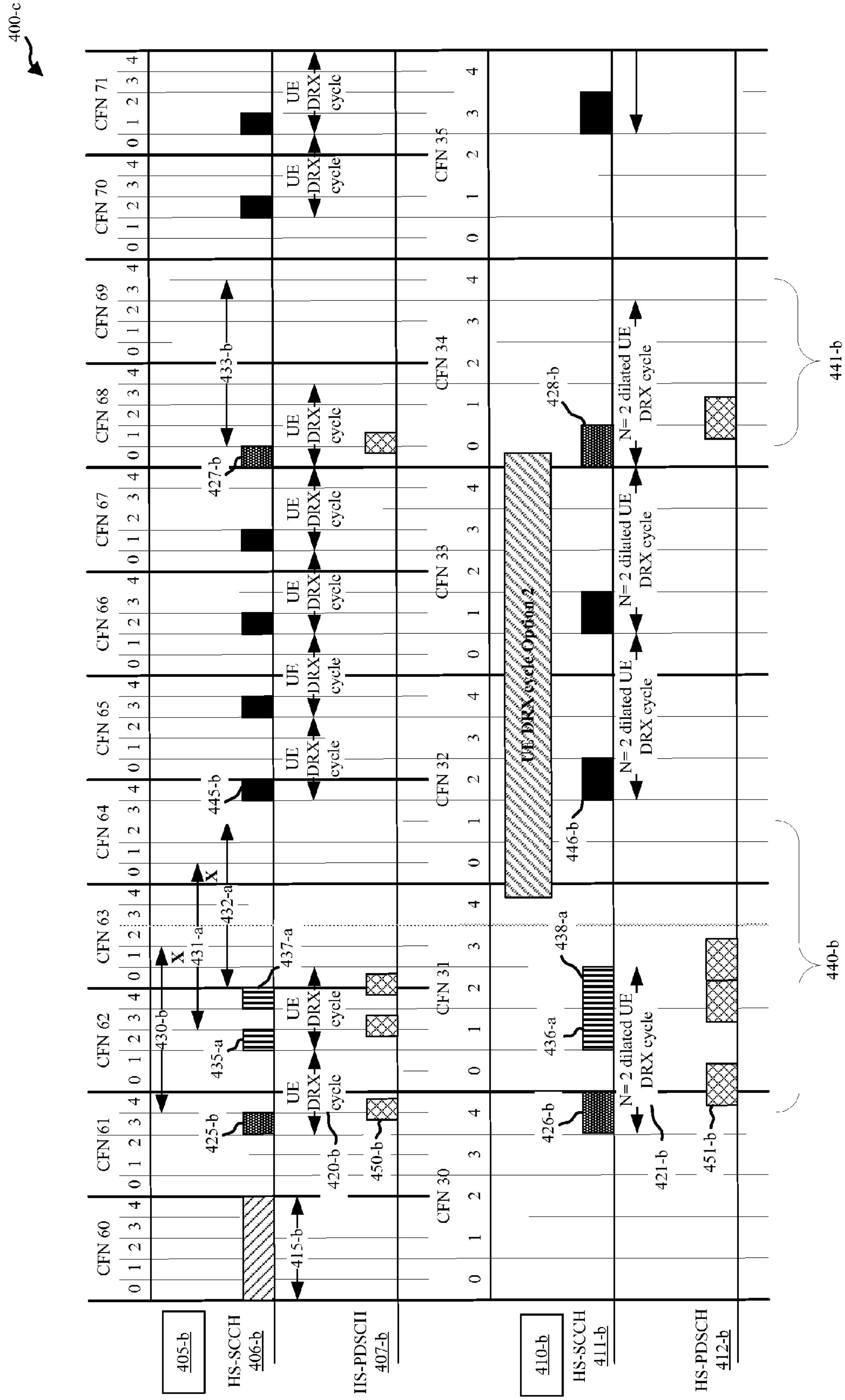

400-c
405-b
HS-SCCH
406-b
HS-PDSCH
407-b
410-b
HS-SCCH
411-b
HS-PDSCH
412-b
CFN 60
CFN 61
CFN 62
CFN 63
CFN 64
CFN 65
CFN 66
CFN 67
CFN 68
CFN 69
CFN 70
CFN 71
CFN 30
CFN 31
CFN 32
CFN 33
CFN 34
CFN 35
415-b
420-b
425-b
430-b
431-a
432-a
433-b
435-a
437-a
427-b
445-b
450-b
UE DRX cycle
426-b
436-a
438-a
446-b
428-b
421-b
451-b
N= 2 dilated UE DRX cycle
UE DRX cycle Option 2
440-b
441-b
X

FIG. 4C

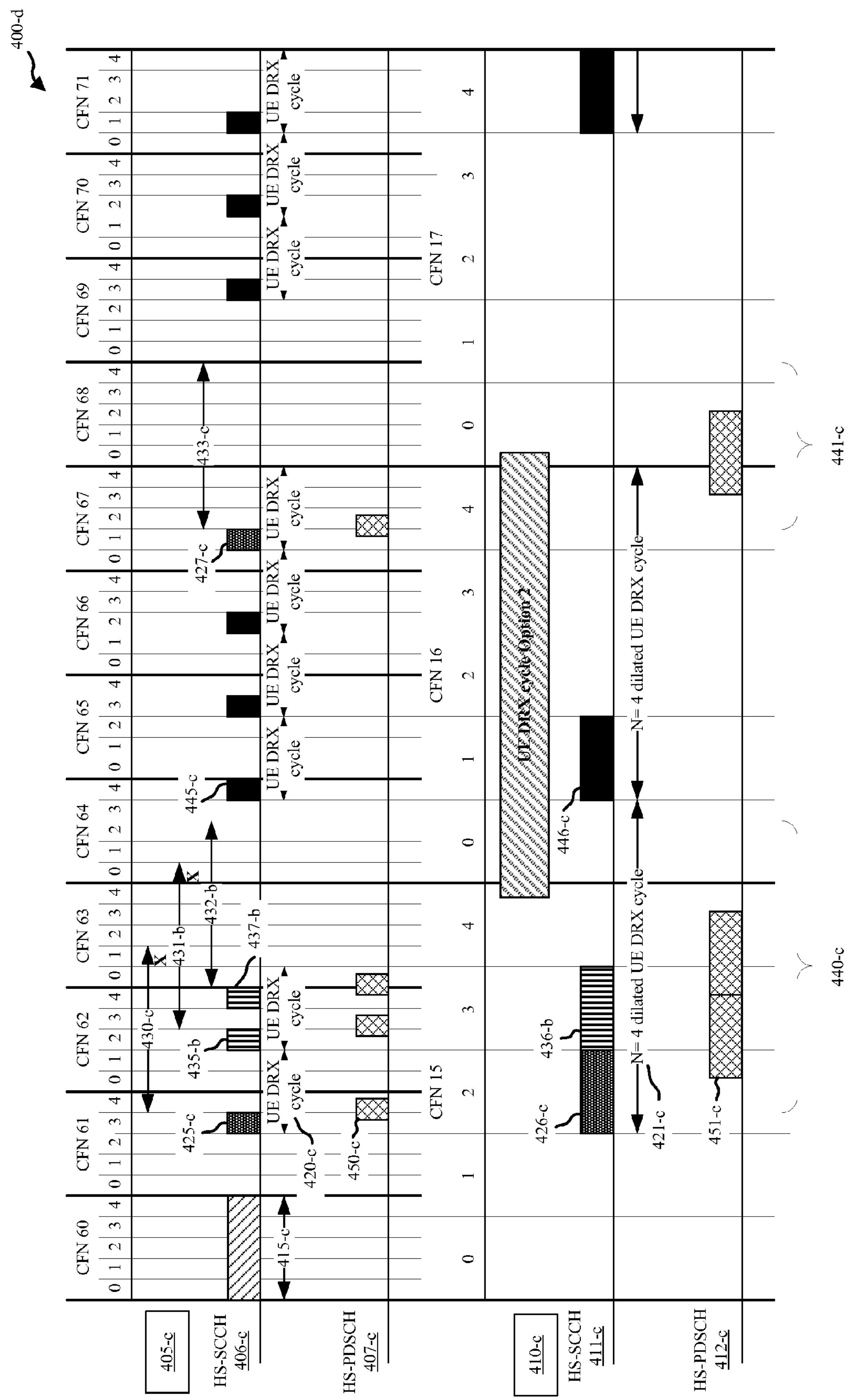

400-d
405-c
HS-SCCH 406-c
HS-PDSCH 407-c
410-c
HS-SCCH 411-c
HS-PDSCH 412-c
CFN 60
CFN 61
CFN 62
CFN 63
CFN 64
CFN 65
CFN 66
CFN 67
CFN 68
CFN 69
CFN 70
CFN 71
CFN 15
CFN 16
CFN 17
UE DRX cycle
UE DRX cycle Option 2
N= 4 dilated UE DRX cycle
415-c
420-c
421-c
425-c
426-c
427-c
430-c
431-b
432-b
433-c
435-b
436-b
437-b
440-c
441-c
445-c
446-c
450-c
451-c
X

FIG. 4D

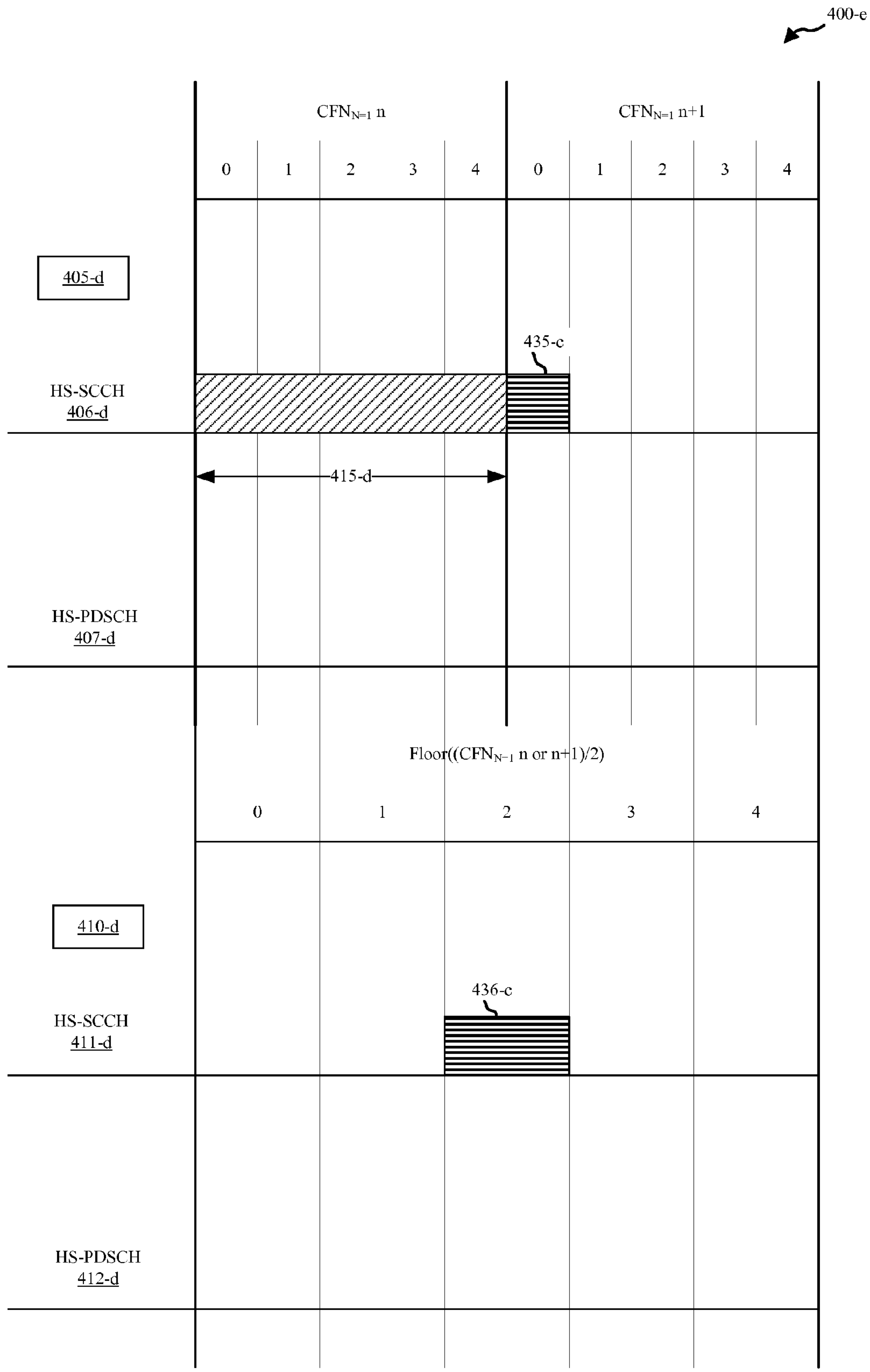

400-e
CFN_{N=1} n
CFN_{N=1} n+1
0
1
2
3
4
405-d
435-c
HS-SCCH
406-d
415-d
HS-PDSCH
407-d
Floor((CFN_{N-1} n or n+1)/2)
410-d
436-c
HS-SCCH
411-d
HS-PDSCH
412-d

FIG. 4E

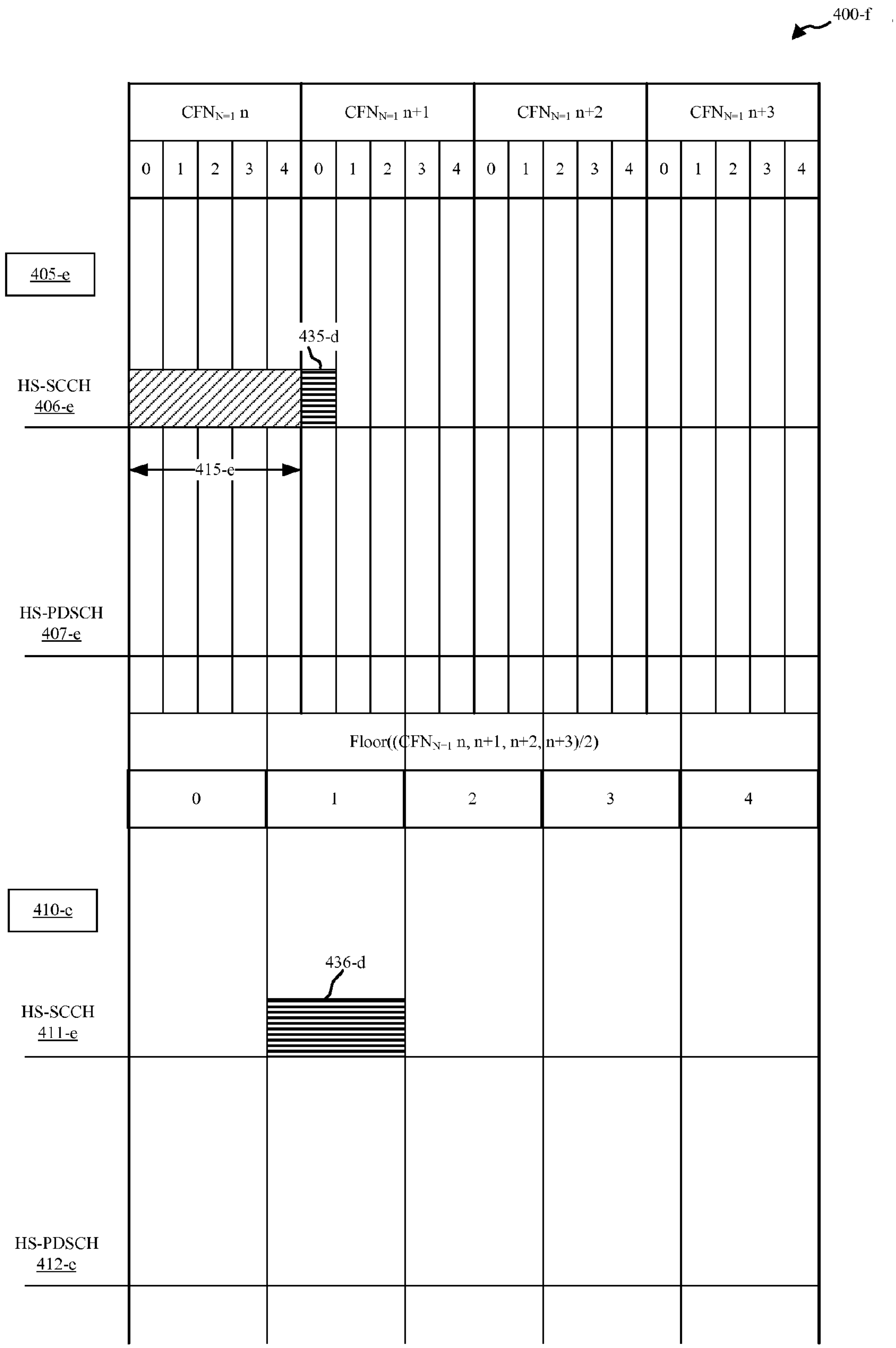

400-f
CFN$_{N=1}$ n
CFN$_{N=1}$ n+1
CFN$_{N=1}$ n+2
CFN$_{N=1}$ n+3
0 1 2 3 4 0 1 2 3 4 0 1 2 3 4 0 1 2 3 4
405-e
435-d
HS-SCCH
406-e
415-e
HS-PDSCH
407-e
Floor((CFN$_{N=1}$ n, n+1, n+2, n+3)/2)
0 1 2 3 4
410-e
436-d
HS-SCCH
411-e
HS-PDSCH
412-e

FIG. 4F

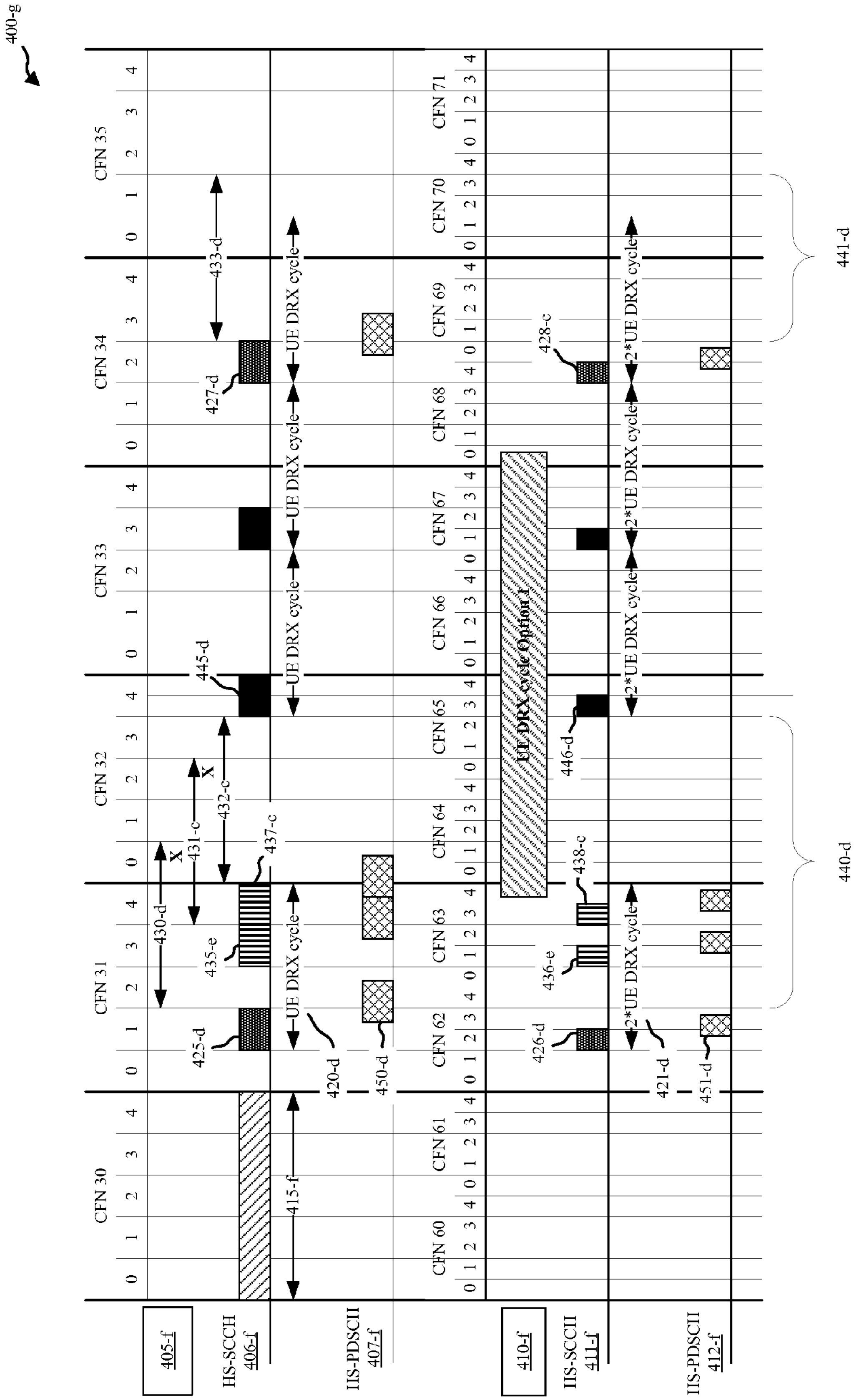

400-g
405-f
HS-SCCH
406-f
HS-PDSCH
407-f
410-f
HS-SCCH
411-f
HS-PDSCH
412-f
CFN 30
CFN 31
CFN 32
CFN 33
CFN 34
CFN 35
CFN 60
CFN 61
CFN 62
CFN 63
CFN 64
CFN 65
CFN 66
CFN 67
CFN 68
CFN 69
CFN 70
CFN 71
415-f
420-d
425-d
427-d
430-d
431-c
432-c
433-d
435-e
437-c
445-d
450-d
421-d
426-d
428-c
436-e
438-c
446-d
451-d
440-d
441-d
X
UE DRX cycle
2*UE DRX cycle
UE DRX cycle Option 1

FIG. 4G

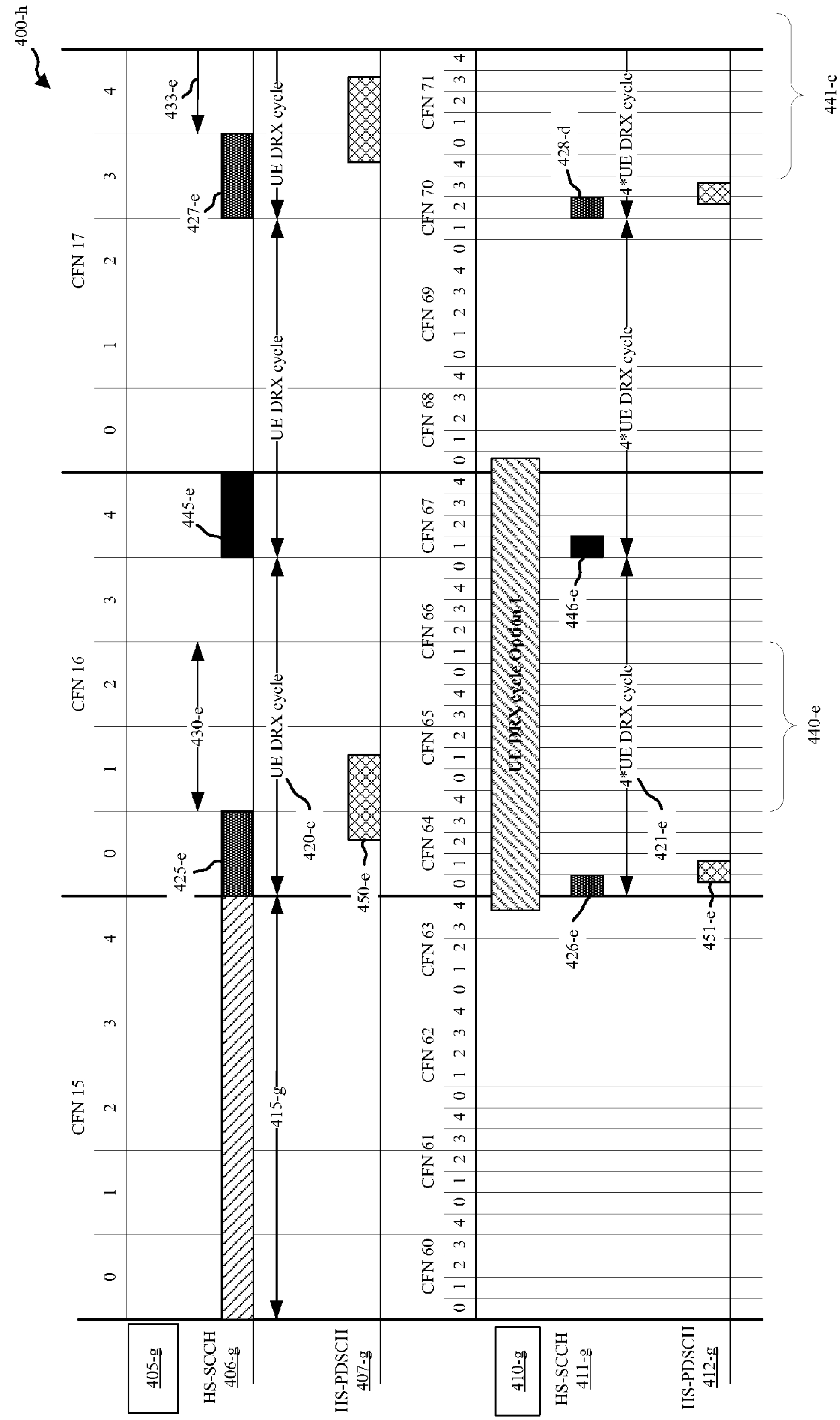

400-h
405-g
HS-SCCH 406-g
HS-PDSCH 407-g
410-g
HS-SCCH 411-g
HS-PDSCH 412-g
CFN 15
CFN 16
CFN 17
CFN 60
CFN 61
CFN 62
CFN 63
CFN 64
CFN 65
CFN 66
CFN 67
CFN 68
CFN 69
CFN 70
CFN 71
415-g
420-e
421-e
425-e
426-e
427-e
428-d
430-e
433-e
440-e
441-e
445-e
446-e
450-e
451-e
UE DRX cycle
4*UE DRX cycle
UE DRX cycle Option 1

FIG. 4H

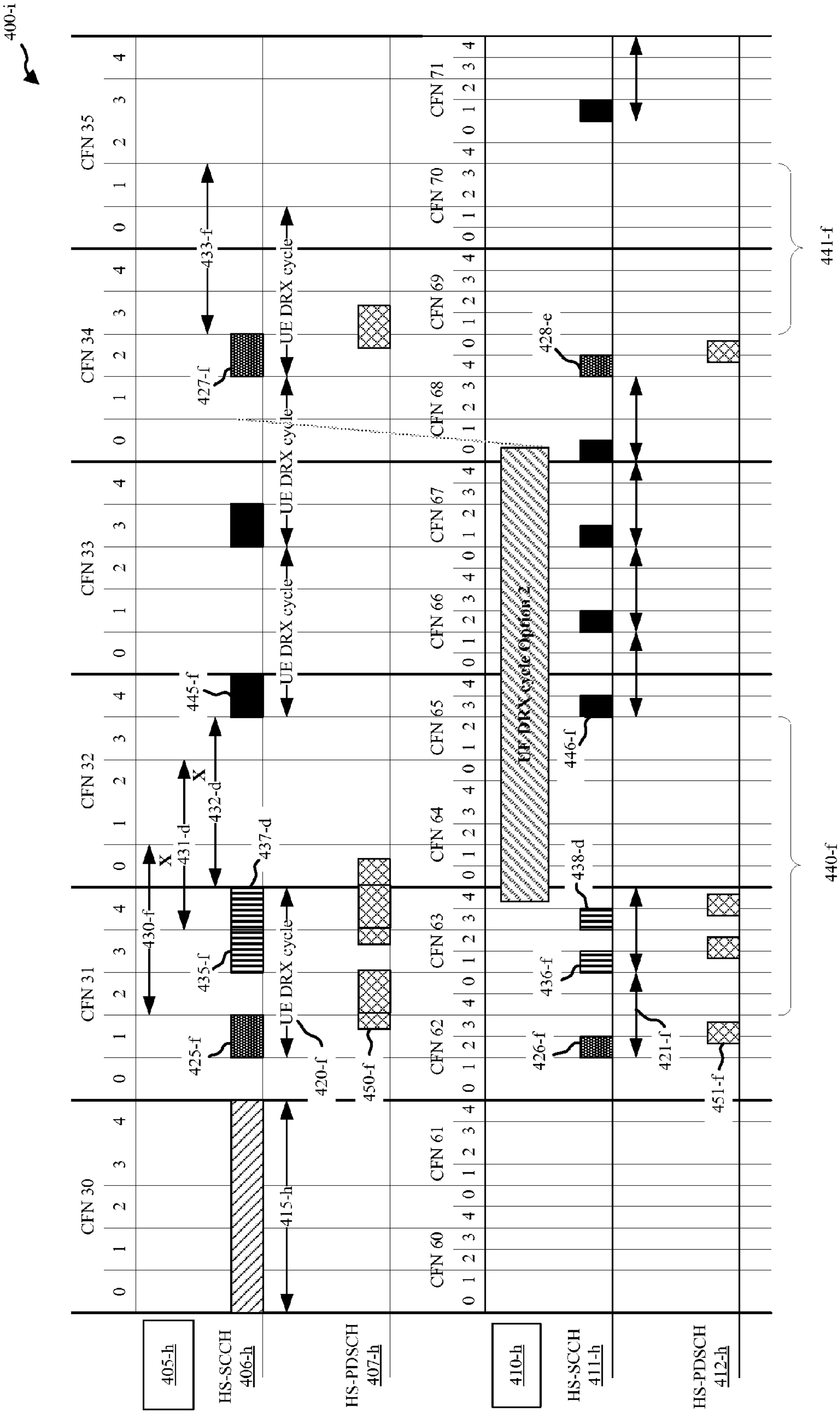

400-i
405-h
HS-SCCH 406-h
HS-PDSCH 407-h
410-h
HS-SCCH 411-h
HS-PDSCH 412-h
CFN 30
CFN 31
CFN 32
CFN 33
CFN 34
CFN 35
CFN 60
CFN 61
CFN 62
CFN 63
CFN 64
CFN 65
CFN 66
CFN 67
CFN 68
CFN 69
CFN 70
CFN 71
415-h
420-f
UE DRX cycle
425-f
427-f
430-f
431-d
432-d
433-f
435-f
437-d
445-f
X
450-f
426-f
436-f
438-d
446-f
428-e
421-f
451-f
440-f
441-f
FF DRX cycle Option 2

FIG. 4I

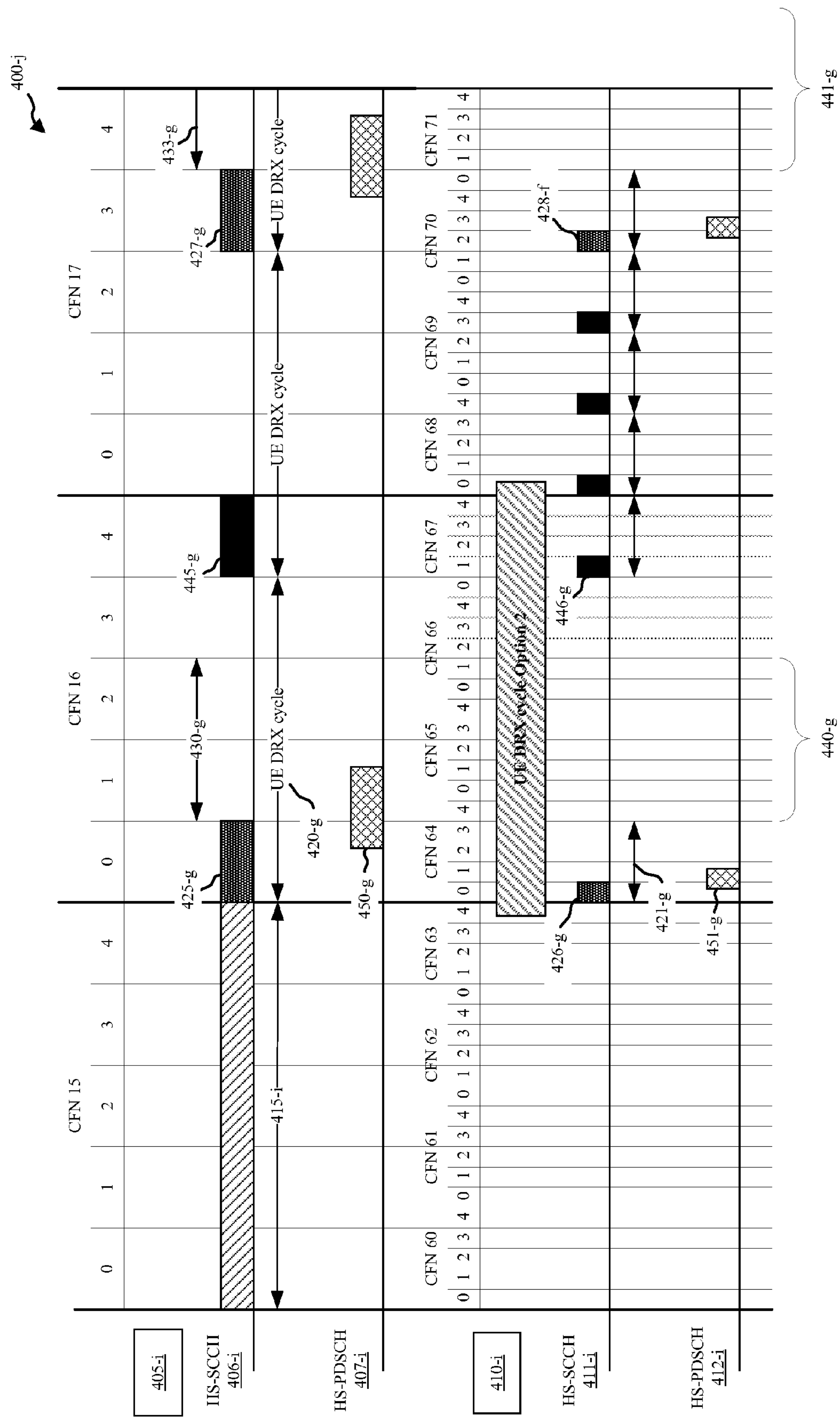

400-j
405-i
HS-SCCH 406-i
HS-PDSCH 407-i
410-i
HS-SCCH 411-i
HS-PDSCH 412-i
CFN 15
CFN 16
CFN 17
CFN 60
CFN 61
CFN 62
CFN 63
CFN 64
CFN 65
CFN 66
CFN 67
CFN 68
CFN 69
CFN 70
CFN 71
UE DRX cycle
UE DRX cycle
UE DRX cycle
UE DRX cycle Option 2
415-i
420-g
421-g
425-g
426-g
427-g
428-f
430-g
433-g
440-g
441-g
445-g
446-g
450-g
451-g

FIG. 4J

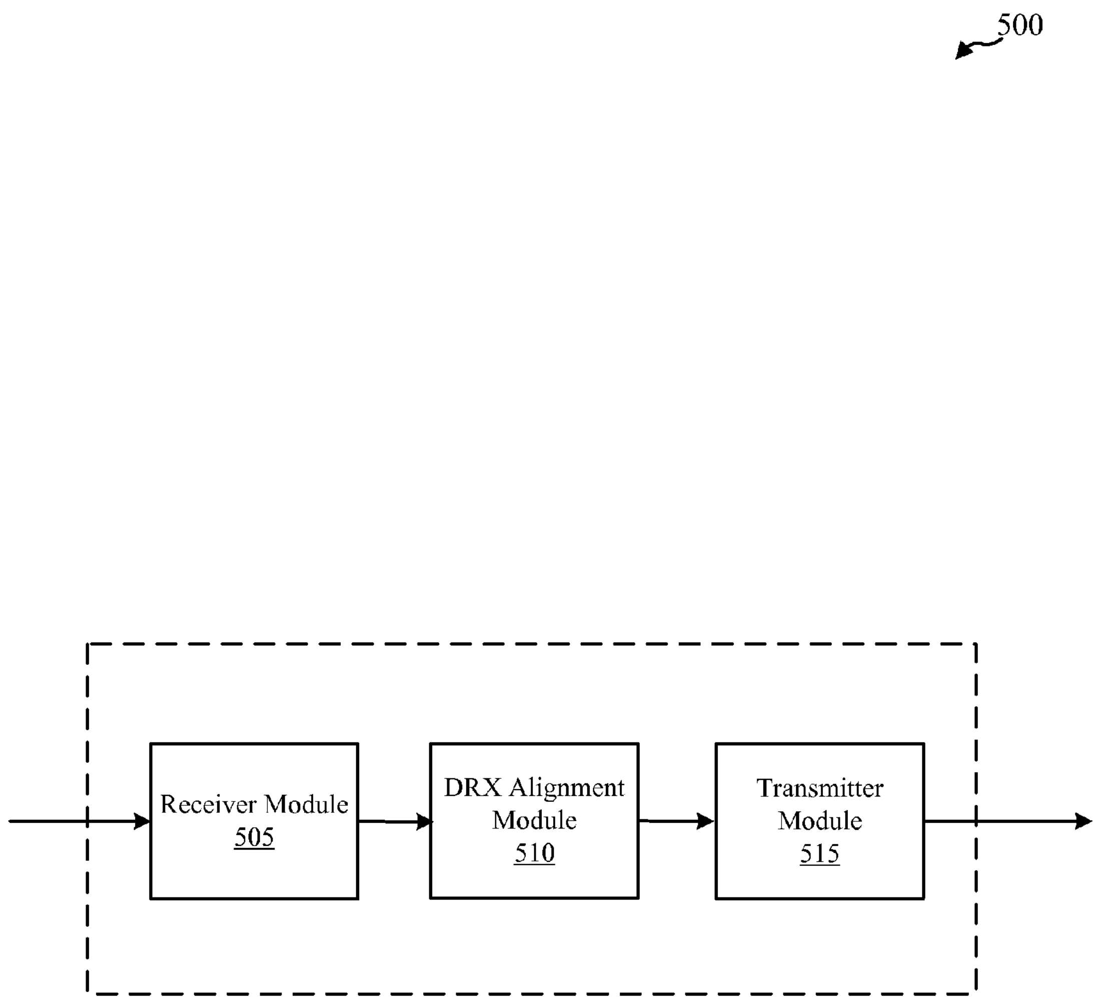

500
Receiver Module
505
DRX Alignment
Module
510
Transmitter
Module
515

FIG. 5A

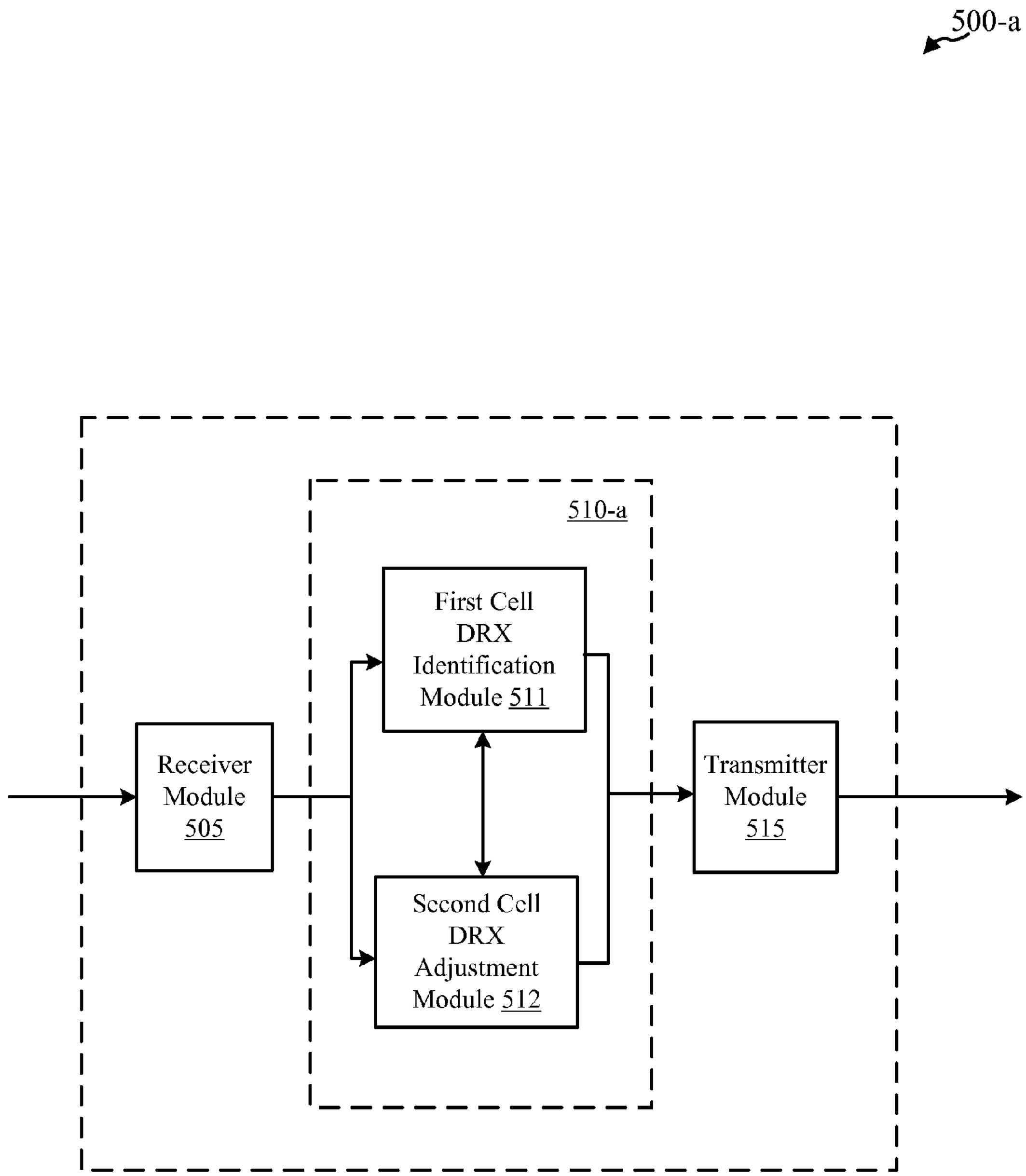

500-a
510-a
First Cell DRX Identification Module 511
Receiver Module 505
Transmitter Module 515
Second Cell DRX Adjustment Module 512

FIG. 5B

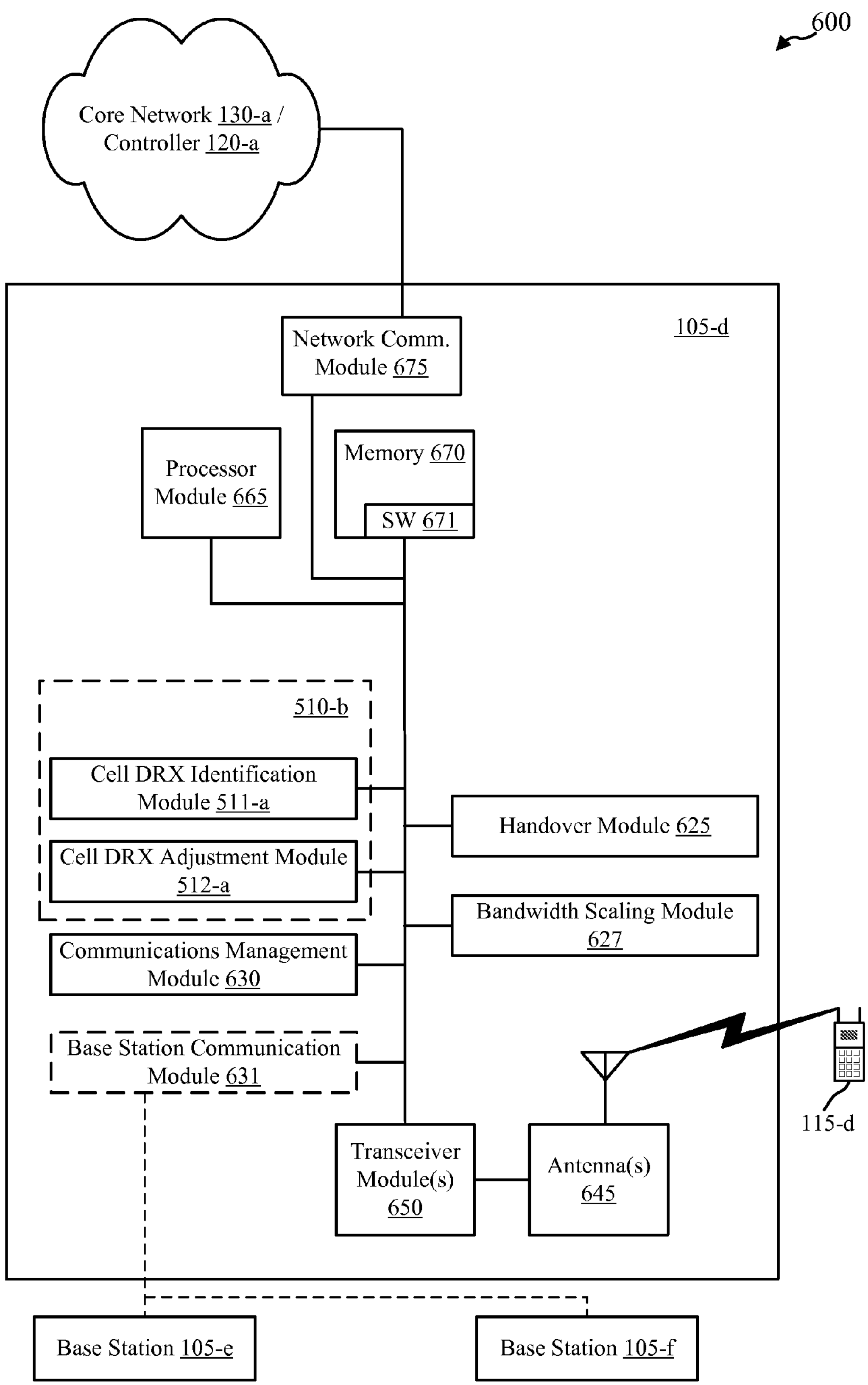

600
Core Network 130-a /
Controller 120-a
105-d
Network Comm.
Module 675
Processor
Module 665
Memory 670
SW 671
510-b
Cell DRX Identification
Module 511-a
Cell DRX Adjustment Module
512-a
Handover Module 625
Bandwidth Scaling Module
627
Communications Management
Module 630
Base Station Communication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

FIG. 6

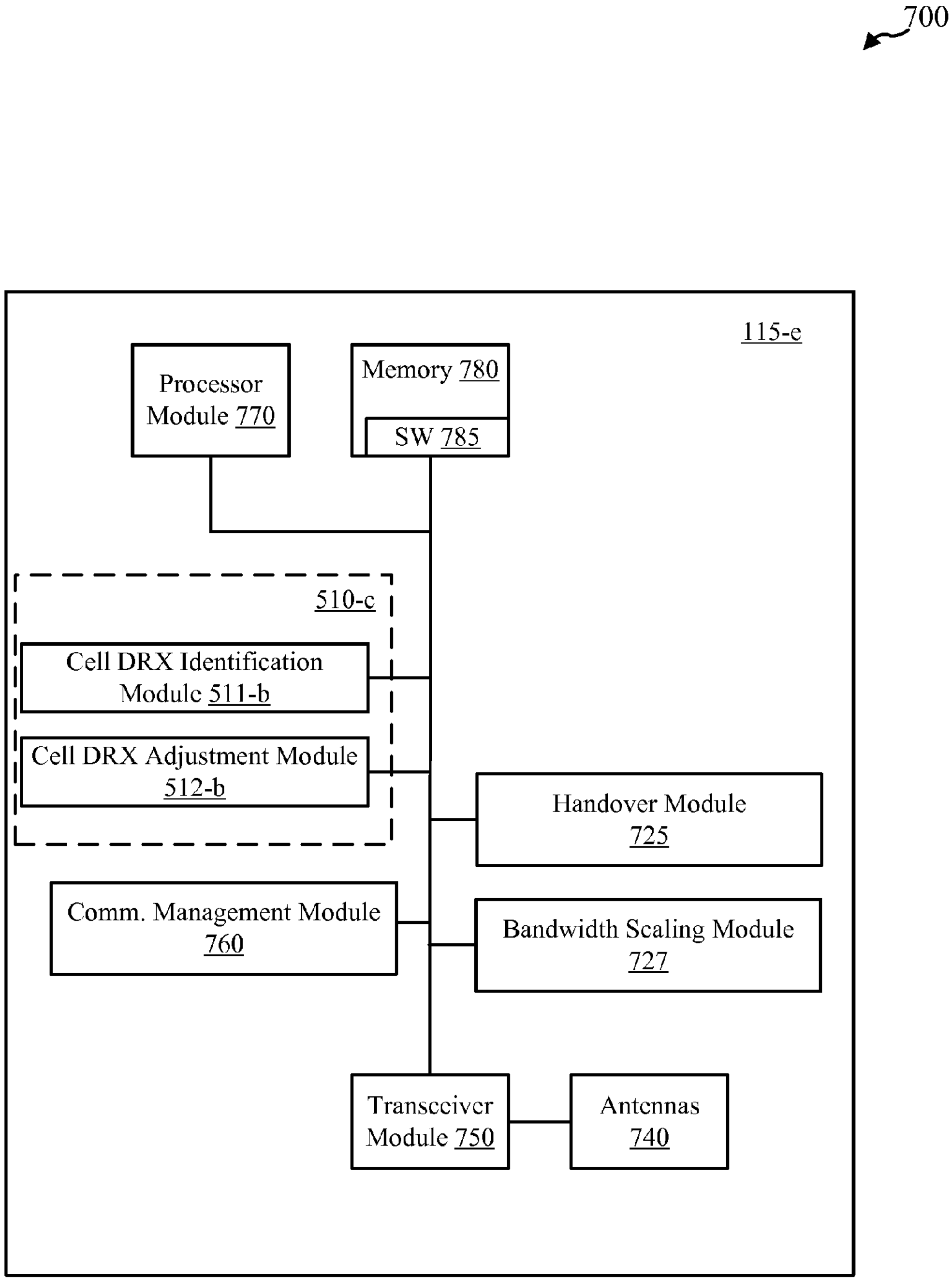

700
115-e
Processor Module 770
Memory 780
SW 785
510-c
Cell DRX Identification Module 511-b
Cell DRX Adjustment Module 512-b
Handover Module 725
Comm. Management Module 760
Bandwidth Scaling Module 727
Transceiver Module 750
Antennas 740

FIG. 7

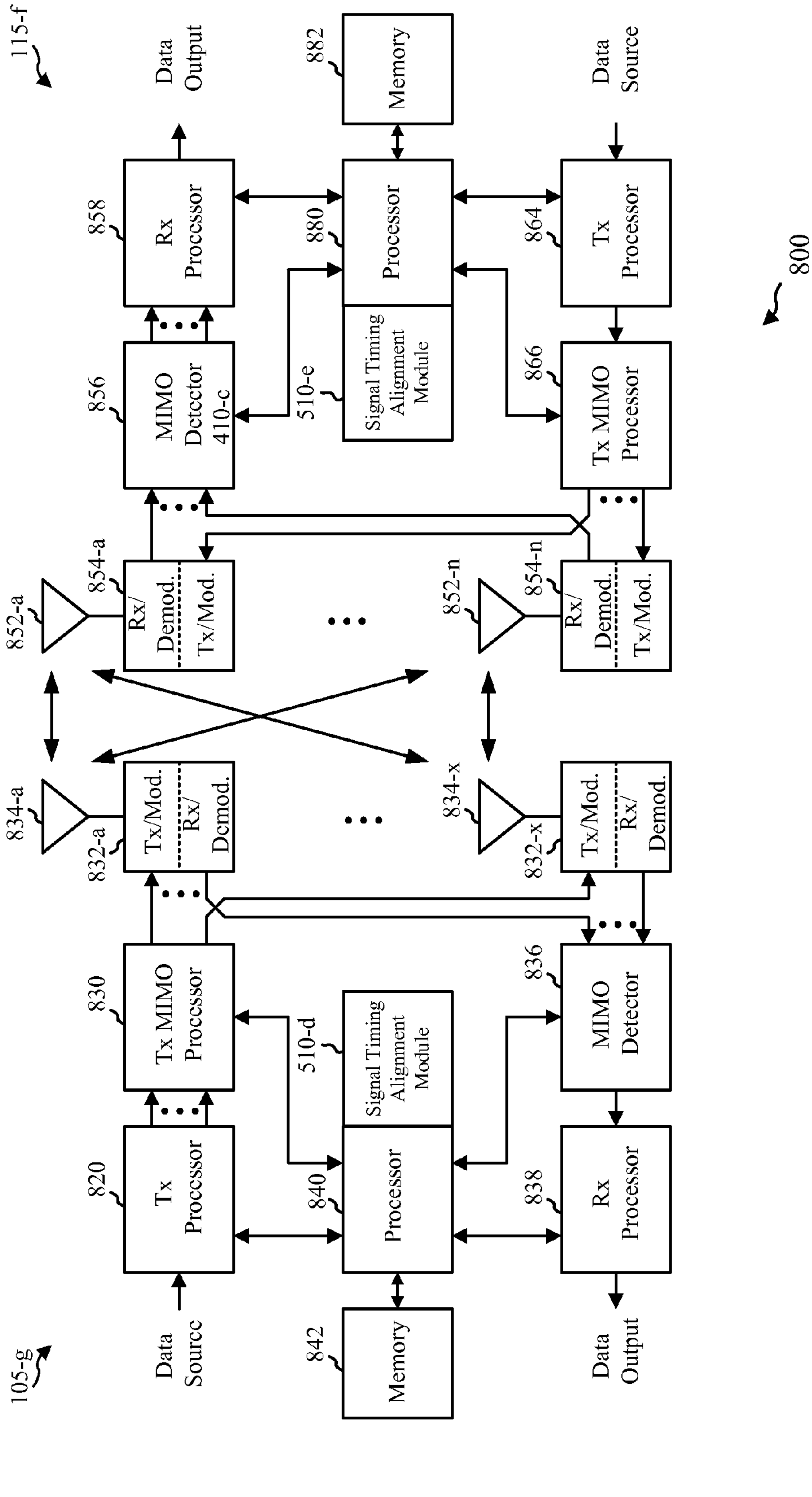

115-f
Data Output
882
Memory
Data Source
858
Rx Processor
880
Processor
864
Tx Processor
800
856
MIMO Detector 410-c
510-e
Signal Timing Alignment Module
866
Tx MIMO Processor
852-a
854-a
Rx/ Demod.
Tx/Mod.
852-n
854-n
Rx/ Demod.
Tx/Mod.
834-a
832-a
Tx/Mod.
Rx/ Demod.
834-x
832-x
Tx/Mod.
Rx/ Demod.
830
Tx MIMO Processor
510-d
Signal Timing Alignment Module
836
MIMO Detector
820
Tx Processor
840
Processor
838
Rx Processor
105-g
Data Source
842
Memory
Data Output

FIG. 8

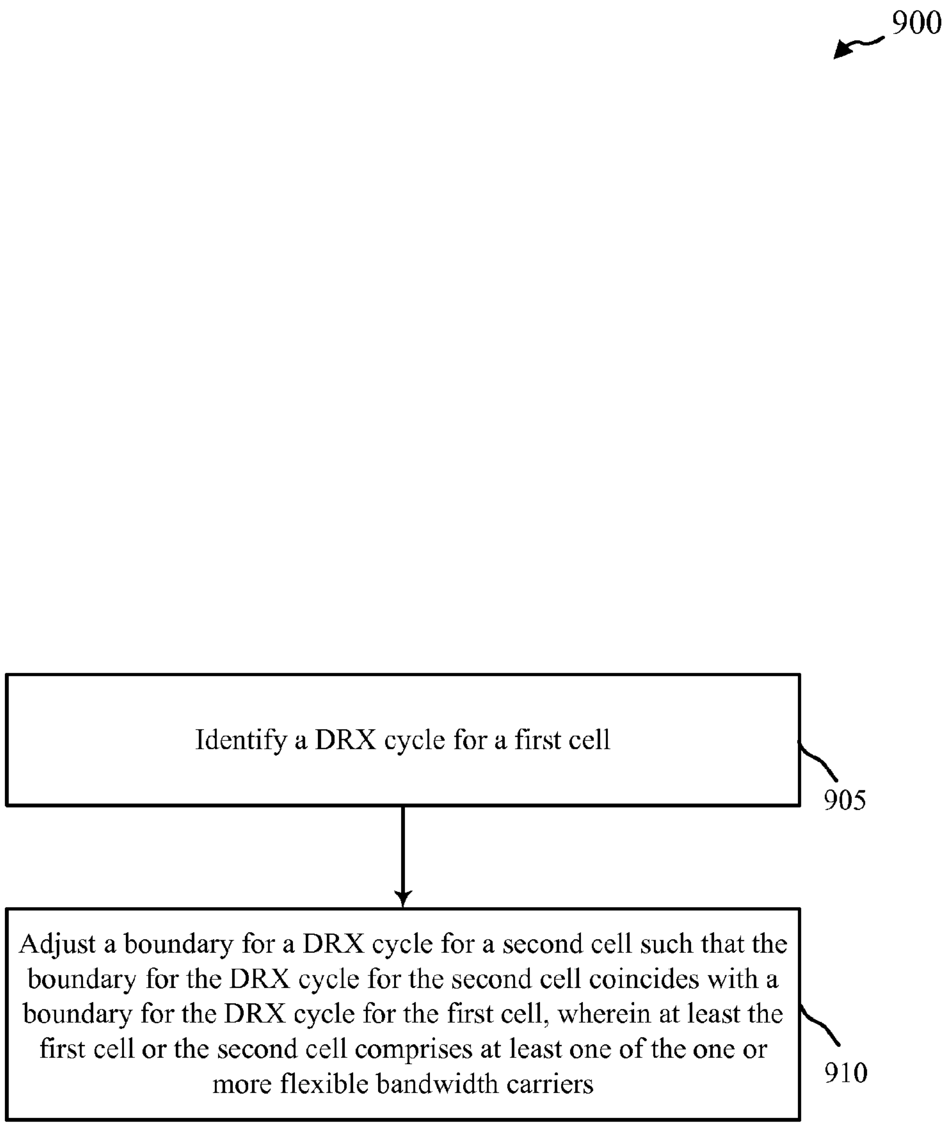

900
Identify a DRX cycle for a first cell
905
Adjust a boundary for a DRX cycle for a second cell such that the boundary for the DRX cycle for the second cell coincides with a boundary for the DRX cycle for the first cell, wherein at least the first cell or the second cell comprises at least one of the one or more flexible bandwidth carriers
910

FIG. 9A

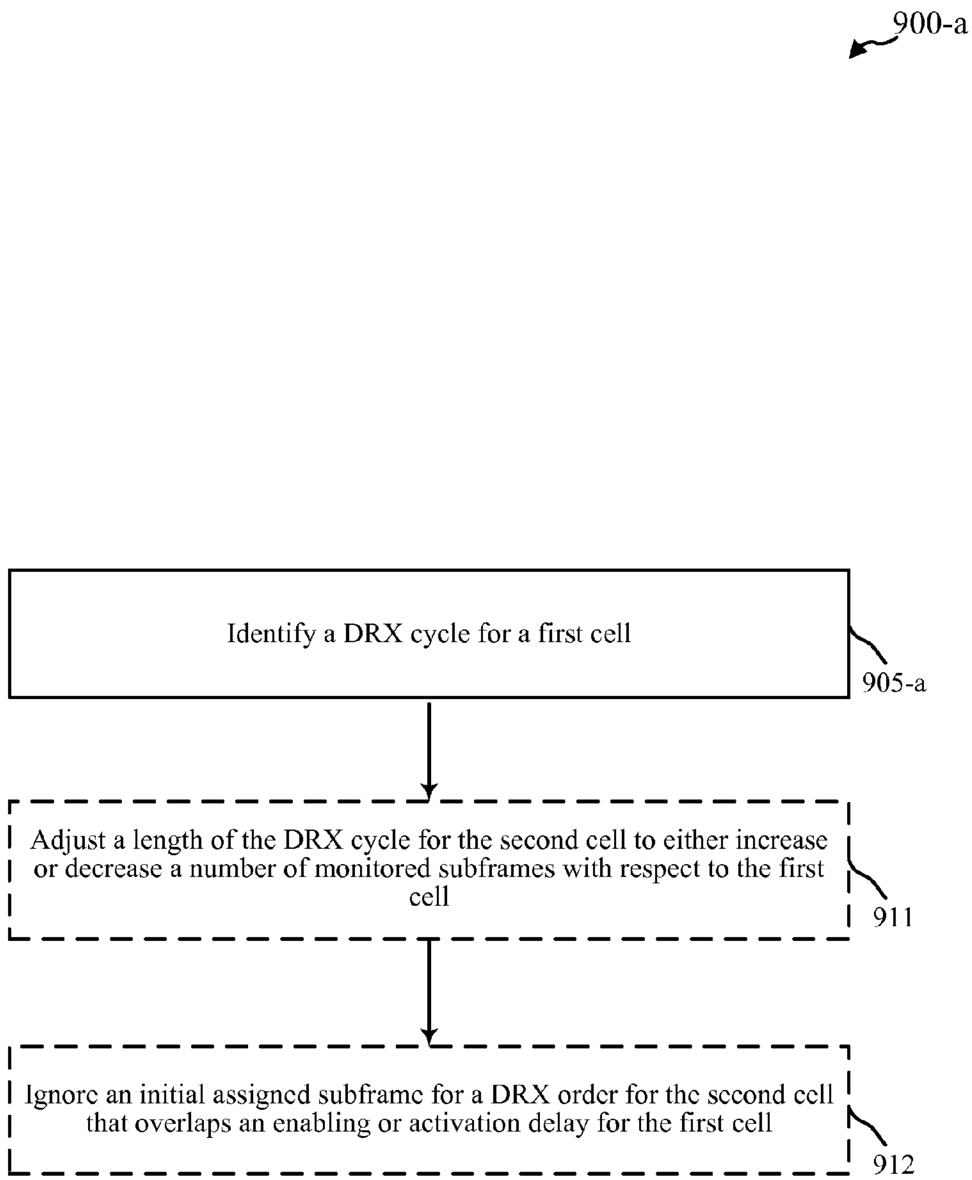

900-a
Identify a DRX cycle for a first cell
905-a
Adjust a length of the DRX cycle for the second cell to either increase or decrease a number of monitored subframes with respect to the first cell
911
Ignore an initial assigned subframe for a DRX order for the second cell that overlaps an enabling or activation delay for the first cell
912

FIG. 9B

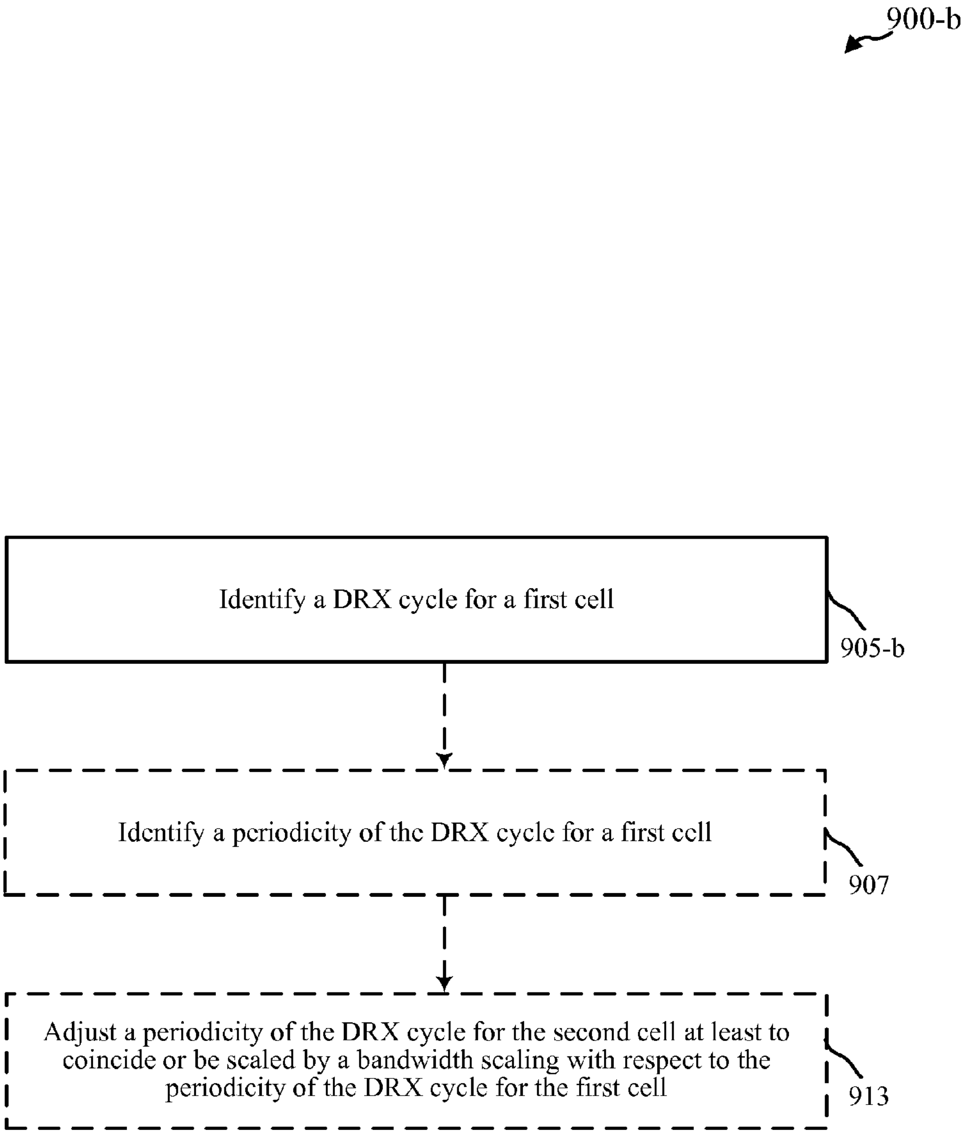

900-b
Identify a DRX cycle for a first cell
905-b
Identify a periodicity of the DRX cycle for a first cell
907
Adjust a periodicity of the DRX cycle for the second cell at least to coincide or be scaled by a bandwidth scaling with respect to the periodicity of the DRX cycle for the first cell
913

FIG. 9C

DISCONTINUOUS RECEPTION FOR MULTICARRIER SYSTEMS WITH FLEXIBLE BANDWIDTH CARRIER

CROSS REFERENCES

[0001] The present application claims priority to U.S. Provisional Patent Application No. 61/812,164, titled: "SIGNALING ALIGNMENT FOR MULTICARRIER SYSTEMS WITH FLEXIBLE BANDWIDTH CARRIER," filed on Apr. 15, 2013, assigned to the assignee hereof, and expressly incorporated by reference herein for all purposes.

BACKGROUND

[0002] 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.

[0003] 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.

[0004] 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, including discontinuous reception signaling timing, when they include multiple carriers that utilize different bandwidths.

SUMMARY

[0005] Methods, systems, and devices are provided for discontinuous reception (DRX) in a multicarrier system that may utilize one or more flexible bandwidth carriers. For example, tools and techniques are provided that may help ensure alignment with respect to DRX cycles in multicarrier systems that may utilize one or more normal bandwidth carriers and one or more flexible bandwidth carriers or in systems that may utilize multiple different flexible bandwidth carriers.

[0006] 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.

[0007] In multicarrier systems that may utilize one or more flexible bandwidth carriers, misalignment of DRX cycles between multiple carriers may cause an increase in power consumption. An increase in power consumption may be due to the fact that the DRX cycles are misaligned and do not have the same period (e.g., due to time dilation, the 'wake-up' period is longer for N=2 or 4 vs. N=1) and consequently the receiver is listening for a longer time period per DRX cycle than would otherwise be the case. These problems may be addressed by aligning the DRX cycles for at least two carriers in a multicarrier system, for example, by aligning at least one boundary, such as a starting boundary and/or an ending boundary, of the DRX cycles. Other solutions may include adjusting a length of the DRX cycle for the second cell to either increase or decrease a number of monitored subframes with respect to the first cell. These problems may also be addressed by identifying a periodicity for a first cell and adjusting a periodicity of the DRX cycle for the second cell to be scaled by a bandwidth scaling factor with of the first cell. In some embodiments, these problems may be addressed by transmitting to and/or receiving at a user equipment (UE) at least one or more offsets or cycle lengths to facilitate adjusting the boundary for the DRX cycle for the second cell.

[0008] Some embodiments include a method of discontinuous reception (DRX) in a multicarrier system that utilizes one or more flexible bandwidth carriers. The method may include: identifying a DRX cycle for a first cell; and/or adjusting a boundary for a DRX cycle for a second cell such that the boundary for the DRX cycle for the second cell coincides with a boundary for the DRX cycle for the first cell. At least the first cell or the second cell may include at least one of the one or more flexible bandwidth carriers.

[0009] In some embodiments, the boundary for the DRX cycle for the first cell and the boundary for the DRX cycle for the second cell both include at least a starting boundary or an ending boundary. In some cases, a period of the DRX cycle for the second cell is different from a period of the DRX cycle for the first cell.

[0010] Some embodiments of the method further include adjusting a length of the DRX cycle for the second cell to either increase or decrease a number of monitored subframes with respect to the first cell. Some embodiments include: identifying a periodicity of the DRX cycle for the first cell; and/or adjusting a periodicity of the DRX cycle for the second cell at least to coincide or be scaled by a bandwidth scaling factor with respect to the periodicity of the DRX cycle for the first cell. Some embodiments include transmitting to and/or receiving at a user equipment (UE) at least one or more offsets or cycle lengths to facilitate adjusting the boundary for the DRX cycle for the second cell. Some embodiments include ignoring an initial assigned subframe for a DRX order for the second cell that overlaps an enabling or activation delay for the first cell.

[0011] In some embodiments, the first cell includes a normal bandwidth carrier and the second cell comprises one of the one or more flexible bandwidth carriers. In some embodiments, the first cell includes a flexible bandwidth carrier and the second cell includes one of the one or more flexible bandwidth carriers different from the first cell. In some configurations, the first cell includes one of the one or more flexible bandwidth carriers and the second cell includes a normal bandwidth carrier. The first cell may include one of the one or more flexible bandwidth carriers and the second cell may include one of the one or more flexible bandwidth carriers different from the first cell in some configurations. The first cell may include a bandwidth scaling factor equal to 1 and the second cell may include a bandwidth scaling factor equal to 2 or 4 in some configurations.

[0012] Some embodiments include a system for discontinuous reception (DRX) in a multicarrier system that utilizes one or more flexible bandwidth carriers. The system may include: means for identifying a DRX cycle for a first cell; and/or means for adjusting a boundary for a DRX cycle for a second cell such that the boundary for the DRX cycle for the second cell coincides with a boundary for the DRX cycle for the first cell. At least the first cell or the second cell may include at least one of the one or more flexible bandwidth carriers.

[0013] In some embodiments, the boundary for the DRX cycle for the first cell and the boundary for the DRX cycle for the second cell both include at least a starting boundary or an ending boundary. A period of the DRX cycle for the second cell may be different from a period of the DRX cycle for the first cell.

[0014] Some embodiments include means for adjusting a length of the DRX cycle for the second cell to either increase or decrease a number of monitored subframes with respect to the first cell. Some embodiments include: means for identifying a periodicity of the DRX cycle for the first cell; and/or means for adjusting a periodicity of the DRX cycle for the second cell at least to coincide or be scaled by a bandwidth scaling factor with respect to the periodicity of the DRX cycle for the first cell. Some embodiments include means for transmitting to and/or receiving at a user equipment (UE) at least one or more offsets or cycle lengths to facilitate adjusting the boundary for the DRX cycle for the second cell. Some embodiments include means for ignoring an initial assigned subframe for a DRX order for the second cell that overlaps an enabling or activation delay for the first cell.

[0015] In some embodiments of the system, the first cell includes a normal bandwidth carrier and the second cell comprises one of the one or more flexible bandwidth carriers. In some embodiments, the first cell includes a flexible bandwidth carrier and the second cell includes one of the one or more flexible bandwidth carriers different from the first cell. In some configurations, the first cell includes one of the one or more flexible bandwidth carriers and the second cell includes a normal bandwidth carrier. The first cell may include one of the one or more flexible bandwidth carriers and the second cell may include one of the one or more flexible bandwidth carriers different from the first cell in some configurations. The first cell may include a bandwidth scaling factor equal to 1 and the second cell may include a bandwidth scaling factor equal to 2 or 4 in some configurations.

[0016] Some embodiments include a computer program product for discontinuous reception (DRX) in a multicarrier system that utilizes one or more flexible bandwidth carriers that may include a non-transitory computer-readable medium that may include: code for identifying a DRX cycle for a first cell; and/or code for adjusting a boundary for a DRX cycle for a second cell such that the boundary for the DRX cycle for the second cell coincides with a boundary for the DRX cycle for the first cell. At least the first cell or the second cell comprises at least one of the one or more flexible bandwidth carriers.

[0017] In some embodiments, the boundary for the DRX cycle for the first cell and the boundary for the DRX cycle for the second cell both include at least a starting boundary or an ending boundary. A period of the DRX cycle for the second cell is different from a period of the DRX cycle for the first cell.

[0018] Some embodiments include code for adjusting a length of the DRX cycle for the second cell to either increase or decrease a number of monitored subframes with respect to the first cell. Some embodiments include: code for identifying a periodicity of the DRX cycle for the first cell; and/or code for adjusting a periodicity of the DRX cycle for the second cell at least to coincide or be scaled by a bandwidth scaling factor with respect to the periodicity of the DRX cycle for the first cell. Some embodiments include code for transmitting to and/or receiving at a user equipment (UE) at least one or more offsets or cycle lengths to facilitate adjusting the boundary for the DRX cycle for the second cell. Some embodiments include code for ignoring an initial assigned subframe for a DRX order for the second cell that overlaps an enabling or activation delay for the first cell.

[0019] In some embodiments of the computer program product, the first cell includes a normal bandwidth carrier and the second cell comprises one of the one or more flexible bandwidth carriers. In some embodiments, the first cell includes a flexible bandwidth carrier and the second cell includes one of the one or more flexible bandwidth carriers different from the first cell. In some configurations, the first cell includes one of the one or more flexible bandwidth carriers and the second cell includes a normal bandwidth carrier. The first cell may include one of the one or more flexible bandwidth carriers and the second cell may include one of the one or more flexible bandwidth carriers different from the first cell in some configurations. The first cell may include a bandwidth scaling factor equal to 1 and the second cell may include a bandwidth scaling factor equal to 2 or 4 in some configurations.

[0020] Some embodiments include a wireless communications device configured for discontinuous reception (DRX) in a multicarrier system that utilizes one or more flexible bandwidth carriers. The device may include at least one processor that may be configured to: identify a DRX cycle for a first cell; and/or adjust a boundary for a DRX cycle for a second cell such that the boundary for the DRX cycle for the second cell coincides with a boundary for the DRX cycle for the first cell. At least the first cell or the second cell may include at least one of the one or more flexible bandwidth carriers.

[0021] The boundary for the DRX cycle for the first cell and the boundary for the DRX cycle for the second cell both may include at least a starting boundary or an ending boundary. A period of the DRX cycle for the second cell may be different from a period of the DRX cycle for the first cell.

[0022] The at least one processor may be further configured to: adjust a length of the DRX cycle for the second cell to either increase or decrease a number of monitored subframes with respect to the first cell. The at least one processor may be further configured to: identify a periodicity of the DRX cycle for the first cell; and/or adjust a periodicity of the DRX cycle for the second cell at least to coincide or be scaled by a bandwidth scaling factor with respect to the periodicity of the DRX cycle for the first cell. The at least one processor may be further configured to transmit to and/or receiving at a user equipment (UE) at least one or more offsets or cycle lengths to facilitate adjusting the boundary for the DRX cycle for the second cell. The at least one processor may be further configured to ignore an initial assigned subframe for a DRX order for the second cell that overlaps an enabling or activation delay for the first cell.

[0023] In some embodiments of the device, the first cell includes a normal bandwidth carrier and the second cell comprises one of the one or more flexible bandwidth carriers. In some embodiments, the first cell includes a flexible bandwidth carrier and the second cell includes one of the one or more flexible bandwidth carriers different from the first cell. In some configurations, the first cell includes one of the one or more flexible bandwidth carriers and the second cell includes a normal bandwidth carrier. The first cell may include one of the one or more flexible bandwidth carriers and the second cell may include one of the one or more flexible bandwidth carriers different from the first cell in some configurations. The first cell may include a bandwidth scaling factor equal to 1 and the second cell may include a bandwidth scaling factor equal to 2 or 4 in some configurations.

[0024] 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

[0025] A further understanding of the nature and advantages of the present invention 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. The same reference number, followed by different alphabetical descriptors across multiple figures may indicate different (or identical) versions of the same or similar element or component.

[0026] FIG. **1** shows a block diagram of a wireless communications system in accordance with various embodiments;

[0027] FIG. **2**A shows an example of a wireless communications system where a flexible bandwidth waveform, also referred to as a scalable bandwidth waveform, fits into a portion of spectrum not broad enough to fit a normal waveform in accordance with various embodiments;

[0028] 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;

[0029] FIG. **3** shows a block diagram of a wireless communications system in accordance with various embodiments;

[0030] FIG. **4**A shows a DRX timing diagram of two carriers having different scaling factors in accordance with various embodiments;

[0031] FIG. **4**B shows a DRX timing diagram of two carriers having different scaling factors in accordance with various embodiments;

[0032] FIG. **4**C shows a DRX timing diagram of two carriers having different scaling factors in accordance with various embodiments;

[0033] FIG. **4**D shows a DRX timing diagram of two carriers having different scaling factors in accordance with various embodiments;

[0034] FIG. **4**E shows a DRX timing diagram of two carriers having different scaling factors in accordance with various embodiments;

[0035] FIG. **4**F shows a DRX timing diagram of two carriers having different scaling factors in accordance with various embodiments;

[0036] FIG. **4**G shows a DRX timing diagram of two carriers having different scaling factors in accordance with various embodiments;

[0037] FIG. **4**H shows a DRX timing diagram of two carriers having different scaling factors in accordance with various embodiments;

[0038] FIG. **4**I shows a DRX timing diagram of two carriers having different scaling factors in accordance with various embodiments;

[0039] FIG. **4**J shows a DRX timing diagram of two carriers having different scaling factors in accordance with various embodiments;

[0040] FIG. **5**A shows a block diagram of a device configured for DRX signaling alignment in a multicarrier system that utilizes flexible bandwidth carrier(s) in accordance with various embodiments;

[0041] FIG. **5**B shows a block diagram of another device configured for DRX signaling alignment in a multicarrier system that utilizes flexible bandwidth carrier(s) in accordance with various embodiments;

[0042] FIG. **6** shows a block diagram of a communications system configured in accordance with various embodiments;

[0043] FIG. **7** shows a block diagram of a user equipment configured in accordance with various embodiments;

[0044] 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;

[0045] FIG. **9**A shows a flow diagram of a method of signaling alignment in a multicarrier system that utilizes flexible bandwidth carrier(s) in accordance with various embodiments;

[0046] FIG. **9**B shows a flow diagram of a method of signaling alignment in a multicarrier system that utilizes flexible bandwidth carrier(s) in accordance with various embodiments; and

[0047] FIG. **9**C shows a flow diagram of another method of signaling alignment in a multicarrier system that utilizes flexible bandwidth carrier(s) in accordance with various embodiments.

DETAILED DESCRIPTION

[0048] Methods, systems, and devices are provided for discontinuous reception (DRX) for multicarrier systems that may utilize one or more flexible bandwidth carriers. For example, tools and techniques are provided that may help ensure signaling alignment, such as with respect to DRX signaling, in multicarrier systems that may utilize one or more normal bandwidth carriers and one or more flexible bandwidth carriers and/or systems that may utilize multiple different flexible bandwidth carriers.

[0049] 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.

[0050] In multicarrier systems that may utilize one or more of these flexible bandwidth carriers, misalignment of DRX cycles between multiple carriers may cause an increase in power consumption. An increase in power consumption may be due to the fact that the DRX cycles are misaligned and do not have the same period (e.g., due to time dilation the 'wake-up' period is longer for N=2 or 4 vs. N=1) and consequently the receiver is listening for a longer time period per DRX cycle than would otherwise be the case. These problems may be addressed by aligning the DRX cycles for at least two carriers in a multicarrier system, for example, by aligning at least one boundary, such as a starting boundary and/or an ending boundary, of the DRX cycles or by aligning the periodicity of the DRX cycles for a first and a second carrier.

[0051] Methods for DRX cycle alignment in a multicarrier system that may utilize one or more flexible bandwidth may include identifying a DRX cycle for a first cell. A boundary, such as starting boundary and/or an ending boundary for a DRX cycle for a second cell may be adjusted such that the boundary for the DRX cycle for the second cell coincides with a boundary, such as a starting boundary and/or an ending boundary, for the DRX cycle for the first cell. Methods for DRX cycle alignment may be particularly useful when at least the first cell or the second cell includes at least one flexible bandwidth carrier.

[0052] In some cases, the DRX cycle for the second cell may have a same periodicity as the DRX cycle of the first cell. The DRX cycle for the second cell may have a periodicity related to a periodicity of the DRX cycle of the first cell based on an integer factor, such as a bandwidth scaling factor. A periodicity of the DRX cycle of the second cell may be less than a periodicity of the DRX cycle of the first cell, by an integer factor. It may be useful to align the periodicity of the DRX cycles of the second cell with the first cell, by, for example, adjusting the length of the DRX cycle of the second cell to better align the starting boundaries and/or the ending boundaries of the first and second cells.

[0053] In some embodiments, adjusting the length of the DRX cycle for the second cell may also be used to either increase or decrease a number of monitored subframes with respect to the first cell. In some cases, transmitting to and/or receiving at a user equipment (UE) at least one or more offsets or cycle lengths may further facilitate adjusting the starting boundary for the DRX cycle for the second cell. Some implementations may include ignoring an initial assigned subframe for a DRX order for the second cell that overlaps an enabling or activation delay for the first cell to better align the respective DRX cycles of the first and second cells.

[0054] Methods for DRX may be particularly useful in a multicarrier High Speed Downlink Packet Access (HSDPA) network that utilizes 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. The methods and systems may support downlink discontinuous reception (DL DRX) so that the subframes that need to be monitored by a user equipment (UE) during DL DRX may be aligned between the primary serving HS-DSCH cell (which may be N=1) and secondary serving HS-DSCH cell(s) (which may utilize a flexible bandwidth carrier, such as with N=2 or N=4) or vice versa.

[0055] In some implementations, the first cell may include a normal bandwidth carrier and the second cell may include one of the one or more flexible bandwidth carriers. In other implementations, the first cell may include a flexible bandwidth carrier and the second cell may include one of the one or more flexible bandwidth carriers different from the first cell. In some cases, the flexible bandwidth of the first cell may be greater than the flexible bandwidth of the second cell.

[0056] The methods of DRX as described herein can also be beneficially implemented when the first cell includes one or more flexible bandwidth carriers and the second cell includes a normal bandwidth carrier. In some cases, the first may cell include one or more flexible bandwidth carriers and the second cell may include one or more flexible bandwidth carriers different from the first cell. In some cases, the flexible bandwidth of the first cell may be less than the flexible bandwidth of the second cell.

[0057] In yet other cases, the methods described herein can be implemented where the first cell may include a bandwidth scaling factor equal to 1 and the second cell may include a bandwidth scaling factor equal to 2 or 4. In some cases, the first cell may include a bandwidth scaling factor equal to 2 or 4 and the second cell may include a bandwidth scaling factor equal to 1.

[0058] 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 1X, 1X, etc. IS-856 (TIA-856) is commonly referred to as CDMA2000 1xEV-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.

[0059] 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.

[0060] 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 **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.

[0061] 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.

[0062] 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.

[0063] 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).

[0064] 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.

[0065] 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. 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.

[0066] In some embodiments, 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 identify a DRX cycle for a first cell. 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 adjust at least one boundary, for example a starting boundary and/or an ending boundary for a DRX cycle for a second cell so that the at least one boundary for the DRX cycle for the second cell coincides with a boundary, such as a staring boundary and/or ending boundary for the DRX cycle for the first cell. At least the first cell or the second cell may include at least one of the one or more flexible bandwidth carriers.

[0067] 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*.

[0068] FIG. 2B 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.

[0069] In some embodiments, different aspects of systems **200**-*a* and/or **200**-*b*, such as the user equipment **115**-*a* and/or **115**-*b* and/or the base stations **105**-*a* and/or **105**-*b* b may be configured to identify a DRX cycle for a first cell. 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 adjust at least one boundary, for example a starting boundary and/or an ending boundary for a DRX cycle for a second cell so that the at least one boundary for the DRX cycle for the second cell coincides with a boundary, such as a staring boundary and/or ending boundary for the DRX cycle for the first cell. At least the first cell or the second cell may include at least one of the one or more flexible bandwidth carriers.

[0070] 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).

[0071] 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.

[0072] 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 DRX in system **300** that may utilize multiple carriers including one or more flexible bandwidth carriers.

[0073] 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.

[0074] Different aspects of system **300**, such as the user equipment **115**-*c* and/or the base stations **105**-*c*, may be configured for identifying a DRX cycle for a first cell, which may be a primary serving cell. The user equipment **115**-*c* and/or the base stations **105**-*c* may adjust a boundary, such a starting and/or ending boundary for a DRX cycle for a second cell, which may be a secondary serving cell, such that the boundary for the DRX cycle for the second cell coincides with a boundary, such as a starting and/or ending boundary, for the DRX cycle for the first cell. At least the first cell or the second cell may include at least one of the one or more flexible bandwidth carriers. In some embodiments, a period of the DRX cycle for the second cell may be different from a period of the DRX cycle for the first cell.

[0075] In some embodiments, the user equipment **115**-*c* and/or the base stations **105**-*c*, may be configured for identifying a periodicity of the DRX cycle for the first cell. A periodicity of the DRX cycle for the second cell may be adjusted, by for example the user equipment **115**-*c* and/or the base stations **105**-*c*, at least to coincide or be scaled by a bandwidth scaling factor with respect to the periodicity of the DRX cycle for the first cell.

[0076] In some embodiments, the user equipment **115**-*c* and/or the base stations **105**-*c* may be configured for adjusting a length of the DRX cycle for the second cell to either increase or decrease a number of monitored subframes with respect to the first cell. Some embodiments may further include transmitting to and/or receiving at the user equipment **115**-*c* at least one or more offsets or cycle lengths to facilitate adjusting a boundary, which may include a starting and or ending boundary, for the DRX cycle for the second cell. In some embodiments, the user equipment **115**-*c* and/or the base stations **105**-*c* may ignore an initial assigned subframe for a DRX order for the second cell that overlaps an enabling or activation delay for the first cell to further enable DRX cycle alignment between multiple carriers,

[0077] In some embodiments, transmission **305**-*a* may include one of the one or more flexible bandwidth carriers and transmission **305**-*b* may include a normal bandwidth carrier. In some embodiments, transmission **305**-*a* may include one of the one or more flexible bandwidth carriers and transmission **305**-*b* may include one of the one or more flexible bandwidth carriers different from the first cell.

[0078] In some embodiments, transmission **305**-*a* may include a bandwidth scaling factor equal to 1 and transmission **305**-*b* may include a bandwidth scaling factor equal to 2 or 4. In other embodiments, transmission **305**-*a* may include a bandwidth scaling factor equal to 2 or 4 and the transmission **305**-*b* may include a bandwidth scaling factor equal to 1. In some embodiments, transmission **305**-*a* may include a bandwidth scaling factor equal to 2 or 4 and transmission **305**-*b* may include a bandwidth scaling factor equal to 2 or 4.

[0079] System **300** may be an example of 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 downlink discontinuous reception (DL DRX) so that the subframes that may need to be monitored by a user equipment (UE) during DL DRX may be aligned between the primary serving HS-DSCH cell (which may be N=1) and secondary serving HS-DSCH cell(s) (which may utilize a flexible bandwidth carrier, such as with N=2 or N=4) or vice versa.

[0080] 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.

[0081] 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 Rate×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.

[0082] 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.

[0083] Turning next to FIGS. **4**A-**4**J, DRX timing diagrams illustrate multiple configuration **400**, including configurations **400**-*a*, **400**-*b*, **400**-*c*, **400**-*d*, **400**-*e*, **400**-*f*, **400**-*g*, **400**-*h*, **400**-*i*, and **400**-*j* that each include DRX functionality in a multicarrier system that utilizes one or more flexible bandwidth carriers in accordance with various embodiments. The DRX timing diagrams may be examples of DRX methods, such as DRX signaling alignment, 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. **4**A-**4**J will be described generally, and the particulars of each FIG. will then be described separately.

[0084] In some embodiments, configurations **400** may be implemented in a wireless communication system utilizing High-Speed Downlink Packet Access (HSDPA). A primary serving cell **405**, such as a High-Speed Downlink Shared Channel (HS-DSCH), may have a scaling factor of N=1. A secondary serving cell **410**, which may also be a HS-DSCH cell, may have a scaling factor of N=2 or N=4. Conversely, in some embodiments, the primary serving cell **405** may have a scaling factor of N=2 or N=4, and the secondary serving cell **410** may have a scaling factor of N=1.

[0085] In some embodiments, the primary serving cell **405** may include multiple channels, such as a High Speed-Shared Control Channel (HS-SCCH) **406** and/or a High Speed-Physical Downlink Shared Channel (HS-PDSCH) **407**. After an activation or enabling delay **415**, which may be of a length of 1 frame and which may be enabled via RRC signaling, a UE **115**, for example in a next frame, may continuously listen for communications across the HS-SCCH **406** and/or the HS-PDSCH **407**, such as for paging information including one or more resource grants, during one or more DRX cycles, such as UE DRX cycle **420**. Each UE DRX cycle **420** may be 4 subframes in length, or any other suitable length. In some cases, each UE DRX cycle **420** may be 8 subframes in length. The UE **115** may receive a HS-SCCH DRX burst **425**, and upon the completion of reception of the HS-SCCH DRX burst **425**, an inactivity threshold **430** for a UE DRX cycle **420** may begin. In some embodiments, the inactivity threshold **430** may be 8 subframes in length. In other embodiments, an inactivity threshold for a UE DRX cycle **420** may be 4 subframes in length. After completion of the HS-SCCH DRX burst **425** and during the inactivity threshold **430**, the UE **115** may also receive one or more HS-SCCH bursts **435**, **437**. In some cases, upon completion of transmission/reception of each of the one or more HS-SCCH bursts **435**, **437**, an inactivity threshold **431**, **432**, **433** each of a similar length, may be re-started. As a result, the UE **115** may continuously monitor the HS-SCCH **406** for varied lengths of time **440**, **441**, depending on what bursts are received over the HS-SCCH **406**. Upon the passage of an entire inactivity threshold **432** without any reception of signaling across the HS-SCCH **406**, a length of continuous HS-SCCH monitoring **440** may end and the UE **115** may stop continuously monitoring the HS-SCCH **406**.

[0086] In some embodiments, the UE **115** may monitor one or more required inactive HS-SCCH DRX bursts **445**, for example, lasting one subframe each when the UE **115** is not continuously monitoring the HS-SCCH **406**, such as during a DRX cycle **420** after the expiration of an inactivity threshold **432**. In some embodiments, the UE **115** may monitor a required inactive HS-SCCH DRX burst **445** once per every UE DRX cycle **420**. The UE **115** may continue to monitor required inactive HS-SCCH DRX bursts **445** once per every UE DRX cycle **420** until it receives another HS-SCCH DRX burst **427** or another HS-SCCH burst. Upon complete receipt of another burst, the UE may again activate an inactivity threshold timer **433**. In some embodiments, upon the expiration of inactivity threshold timer **433**, a period **441** of continuously monitoring the HS-SCCH **406** may end and the UE may again go back to discontinuously monitoring subframes for transmissions across the HS-SCCH **406**.

[0087] In some embodiments, the HS-PDSCH **407** may carry one or more HS-PDSCH bursts **450**, which may be slightly delayed, for example by 2 slots, which may be equivalent to 1.33 ms, behind a corresponding burst, such as burst **425**, **427**, **435**, and/or **436**, etc. on the HS-SCCH **406**.

[0088] In some embodiments, the secondary serving cell **410** may include multiple channels, such as a High Speed-Shared Control Channel (HS-SCCH) **411** and/or a High Speed-Physical Downlink Shared Channel (HS-PDSCH) **412**. The UE **115**, for example in a second frame CFN 61, may continuously listen for communications across the HS-SCCH **411** and/or the HS-PDSCH **412**, such as for paging information including one or more resource grants, during one or more DRX cycles **421**. Each DRX cycle **421** may be 4, or 8, for example, subframes in length, or any other suitable length. The UE **115** may receive a HS-SCCH DRX burst **426**, **428**, **436**, **43**, **446** during a DRX cycle **421**. In some embodiments, the DRX cycles **421** may be scaled down or up by an integer factor, such as by a bandwidth scaling factor, to align the periodicity of the secondary serving cell **410** with a periodicity of the primary serving cell **405**.

[0089] In some embodiments, after completion of the HS-SCCH DRX burst **426**, the UE **115** may also receive one or more HS-SCCH bursts **436**, **438**. In some cases, the UE **115** may continuously monitor the HS-SCCH **411** for varied lengths of time **440**, **441**, depending on what bursts are received over the HS-SCCH **411**. The passage of an inactivity threshold **430**, **431**, **432**, **433** on the HS-SCCH **406** of the primary serving cell **405** without reception of a burst may trigger discontinuous monitoring of the HS-SCCH **411** for further bursts.

[0090] In some embodiments, the UE **115** may monitor one or more required inactive HS-SCCH DRX bursts **446**, for example, lasting one subframe each when the UE **115** is not continuously monitoring the HS-SCCH **411**, such as during a DRX cycle **421** after the expiration of an inactivity threshold **430**, **431**, **432**, **433** on the HS-SCCH **406**. In some embodiments, the UE **115** may monitor a required inactive HS-SCCH DRX burst **446** for 1 subframe per every DRX cycle **421**. The UE **115** may continue to monitor a required inactive HS-SCCH DRX burst **446** for 1 subframe per every DRX cycle **421** until it receives another HS-SCCH DRX burst **428** or another HS-SCCH burst.

[0091] In some embodiments, the HS-PDSCH **412** may carry one or more HS-PDSCH bursts **451**, which may be slightly delayed, for example 2 dilated slots, which may be equivalent to 2.67 ms, behind a corresponding burst, such as burst **426**, **428**, **436**, and/or **438**, etc. on the HS-SCCH **411**.

[0092] In the following embodiments, it may be assumed that the UE DRX cycle **420** may be an integer multiple or divisor of a UE discontinues transmission (DTX) cycle, however the claimed subject matter is not so limited. The following methods, systems, and devices may be implemented for other configurations of UE DTX cycles. Furthermore, in some cases it may be assumed that a UE DTX DRX offset shall fulfill the following relationship:

$$\text{UE } \mathit{DTX\ DRX} \text{ Offset mod } 5=0 \text{ for } \mathit{E\text{-}DCH\ TTI}=10 \text{ ms} \quad (1)$$

for ease of implementation with current standards and practices, for example. However the claimed subject matter is not to be so limited.

[0093] In the embodiments to be detailed further below, when multiple carriers are implemented having different bandwidth scaling factors, DRX misalignment may occur. Methods are herein provided for DRX, including methods to mitigate this DRX misalignment problem to align one or more required inactive HS-SCCH DRX bursts **445** on a first carrier, such as primary serving cell **405** to those required inactive HS-SCCH DRX bursts **446** on a second carrier, such as secondary serving cell **410**.

[0094] In particular, FIG. **4**A shows a configuration **400**-*a*, where for the primary serving cell **405**, N=1, and for the secondary serving cell **410**, N=2. A standard DRX pattern, i.e., N=1, can be described by:

$$((5*CFN\_DRX-UE\_DTX\_DRX\_Offset+S\_DRX) \text{ MOD } UE\_DRX\_cycle)=0 \quad (2)$$

where

$$S\_DRX=\text{HS-SCCH/HS-PDSCH subframe number if } \tau_{DPCH}=0 \quad (3)$$

In some cases, such as when the primary serving cell **405** has a bandwidth scaling factor of N=1 and the secondary serving cell **410** has a bandwidth scaling factor of N=2 (or 4 as will be described below in reference to FIG. 4B), the flexible DRX pattern, e.g., N=1, 2, or 4, can be described by:

$$((5*CFN\_DRX_N-UE\_DTX\_DRX\_Offset_N+S\_DRX_N) \text{ MOD } UE\_DRX\_cycle_N)=0 \quad (4)$$

[0095] where N=1, 2, or 4; and

$$CFN\_DRX_{N=2\ or\ 4}=\text{Floor}((CFN\_DRX_{N=1})/N) \quad (5)$$

$$UE\_DTX\_DRX\_Offset_{N=2\ or\ 4}=\text{Floor}((UE\_DTX\_DRX\_Offset_{N=1})/N) \quad (6)$$

$$UE\ DRX\ cycle_{N=2\ or\ 4}=\text{Floor}(UE\ DRX\ cycle_{N=1})/N \quad (6a)$$

[0096] where Floor(x) is the largest integer not greater than x (e.g., Floor(3.5)=3).

[0097] In some embodiments, according to equations (6) and (6a), for the secondary serving cell **410**, the DRX cycle **421**, which as shown is divided by 2, over the HS-SCCH **411** is equal to the UE DRX cycle **420** for the primary serving cell **405**. By dividing the DRX cycle **421** across the HS-SCCH **411** of the secondary serving cell **410** by 2 and then invoking the floor function represented by equations (6) and (6a), DRX cycle alignment may be realized. For example, dividing the DRX cycle **421** by **2** and then invoking the floor function, the periodicity of the secondary serving cell **410** may be aligned with the periodicity of the primary serving cell **405** such that each of the required inactive HS-SCCH DRX bursts **445** across the HS-SCCH **406** of the primary serving cell **405** may begin at the same time as/align with the required inactive HS-SCCH DRX bursts **446** across the HS-SCCH **411** of the secondary serving cell **410**. In some embodiments, an ending time of the required inactive HS-SCCH DRX bursts **445** and the required inactive HS-SCCH DRX bursts **446** may be aligned in a similar manner (not shown). This may be further be represented by:

$$UE\ DTX\ DRX\ Offset_{N=2}=\text{Floor}((UE\ DTX\ DRX\ Offset_{N=1})/2) \quad (7)$$

$$UE\ DRX\ cycle_{N=2}=(UE\ DRX\ cycle_{N=1})/2 \text{ where } UE\ DRX\ cycle_{N=1}\neq 5 \quad (8)$$

[0098] where the floor function represented by equation (7) may only be required for UE DRX cycle if UE DRX $cycle_{N=1}=5$.

[0099] By configuring the second serving cell **405** in such a way, an "off time" for DRX reception, e.g. a time between continuous monitoring of the HS-SCCH **411** for varied lengths of time **440** and **441**, may be aligned with the primary serving cell **405** HS-SCCH **406**. In some embodiments, the UE DRX cycle **420** may not equal 5, as this may result in periodic misalignment between the required inactive HS-SCCH DRX bursts **445** and the required inactive HS-SCCH DRX bursts **446** in primary and secondary serving HS-DSCH cells **405**, **410**.

[0100] In some embodiments, values for the UE DTX DRX $OFFSET_{N=2}$ and the UE DRX $cycle_{N=2}$, which may correspond to UE DRX cycle **420**, may be transmitted to/received by the UE **115** via RRC signaling, which may not be activated until the end of an enabling delay period **415**. These values may represent an offset value and a cycle length for DRX alignment. In some cases, these values may be appropriately scaled for other cells having different bandwidth scaling factors, such as secondary serving cell **410**, which has a bandwidth scaling factor N=2. These values may also be appropriately scaled for other cells having different bandwidth scaling factors, such as secondary serving cell **410**-*a* of FIG. 4B, as described below, with N=4.

[0101] In some embodiments, adjusting a length of the DRX cycle **421** for the secondary serving cell **410** may result in either an increase or a decrease in a number of monitored subframes with respect to the primary serving cell **405**.

[0102] In some embodiments, dividing the floor DRX cycle **421** of the HS-SCCH **411**-*a* on the secondary serving cell **410** by the bandwidth scaling factor of the secondary serving cell relative to the primary serving cell **405** and then invoking the relevant floor function, may further align other bursts across HS-SCCH **406** and HS-SCCH **411**, such as HS-SCCH DRX burst **425** and HS-SCCH DRX burst **426**, HS-SCCH DRX burst **427** and HS-SCCH DRX burst **428**, and/or HS-SCCH bursts **435** and **437** with HS-SCCH burts **436** and **438**.

[0103] In some cases, if the HS-SCCH **406** is transmitted via the primary serving cell **405** to the UE **115**, or if the HS-SCCH **406** and the HS-SCCH **411** are both transmitted to the UE **115**, then it may be beneficial to start the inactivity timer **430**, **431**, **432**, and/or **433** in the HS-SCCH **406** subframe after an HS-SCCH DRX burst **425**, **427** and/or an HS-SCCH burst **435**, **437** is received by the UE **115** via the HS-SCCH **406**. In other cases, if only the HS-SCCH **411** is transmitted to the UE **115**, then it may be beneficial to start an inactivity timer, such as **430**, **431**, **432**, and/or **433** in the HS-SCCH **406** subframe after an HS-SCCH DRX burst **426**, **428** and/or an HS-SCCH burst **436**, **438** is received by the UE **115** via the HS-SCCH **411**.

[0104] In alternative embodiments, two separate inactivity timers for the UE DRX cycle **420** and the DRX cycle **421** could be implemented, e.g. one on the HS-SCCH **406** for the primary serving cell **405** and one on the HS-SCCH **411** on the secondary serving cell **410**.

[0105] Turning next to FIG. 4B, a timing diagram illustrates a configuration **400**-*b*, where for the primary serving cell **405**-*a*, N=1, and for the secondary serving cell **410**-*a*, N=4. In some cases, a UE DRX cycle **420**-*a* may be 8 subframes in length. For the secondary serving cell **410**-*a*, the DRX cycle **421**-*a* over the HS-SCCH **411**-*a* is the same subframe length as UE DRX cycle **420**-*c* (8 subframes), but because secondary serving cell **410**-*a* is dilated with respect to cell **405**-*a* by a bandwidth scaling factor of 4, the DRX cycle **421**-*a* is four times as long in time relative to the UE DRX cycle **420**-*a* of the primary serving cell **405**-*a*. By dividing the DRX cycle **421**-*a* across the HS-SCCH **411** of the secondary serving cell **410**-*a* by **4** and then invoking the relevant floor function, DRX cycle alignment may be realized. For example, dividing the DRX cycle **421**-*a* by **4** and then invoking the relevant floor function, the periodicity of the secondary serving cell **410**-*a* may be aligned with the periodicity of the primary serving cell **405**-*a* such that each of the required inactive HS-SCCH DRX bursts **445**-*a* across the HS-SCCH **406**-*a* of the primary serving cell **405**-*a* may begin and/or end at the same time as/align with the required inactive HS-SCCH DRX bursts **446**-*a* across the HS-SCCH **411**-*a* of the secondary serving cell **410**-*a*. This may be represented by:

$$\text{UE } DTX\ DRX \text{ Offset}_{N=4}=\text{Floor}((\text{UE } DTX\ DRX \text{ Offset}_{N=1})/4) \quad (9)$$

$$\text{UE } DRX \text{ cycle}_{N=4}=(\text{UE } DRX \text{ cycle}_{N=1})/4 \text{ where UE } DRX \text{ cycle}_{N=1}>5 \text{ and } \neq 10 \quad (10)$$

[0106] where UE DRX cycle$_{N=1}$ could also be ÷2 instead of ÷4,

[0107] and where the floor function represented by equation (9) may only be required for UE DRX cycle if UE DRX cycle$_{N=1}$=5 or 10.

[0108] By configuring the second serving cell **405**-*a* in such a way, an "off time" for DRX reception, e.g. a time between continuous monitoring of the HS-SCCH **411**-*a* for varied lengths of time **440**-*a* and **441**-*a*, may be aligned with the primary serving cell **405**-*a* HS-SCCH **406**-*a*. In some embodiments, the UE DRX cycle **420**-*a* may be greater than (not equal to) **5** and not equal to 10, as either of these cases may result in periodic misalignment between the required inactive HS-SCCH DRX bursts **445**-*a* and the required inactive HS-SCCH DRX bursts **446**-*a* in primary and secondary serving HS-DSCH cells **405**-*a*, **410**-*a* based on the assumption represented in equations (1) and/or (4). In some cases, the UE DRX cycle **420**-*a* may also not be equal to 4, as this may result in no DRX for the secondary serving cell **410**-*a* when that cell has a bandwidth scaling factor of 4.

[0109] In some embodiments, values for the UE DTX DRX OFFSET$_{N=4}$ and the UE DRX cycle$_{N=4}$, which may correspond to UE DRX cycle **420**-*a*, may be transmitted to/received by the UE **115** via RRC signaling, which in some cases is not activated until the end of an enabling delay period **415**-*a*. These values may represent an offset value and a cycle length for DRX alignment. In some cases, these values may be appropriately scaled for other cells having different bandwidth scaling factors, such as secondary serving cell **410**-*a*, which has a bandwidth scaling factor N=4.

[0110] In some embodiments, adjusting a length of the DRX cycle **421**-*a* for the secondary serving cell **410**-*a* may result in either an increase or a decrease in a number of monitored subframes with respect to the primary serving cell **405**-*a*.

[0111] In some embodiments, dividing the DRX cycle **421**-*a* of the HS-SCCH **411**-*a* on the secondary serving cell **410**-*a* by the bandwidth scaling factor of the secondary serving cell **410**-*a* relative to the primary serving cell **405**-*a* and then invoking the relevant floor function, may further align other bursts across HS-SCCH **406**-*a* and HS-SCCH **411**-*a*, such as HS-SCCH DRX burst **425**-*a* and HS-SCCH DRX burst **426**-*a*, HS-SCCH DRX burst **427**-*a* and HS-SCCH DRX burst **428**-*a*, and/or HS-SCCH burst **435** and **437** with HS-SCCH bursts **436** and **438** (not shown).

[0112] In some embodiments, the DRX cycle **421**-*a* could also be divided by 2, such as after invoking the relevant floor function, to align twice as many required inactive HS-SCCH DRX bursts **445**-*a* across the HS-SCCH **406**-*a* of the primary serving cell **405**-*a* with the required inactive HS-SCCH DRX bursts **446**-*a* across the HS-SCCH **411**-*a* of the secondary serving cell **410**-*a*, than the normally dilated (by a factor of 4) secondary serving cell **405**-*a*. This may further allow DRX alignment when the UE DRX cycle **420**-*a* is not equal to 4 (same as the N=2 case above described in reference to FIG. **4**A).

[0113] In some cases, if the HS-SCCH **406**-*a* is transmitted via the primary serving cell **405**-*a* to the UE **115**, or if the HS-SCCH **406**-*a* and the HS-SCCH **411**-*a* are both transmitted to the UE **115**, then it may be beneficial to start the inactivity timer **430**-*a* and/or **433**-*a* in the HS-SCCH **406**-*a* subframe after an HS-SCCH DRX burst **425**-*a*, **427**-*a* is received by the UE via the HS-SCCH **406**-*a*. In other cases, if only the HS-SCCH **411**-*a* is transmitted to the UE **115**, then it may be beneficial to start an inactivity timer, such as **430**-*a* and/or **433**-*a* in the HS-SCCH **406**-*a* subframe after an HS-SCCH DRX burst **426**-*a*, **428**-*a* is received by the UE **115** via the HS-SCCH **411**.

[0114] In alternative embodiments, two separate inactivity timers for the UE DRX cycle **420**-*a* and the DRX cycle **421**-*a* could be implemented, e.g. one on the HS-SCCH **406**-*a* for the primary serving cell **405**-*a* and one on the HS-SCCH **411**-*a* on the secondary serving cell **410**-*a*.

[0115] Turning next to FIG. **4**C, a timing diagram illustrates a configuration **400**-*c*, where for the primary serving cell **405**-*b*, N=1, and for the secondary serving cell **410**-*b*, N=2. For the secondary serving cell **410**-*b*, the DRX cycle **421**-*b* over the HS-SCCH **411**-*b* is the same length in subframes (**4**) as UE DRX cycle **420**-*b*, but because secondary serving cell **410**-*b* is dilated with respect to cell **405**-*b* by a bandwidth scaling factor of 2, the DRX cycle **421**-*b*, although the same subframe length as the UE DRX cycle **420**-*b* (4 subframes), is twice as long in time relative to the UE DRX cycle **420**-*b* of the primary serving cell **405**-*b*.

[0116] In some embodiments, to align the respective DRX cycles of the primary and secondary serving cells **405**-*b* and **410**-*b*, and more specifically the required inactive HS-SCCH DRX bursts **445**-*b* across the HS-SCCH **406**-*b* with the required inactive HS-SCCH DRX bursts **446**-*b* across the HS-SCCH **411**-*b*, it may be useful to align a boundary of these bursts **445**-*b* and **446**-*b*. In some embodiments, this may include aligning a starting boundary and/or an ending boundary (not shown) of the required inactive HS-SCCH DRX bursts **445**-*b* with a boundary of the required inactive HS-SCCH DRX bursts **446**-*b*. In some cases, this result may be obtained by transmitting to/receiving by the UE **115** an offset value and/or a cycle length via RRC signaling, for example, with the alignment being activated after an enabling delay **415**-*b*. In some cases, because the HS-SCCH **411**-*b* of the secondary serving cell **410**-*b* is scaled by a factor of 2 with respect to the HS-SCCH **406**-*b* of the primary serving cell **405**-*b*, each required inactive HS-SCCH DRX burst **446**-*b* may align with every other required inactive HS-SCCH DRX burst **445**-*b*. In other words, this may result in an aligned DRX pattern for the respective cells, but with a longer "off time" for the secondary serving cell **410**-*b*. Also, because the secondary serving cell **410**-*b* is scaled by a factor of 2 with respect to the primary serving cell **405**-*b*, each required inactive HS-SCCH DRX burst **446**-*b* may be twice as long as each required inactive HS-SCCH DRX burst **445**-*b*. This configuration may be further represented by:

$$\text{UE } DTX\ DRX \text{ Offset}_{N=2}=\text{Floor}((\text{UE } DTX\ DRX \text{ Offset}_{N=1})/2) \quad (11)$$

$$\text{UE } DRX \text{ cycle}_{N=2}=\text{"}N\text{=2" dilated UE } DRX \text{ cycle}_{N=1} \quad (12)$$

[0117] In some embodiments, the DRX pattern may be determined by:

$$((5*CFN\_DRX_N-\text{UE}\_DTX\_DRX\_\text{Offset}_N+S\_DRX_N)\text{MOD UE}\_DRX\_\text{cycle}_N)=0 \quad (13)$$

Equation (13) may be particularly useful when DRX is applied after being activated either by RRC signaling, such as after an enabling delay **415**-*b* or by an HS-SCCH order, such as after a delay of 12 slots starting from the end of the HS-SCCH order subframe, when the primary and secondary serving cell **405**-*b*, **410**-*b* subframes are already aligned. i.e., when the DRX cycles **420**-*b*, **421**-*b* begin at the same time/in the same subframe. However, in other embodiments, when the subframes across the primary and secondary serving cells **405**-*b* and **410**-*b* are not aligned, i.e., when the DRX cycles **420**-*b*, **421**-*b* do not begin at the same time/in the same subframe, or when it is desired to align the initial subframes across these cells, the DRX pattern may be determined by:

$$((5*CFN\_DRX_N - UE\_DTX\_DRX\_Offset_N + S\_DRX_N - \text{Floor}(UE\_DRX\ cycle_N/N))\ \text{MOD}\ UE\_DRX\_cycle_N)=0 \quad (14)$$

The Floor($UE\_DRX\_cycle_N$/N) term in equation (14) corresponds to the DRX cycle **421**-*b* divided by the bandwidth scaling factor of the secondary serving cell **410**-*b*, such as by 2, after which the relevant floor function may be invoked, as shown.

[0118] In some embodiments, values for the UE DTX DRX $OFFSET_{N=2}$ and the UE DRX $cycle_{N=2}$, which may correspond to UE DRX cycle **420**-*b*, may be transmitted to/received by the UE **115** via RRC signaling, and in some cases, not activated until the end of an enabling delay period **415**-*b*. These values may represent an offset value and a cycle length. In some cases, these values may be appropriately scaled for other cells having different bandwidth scaling factors, such as secondary serving cell **410**-*b*, which has a bandwidth scaling factor N=2.

[0119] In some embodiments, adjusting a length of the DRX cycle **421**-*b* for the secondary serving cell **410**-*b* may result in either an increase or a decrease in a number of monitored subframes with respect to the primary serving cell **405**-*b*.

[0120] In some cases, if the HS-SCCH **406**-*b* is transmitted via the primary serving cell **405**-*b* to the UE **115**, or if the HS-SCCH **406**-*b* and the HS-SCCH **411**-*b* are both transmitted to the UE **115**, then it may be beneficial to start the inactivity timer **430**-*b*, **431**-*a*, **432**-*a*, and/or **433**-*b* in the HS-SCCH **406**-*b* subframe after an HS-SCCH DRX burst **425**-*b*, **427**-*b* and/or an HS-SCCH burst **435**-*a*, **437**-*a* is received by the UE **115** via the HS-SCCH **406**-*b*. In other cases, if only the HS-SCCH **411**-*b* is transmitted to the UE **115**, then it may be beneficial to start an inactivity timer, such as **430**-*b*, **431**-*a*, **432**-*a*, and/or **433**-*b* in the HS-SCCH **406**-*b* subframe after an HS-SCCH DRX burst **426**-*b*, **428**-*b* and/or an HS-SCCH burst **436**-*a*, **438**-*a* is received by the UE **115** via the HS-SCCH **411**-*b*.

[0121] In alternative embodiments, two separate inactivity timers for the UE DRX cycle **420**-*b* and the DRX cycle **421**-*b* could be implemented, e.g. one on the HS-SCCH **406**-*b* for the primary serving cell **405**-*b* and one on the HS-SCCH **411**-*b* on the secondary serving cell **410**-*b*.

[0122] Turning next to FIG. 4D, a timing diagram illustrates a configuration **400**-*d*, where for the primary serving cell **405**-*c*, N=1, and for the secondary serving cell **410**-*c*, N=4. For the secondary serving cell **410**-*c*, the DRX cycle **421**-*c* over the HS-SCCH **411**-*c* is the same subframe length as UE DRX cycle **420**-*c* (4 subframes), but because secondary serving cell **410**-*c* is dilated with respect to cell **405**-*c* by a bandwidth scaling factor of 4, the DRX cycle **421**-*c*, is four times as long in time relative to the UE DRX cycle **420**-*c* of the primary serving cell **405**-*b*.

[0123] In some embodiments, to align the respective DRX cycles of the primary and secondary serving cells **405**-*c* and **410**-*c*, and more specifically the required inactive HS-SCCH DRX bursts **445**-*c* across the HS-SCCH **406**-*c* with the required inactive HS-SCCH DRX bursts **446**-*c* across the HS-SCCH **411**-*c*, it may be useful to align a boundary of these bursts **445**-*c* and **446**-*c*. In some embodiments, this may include aligning a starting boundary or an ending boundary (not shown) of the required inactive HS-SCCH DRX bursts **445**-*c* with the starting boundary of the required inactive HS-SCCH DRX bursts **446**-*c*. In some cases, because the HS-SCCH **411**-*c* of the secondary serving cell **410**-*c* is scaled by a factor of 4 with respect to the HS-SCCH **406**-*c* of the primary serving cell **405**-*c*, each HS-SCCH DRX burst **446**-*c* may align with every sixth HS-SCCH DRX burst **445**-*c*. In other words, this may result in an aligned DRX pattern for the respective cells, but with a longer "off time" for the secondary serving cell **410**-*c*. Also, because the secondary serving cell **410**-*c* is scaled by a factor of 4 with respect to the primary serving cell **405**-*c*, each HS-SCCH DRX burst **446**-*c* may be four times as long as each HS-SCCH DRX burst **445**-*c*. This configuration may further represented by:

$$UE\ DTX\ DRX\ Offset_{N=4}=\text{Floor}((UE\ DTX\ DRX\ Offset_{N=i})/4) \quad (15)$$

$$UE\ DRX\ cycle_{N=4} = \text{"}N=4\text{" dilated } UE\ DRX\ cycle_{N=1} \quad (16)$$

[0124] In some embodiments, the DRX pattern may be determined by equation (13) above when DRX is applied after being activated either by RRC signaling, such as after an enabling delay **415**-*c* or by an HS-SCCH order, such as after a delay of 12 slots starting from the end of the HS-SCCH order subframe, when the primary and secondary serving cell **405**-*c*, **410**-*c* subframes are already aligned, i.e., when the DRX cycles **420**-*c*, **421**-*c* begin at the same time/in the same subframe. However, in other embodiments, when the subframes across the primary and secondary serving cells **405**-*c* and **410**-*c* are not aligned, i.e., when the DRX cycles **420**-*c*, **421**-*c* do not begin at the same time/in the same subframe, or when it is desired to align the initial subframes across these cells, the DRX pattern may be determined by equation (14) above. The Floor($UE\_DRX\_cycle_N$/N) term in equation (14) corresponds to the DRX cycle **421**-*c* divided by the bandwidth scaling factor of the secondary serving cell **410**-*c*, such as by **4**, after which the relevant floor function may be invoked as shown. In some cases, this result may be obtained by signaling to/receiving by the UE **115** an offset value and/or a cycle length as indicated above, via RRC signaling, which may not be activated until the end of the enabling delay **415**-*c*.

[0125] In some embodiments, adjusting a length of the DRX cycle **421**-*c* for the secondary serving cell **410**-*c* may result in either an increase or a decrease in a number of monitored subframes with respect to the primary serving cell **405**-*c*.

[0126] In some cases, if the HS-SCCH **406**-*c* is transmitted via the primary serving cell **405**-*c* to the UE **115**, or if the HS-SCCH **406**-*c* and the HS-SCCH **411**-*c* are both transmitted to the UE **115**, then it may be beneficial to start the inactivity timer **430**-*c*, **431**-*b*, **432**-*b*, and/or **433**-*c* in the HS-SCCH **406**-*c* subframe after an HS-SCCH DRX burst **425**-*c*, **427**-*c* and/or an HS-SCCH burst **435**-*b*, **437**-*b* is received by the UE **115** via the HS-SCCH **406**-*c*. In other cases, if only the HS-SCCH **411**-*c* is transmitted to the UE **115**, then it may be beneficial to start an inactivity timer, such as **430**-*c*, **431**-*b*, **432**-*b*, and/or **433**-*c* in the HS-SCCH **406**-*c* subframe after an HS-SCCH DRX burst **426**-*c* and/or an HS-SCCH burst **436**-*b* is received by the UE **115** via the HS-SCCH **411**-*c*.

[0127] In alternative embodiments, two separate inactivity timers for the UE DRX cycle **420**-*c* and the DRX cycle **421**-*c* could be implemented, e.g. one on the HS-SCCH **406**-*c* for the primary serving cell **405**-*c* and one on the HS-SCCH **411**-*c* on the secondary serving cell **410**-*c*.

[0128] Turning next to FIG. **4**E, a timing diagram illustrates a configuration **400**-*e*, where for the primary serving cell **405**-*d*, N=1, and for the secondary serving cell **410**-*d*, N=2. For the primary serving cell **405**-*d*, the DRX may be applied after an enabling delay **415**-*d* equal to 5 subframes in length. An HS-SCCH burst **435**-*b* may occur immediately following the enabling delay **415**-*b*, and may last for 1 subframe. A corresponding HS-SCCH burst **436**-*c* may occur on the HS-SCCH **411**-*d* of the secondary serving cell **410**-*d* overlapping the occurrence of the HS-SCCH burst **435**-*c* on the primary serving cell **405**-*d*. Because the secondary serving cell **410**-*d* is dilated by a factor of 2 with respect to the primary serving cell **405**-*d*, the HS-SCCH burst **436**-*c* is twice as long as the HS-SCCH burst **435**-*c*. In some embodiments, the HS-SCCH burst **436**-*c* and HS-SCCH burst **435**-*c* may end at the same time, but the HS-SCCH burst **436**-*c* may start before the HS-SCCH burst **435**-*c*. However, because the HS-SCCH burst **435**-*c* immediately follows the enabling delay **415**-*d*, the HS-SCCH burst **436**-*c* may overlap the enabling delay **415**-*d*. In some embodiments, this may cause misalignment of reception of the HS-SCCH bursts **435**-*c* and **436**-*c*. Therefore it may be advantageous to ignore the secondary serving cell **410**-*d* HS-SCCH **411**-*d*'s initial assigned subframe, such as burst **436**-*c*, to avoid requiring retransmission across both cells to align the DRX cycles of the respective cells. In some cases, such instructions may be transmitted to/received by the UE **115** via RRC signaling and activated after the enabling delay **415**-*d*.

[0129] Turning next to FIG. **4**F, a timing diagram illustrates a configuration **400**-*f*, where for the primary serving cell **405**-*e*, N=1, and for the secondary serving cell **410**-*e*, N=4. For the primary serving cell **405**-*e*, the DRX may be applied after an enabling delay **415**-*e* equal to 5 subframes in length. An HS-SCCH burst **435**-*d* may occur immediately following the enabling delay **415**-*e*, and may last for 1 subframe. A corresponding HS-SCCH burst **436**-*d* may occur on the HS-SCCH **411**-*e* of the secondary serving cell **410**-*e* overlapping the occurrence of the HS-SCCH burst **435**-*c* on the primary serving cell **405**-*d*. Because the secondary serving cell **410**-*e* is dilated by a factor of 4 with respect to the primary serving cell **405**-*e*, the HS-SCCH burst **436**-*d* is four times as long as the HS-SCCH burst **435**-*d*. In some embodiments, the HS-SCCH burst **436**-*d* may start before the HS-SCCH burst **435**-*d* and end after the HS-SCCH burst **435**-*d*. However, because the HS-SCCH burst **435**-*d* immediately follows the enabling delay **415**-*e*, the HS-SCCH burst **436**-*d* may overlap the enabling delay **415**-*e*. In some embodiments, this may cause misalignment of reception of the HS-SCCH bursts **435**-*d* and **436**-*d*. Therefore it may be advantageous to ignore the secondary serving cell **410**-*e* HS-SCCH **411**-*e*'s initial assigned subframe, such as burst **436**-*d*, to avoid requiring retransmission across both cells to align the DRX cycles of the respective cells. In some cases, such instructions may be transmitted to/received by the UE **115** via RRC signaling and activated after the enabling delay **415**-*e*.

[0130] Turning next to FIG. **4**G, a timing diagram illustrates a configuration **400**-*f*, where for the primary serving cell **405**-*f*, N=2, and for the secondary serving cell **410**-*f*, N=1. The configuration in FIG. **4**G may be implemented in an MC-HSDPA system. In some cases, a Downlink DRX pattern on at least two cells in an MC-HSDPA system, including a primary cell with a bandwidth scaling factor of N=2 or N=4 and a secondary serving cell with a bandwidth scaling factor N=1, may be represented by:

$$((5*CFN\_DRX_N-\mathrm{UE\_}DTX\_DRX\_\mathrm{Offset}_N+S\_DRX_N)\mathrm{MOD\ UE\_}DRX\_\mathrm{cycle}_N)=0 \text{ where } N=1,2, \text{ or } 4 \quad (17)$$

For N=2:

[0131]

$$CFN\_DRX_{N=1}=\{N*CFN\_DRX_{N=2},N*CFN\_DRX_{N=2}+1\} \quad (18)$$

This relationship between multiple cells with different bandwidth scaling factors can also be represented by:

$$\mathrm{UE\_}DTX\_DRX\_\mathrm{Offset}_{N=2\ or\ 4}=N*UE\_DTX\_DRX\_\mathrm{Offset}_{N=1} \quad (19)$$

$$\mathrm{UE}\ DRX\_\mathrm{cycle}_{N=1}=N*UE\ DRX\ \mathrm{cycle}_{N=2\ or\ 4} \text{ where } N=2 \text{ or } 4 \quad (19a)$$

[0132] In some embodiments, according to equation (18), (19), and (19a), to align a boundary, such as a starting boundary or an ending boundary (not shown), of each required inactive HS-SCCH DRX burst **445**-*d* across the HS-SCCH **406**-*f* with each required inactive HS-SCCH DRX burst **446**-*d* across the HS-SCCH **411**-*f*, the DRX cycle **421**-*d* of the secondary serving cell **410**-*f* may be multiplied by 2. In some cases, the UE DRX cycle **420**-*d* and the DRX cycle **421**-*d* may be equal to 4 subframes. However, because the primary serving cell **405**-*f* is scaled by a bandwidth scaling factor N=2 relative to the secondary serving cell **410**-*f* with a bandwidth scaling factor N=1, each required inactive HS-SCCH DRX burst **445**-*d* may be twice as long as each required inactive HS-SCCH DRX burst **446**-*d*. By multiplying the DRX cycle **421**-*d* of the secondary serving cell **410**-*f* by 2, DRX alignment may be realized. For example, multiplying the DRX cycle **421**-*d* by 2, the periodicity of the secondary serving cell **410**-*f* may be aligned with the periodicity of the primary serving cell **405**-*f* such that each of the required inactive HS-SCCH DRX bursts **445**-*d* across the HS-SCCH **406**-*f* of the primary serving cell **405**-*f* may begin at the same time as/align with the required inactive HS-SCCH DRX bursts **446**-*d* across the HS-SCCH **411**-*f* of the secondary serving cell **410**-*f*. This may be further be represented by:

$$\mathrm{UE}\ DTX\ DRX\ \mathrm{Offset}_{N=1}=2*\mathrm{UE}\ DTX\ DRX\ \mathrm{Offset}_{N=2} \quad (20)$$

$$\mathrm{UE}\ DRX\ \mathrm{cycle}_{N=1}=2*\mathrm{UE}\ DRX\ \mathrm{cycle}_{N=2} \quad (21)$$

[0133] By configuring the second serving cell **410**-*f* in such a way, an "off time" for DRX reception, e.g. a time between continuous monitoring of the secondary serving cell **410**-*f* HS-SCCH **411**-*f* for varied lengths of time **440**-*d* and **441**-*d*, may be aligned with the primary serving cell **405**-*f* HS-SCCH **406**-*f*.

[0134] In some embodiments, values for the UE DTX DRX $\mathrm{OFFSET}_{N=2}$ and the UE DRX $\mathrm{cycle}_{N=2}$, which may correspond to UE DRX cycle **420**-*d*, may be transmitted to the UE **115** via RRC signaling, for instance, activated after an enabling delay period **415**-*f*. These values may represent an offset value and a cycle length. In some cases, these values may be appropriately scaled for other cells having different bandwidth scaling factors, such as secondary serving cell **410**-*f*, which has a bandwidth scaling factor N=1.

[0135] In some embodiments, adjusting a length of the DRX cycle **421**-*d* for the secondary serving cell **410**-*f* may result in either an increase or a decrease in a number of monitored subframes with respect to the primary serving cell **405**-*f*.

[0136] In some embodiments, multiplying the DRX cycle **421**-*d* of the HS-SCCH **411**-*f* on the secondary serving cell **410**-*f* by the bandwidth scaling factor of the secondary serving cell relative to the primary serving cell **405**-*f*, may further align other bursts across HS-SCCH **406**-*f* and HS-SCCH **411**-*f*, such as HS-SCCH DRX burst **425**-*d* and HS-SCCH DRX burst **426**-*d*, HS-SCCH DRX burst **427**-*d* and HS-SCCH DRX burst **428**-*d*. However, in some cases, bursts **450**-*d* and **451**-*d* across the HS-PDSCH **407**-*f* may not align.

[0137] In some cases, if the HS-SCCH **406**-*f* is transmitted via the primary serving cell **405**-*f* to the UE **115**, or if the HS-SCCH **406**-*f* and the HS-SCCH **411**-*f* are both transmitted to the UE **115**, then it may be beneficial to start the inactivity timer **430**-*d*, **431**-*c*, **432**-*c*, and/or **433**-*d* in the HS-SCCH **406**-*f* subframe after an HS-SCCH DRX burst **425**-*d*, **427**-*d* and/or an HS-SCCH burst **435**-*e*, **437**-*c* is received by the UE **115** via the HS-SCCH **406**-*f*. In other cases, if only the HS-SCCH **411**-*f* is transmitted to the UE **115**, then it may be beneficial to start an inactivity timer, such as **430**-*d*, **431**-*c*, **432**-*c*, and/or **433**-*d* in the HS-SCCH **406**-*f* subframe after an HS-SCCH DRX burst **426**-*d*, **428**-*c* and/or an HS-SCCH burst **436**-*e*, **438**-*c* is received by the UE **115** via the HS-SCCH **411**-*f*.

[0138] In alternative embodiments, two separate inactivity timers for the UE DRX cycle **420** and the DRX cycle **421** could be implemented, e.g. one on the HS-SCCH **406**-*f* for the primary serving cell **405**-*f* and one on the HS-SCCH **411**-*f* on the secondary serving cell **410**-*f*.

[0139] Turning next to FIG. **4**H, a timing diagram illustrates a configuration **400**-*h*, where for the primary serving cell **405**-*g*, N=4, and for the secondary serving cell **410**-*g*, N=1. The configuration in FIG. **4**G may be implemented in an MC-HSDPA system. In some cases, a Downlink DRX pattern on at least two cells in an MC-HSDPA system, including a primary cell with a bandwidth scaling factor of N=2 or N=4 and a secondary serving cell with a bandwidth scaling factor N=1, may be represented by:

$$((5*CFN\_DRX_N - UE\_DTX\_DRX\_Offset_N + S\_DRX_N) \text{ MOD } UE\_DRX\_cycle_N) = 0 \text{ where } N = 1, 2, \text{ or } 4 \quad (22)$$

For the primary serving cell **405**-*g*, where N=4, this relationship can further be represented by:

$$CFN\_DRX_{N=1} = \{N*CFN\_DRX_{N=4}, N*CFN\_DRX_{N=4}+1, N*CFN\_DRX_{N=4}+2, N*CFN\_DRX_{N=4}+3\} \quad (23)$$

[0140] This relationship between multiple cells with different bandwidth scaling factors can also be represented generally by equations (19) and (19a).

[0141] In some embodiments, to align a boundary, such as a starting boundary or an ending boundary (not shown), of each required inactive HS-SCCH DRX burst **445**-*e* across the HS-SCCH **406**-*g* with each required inactive HS-SCCH DRX burst **446**-*e* across the HS-SCCH **411**-*g*, the DRX cycle **421**-*e* of the secondary serving cell **410**-*g* may be multiplied by 4. In some cases, the UE DRX cycle **420**-*e* and the DRX cycle **421**-*e* may be equal to 4 subframes. However, because the primary serving cell **405**-*g* is scaled by a bandwidth scaling factor N=4 relative to the secondary serving cell **410**-*g* with a bandwidth scaling factor N=1, each required inactive HS-SCCH DRX burst **445**-*e* may be twice as long as each required inactive HS-SCCH DRX burst **446**-*e*. By multiplying the DRX cycle **421**-*e* by **4**, DRX alignment may be realized. For example, multiplying the DRX cycle **421**-*e* of the secondary serving cell **410**-*g* by **4**, the periodicity of the secondary serving cell **410**-*g* may be aligned with the periodicity of the primary serving cell **405**-*g* such that each of the required inactive HS-SCCH DRX bursts **445**-*e* across the HS-SCCH **406**-*g* of the primary serving cell **405**-*g* may begin or end at the same time as/align with the required inactive HS-SCCH DRX bursts **446**-*e* across the HS-SCCH **411**-*g* of the secondary serving cell **410**-*g*. This may be further be represented by:

$$UE\ DTX\ DRX\ Offset_{N=1} = 4*UE\ DTX\ DRX\ Offset_{N=4} \quad (24)$$

$$UE\ DRX\ cycle_{N=1} = 4*UE\ DRX\ cycle_{N=4} \quad (25)$$

[0142] By configuring the second serving cell **410**-*g* in such a way, an "off time" for DRX reception, e.g. a time between continuous monitoring of the secondary serving cell **410**-*g* HS-SCCH **411**-*g* for varied lengths of time **440**-*e* and **441**-*e*, may be aligned with the primary serving cell **405**-*g* HS-SCCH **406**-*g*.

[0143] In some embodiments, values for the UE DTX DRX $OFFSET_{N=4}$ and the UE DRX $cycle_{N=4}$, which may correspond to UE DRX cycle **420**-*e*, may be transmitted to the UE **115** via RRC signaling, for instance, activated after an enabling delay period **415**-*g*. These values may represent an offset value and a cycle length. In some cases, these values may be appropriately scaled for other cells having different bandwidth scaling factors, such as secondary serving cell **410**-*g*, which has a bandwidth scaling factor N=1.

[0144] In some embodiments, adjusting a length of the DRX cycle **421**-*e* for the secondary serving cell **410**-*g* may result in either an increase or a decrease in a number of monitored subframes with respect to the primary serving cell **405**-*g*.

[0145] In some embodiments, multiplying the DRX cycle **421**-*e* of the HS-SCCH **411**-*g* on the secondary serving cell **410**-*g* by the bandwidth scaling factor of the secondary serving cell relative to the primary serving cell **405**-*g*, may further align other bursts across HS-SCCH **406**-*g* and HS-SCCH **411**-*g*, such as HS-SCCH DRX burst **425**-*e* and HS-SCCH DRX burst **426**-*e*, HS-SCCH DRX burst **427**-*e* and HS-SCCH DRX burst **428**-*e*. However, in some cases, bursts **450**-*e* and **451**-*e* across the HS-PDSCH **412**-*g* may not align.

[0146] In some cases, if the HS-SCCH **406**-*g* is transmitted via the primary serving cell **405**-*g* to the UE **115**, or if the HS-SCCH **406**-*g* and the HS-SCCH **411**-*g* are both transmitted to the UE **115**, then it may be beneficial to start the inactivity timer **430**-*e* and/or **433**-*e* in the HS-SCCH **406**-*g* subframe after an HS-SCCH DRX burst **425**-*e*, **427**-*e* is received by the UE **115** via the HS-SCCH **406**-*g*. In other cases, if only the HS-SCCH **411**-*g* is transmitted to the UE **115**, then it may be beneficial to start an inactivity timer, such as **430**-*e* and/or **433**-*e* in the HS-SCCH **406**-*g* subframe after, for example, an HS-SCCH DRX burst **426**-*e*, **428**-*d* is received by the UE **115** via the HS-SCCH **411**-*g*.

[0147] In alternative embodiments, two separate inactivity timers for the UE DRX cycle **420**-*e* and the DRX cycle **421**-*e* could be implemented, e.g. one on the HS-SCCH **406**-*g* for the primary serving cell **405**-*g* and one on the HS-SCCH **411**-*g* on the secondary serving cell **410**-*g*.

[0148] Turning next to FIG. **4**I, a timing diagram illustrates a configuration **400**-*h*, where for the primary serving cell **405**-*h*, N=2, and for the secondary serving cell **410**-*h*, N=1. For the secondary serving cell **410**-*h*, the DRX cycle **421**-*f* over the HS-SCCH **411**-*h* is the same subframe length as UE DRX cycle **420**-*f*, but because primary serving cell **405**-*h* is dilated with respect to the secondary serving cell **410**-*f* by a bandwidth scaling factor of 2, the DRX cycle **421**-*f*, although the same subframe length as the UE DRX cycle **420**-*f* (4 subframes), is half as long in time relative to the UE DRX cycle **420**-*f* of the primary serving cell **405**-*h*.

[0149] In some embodiments, to align the respective DRX cycles of the primary and secondary serving cells **405**-*h* and **410**-*h*, and more specifically the required inactive HS-SCCH DRX bursts **445**-*f* across the HS-SCCH **406**-*h* with the required inactive HS-SCCH

[0150] DRX bursts **446**-*f* across the HS-SCCH **411**-*h*, it may be useful to align a boundary of these bursts **445**-*f* and **446**-*f*. In some embodiments, this may include aligning a starting boundary or an ending boundary (not shown) of the required inactive HS-SCCH DRX bursts **445**-*f* with the corresponding boundary of the required inactive HS-SCCH DRX bursts **446**-*f*. In some cases, because the HS-SCCH **406**-*h* of the primary serving cell **405**-*h* is scaled by a factor of 2 with respect to the HS-SCCH **411**-*h* of the secondary serving cell **405**-*h*, each HS-SCCH DRX burst **445**-*f* may align with every other HS-SCCH DRX burst **446**-*f*. In other words, this may result in an aligned DRX pattern for the respective cells, but with a longer "off time" for the primary serving cell **405**-*h*. Also, because primary serving cell **405**-*h* is scaled by a factor of 2 with respect to the secondary serving cell **410**-*f*, each HS-SCCH DRX burst **445**-*f* may be twice as long as each HS-SCCH DRX burst **446**-*f*. This configuration may further represented by:

$$\text{UE } DTX\,DRX\text{ Offset}_{N=1}=2^*\text{UE } DTX\,DRX\text{ Offset}_{N=2} \quad (26)$$

$$\text{UE } DRX\text{ cycle}_{N=1}=\text{Non-dilated UE } DRX\text{ cycle}_{N=2} \quad (27)$$

[0151] In broader terms, this relationship may be represented for any two cells with different bandwidth scaling factors by:

$$\text{UE\_}DRX\text{\_cycle}_{N=1}=\text{Non-dilated UE\_}DRX\text{\_cycle}_{N=2\ or\ 4} \quad (28)$$

[0152] In some embodiments, values for the UE DTX DRX $\text{OFFSET}_{N=1}$ and the UE DRX $\text{cycle}_{N=1}$, which may correspond to UE DRX cycle **420**-*f*, may be transmitted to/received by the UE **115** via RRC signaling, for instance, activated after an enabling delay period **415**-*h*. These values may represent an offset value and a cycle length. In some cases, these values may be appropriately scaled for other cells having different bandwidth scaling factors, such as secondary serving cell **410**-*h*, which has a bandwidth scaling factor N=1.

[0153] In some embodiments, adjusting a length of the DRX cycle **421**-*f* for the secondary serving cell **410**-*h* may result in either an increase or a decrease in a number of monitored subframes with respect to the primary serving cell **405**-*h*.

[0154] In some cases, if the HS-SCCH **406**-*h* is transmitted via the primary serving cell **405**-*h* to the UE **115**, or if the HS-SCCH **406**-*h* and the HS-SCCH **411**-*h* are both transmitted to the UE **115**, then it may be beneficial to start the inactivity timer **430**-*f*, **431**-*d*, **432**-*d*, and/or **433**-*f* in the HS-SCCH **406**-*h* subframe after an HS-SCCH DRX burst **425**-*f*, **427**-*f*, and or an HS-SCCH burst **435**-*f*, **437**-*d* is received by the UE **115** via the HS-SCCH **406**-*h*. In other cases, if only the HS-SCCH **411**-*h* is transmitted to the UE **115**, then it may be beneficial to start an inactivity timer, such as **430**-*f*, **431**-*d*, **432**-*d*, and/or **433** in the HS-SCCH **406**-*h* subframe after, for example, an HS-SCCH DRX burst **426**-*f*, **428**-*e* and/or an HS-SCCH burst **436**-*f*, **438**-*d* is received by the UE **115** via the HS-SCCH **411**-*h*.

[0155] In alternative embodiments, two separate inactivity timers for the UE DRX cycle **420**-*f* and the DRX cycle **421**-*f* could be implemented, e.g. one on the HS-SCCH **406**-*h* for the primary serving cell **405**-*h* and one on the HS-SCCH **411**-*h* on the secondary serving cell **410**-*h*.

[0156] Turning next to FIG. **4**J, a timing diagram illustrates a configuration **400**-*i*, where for the primary serving cell **405**-*i*, N=4, and for the secondary serving cell **410**-*i*, N=1. For the secondary serving cell **410**-*i*, the DRX cycle **421**-*g* over the HS-SCCH **411**-*i* is the same subframe length as UE DRX cycle **420**-*g*, but because primary serving cell **405**-*i* is dilated with respect to the secondary serving cell **410**-*g* by a bandwidth scaling factor of 4, the DRX cycle **421**-*g*, although the same subframe length as the UE DRX cycle **420**-*g* (4 subframes), is one fourth as long in time relative to the UE DRX cycle **420**-*g* of the primary serving cell **405**-*i*.

[0157] In some embodiments, to align the respective DRX cycles of the primary and secondary serving cells **405**-*i* and **410**-*i*, and more specifically the required inactive HS-SCCH DRX bursts **445**-*g* across the HS-SCCH **406**-*g* with the required inactive HS-SCCH DRX bursts **446**-*g* across the HS-SCCH **411**-*i*, it may be useful to align a boundary of these bursts **445**-*g* and **446**-*g*. In some embodiments, this may include aligning a starting boundary of the required inactive HS-SCCH DRX bursts **445**-*g* with the starting boundary of the required inactive HS-SCCH DRX bursts **446**-*g*. In some cases, because the HS-SCCH **406**-*i* of the primary serving cell **405**-*i* is scaled by a factor of 4 with respect to the HS-SCCH **411**-*i* of the secondary serving cell **405**-*i*, each HS-SCCH DRX burst **445**-*g* may align with every fifth HS-SCCH DRX burst **446**-*g*. In other words, this may result in an aligned DRX pattern for the respective cells, but with a longer "off time" for the primary serving cell **405**-*i*. Also, because primary serving cell **405**-*i* is scaled by a factor of 4 with respect to the secondary serving cell **410**-*g*, each HS-SCCH DRX burst **445**-*g* may be four times as long as each HS-SCCH DRX burst **446**-*g*. This configuration may further represented by:

$$\text{UE } DTX\,DRX\text{ Offset}_{N=1}=4^*\text{UE } DTX\,DRX\text{ Offset}_{N=4} \quad (29)$$

$$\text{UE } DRX\text{ cycle}_{N=1}=\text{Non-dilated UE } DRX\text{ cycle}_{N=4} \quad (30)$$

[0158] In some embodiments, values for the UE DTX DRX $\text{OFFSET}_{N=1}$ and the UE DRX $\text{cycle}_{N=1}$, which may correspond to UE DRX cycle **420**-*g*, may be transmitted to/received by the UE **115** via RRC signaling, for instance, activated after an enabling delay period **415**-*i*. These values may represent an offset value and a cycle length. In some cases, these values may be appropriately scaled for other cells having different bandwidth scaling factors, such as secondary serving cell **410**-*i*, which has a bandwidth scaling factor N=1.

[0159] In some embodiments, adjusting a length of the DRX cycle **421**-*g* for the secondary serving cell **410**-*i* may result in either an increase or a decrease in a number of monitored subframes with respect to the primary serving cell **405**-*i*.

[0160] In some cases, if the HS-SCCH **406**-*i* is transmitted via the primary serving cell **405**-*i* to the UE **115**, or if the HS-SCCH **406**-*i* and the HS-SCCH **411**-*i* are both transmitted to the UE **115**, then it may be beneficial to start the inactivity timer **430**-*g* and/or **433**-*g* in the HS-SCCH **406**-*i* subframe after an HS-SCCH DRX burst **425**-*g*, **427**-*g* is received by the UE **115** via the HS-SCCH **406**-*i*. In other cases, if only the HS-SCCH **411**-*i* is transmitted to the UE **115**, then it may be beneficial to start an inactivity timer, such as **430**-*g* and/or **433**-*g* in the HS-SCCH **406**-*i* subframe after, for example, an HS-SCCH DRX burst **426**-*g*, **428**-*f* is received by the UE **115** via the HS-SCCH **411**-*i*.

[0161] In alternative embodiments, two separate inactivity timers for the UE DRX cycle **420**-*g* and the DRX cycle **421**-*g* could be implemented, e.g. one on the HS-SCCH **406**-*i* for the primary serving cell **405**-*i* and one on the HS-SCCH **411**-*i* on the secondary serving cell **410**-*i*.

[0162] Turning next to FIG. **5**A, a block diagram illustrates a device **500** that includes DRX 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 aspects of: the base stations **105** of FIG. **1**, FIG. **2**A, FIG. **2**B, and/or FIG. **3**, and/or the user equipment **115** of FIG. **1**, FIG. **2**A, FIG. **2**B, and/or FIG. **3**, and/or the controller **120**/core network **130** of FIG. **1**; and or aspects of systems **400**-*a*, **400**-*b*, **400**-*c*, **400**-*d*, **400**-*e*, **400**-*f*, **400**-*g*, **400**-*h*, **400**-*i*, and/or **400**-*j* of FIGS. **4**A, **4**B, **4**C, **4**D, **4**E, **4**F, **4**G, **4**H, **4**I, and/or **4**J. The device **500** may include a receiver module **505**, a DRX alignment module **510**, and a transmitter module **515**. Each of these components may be in communication with each other. In some cases, device **500** may be a UE, such as UE **115** of FIG. **1**, FIG. **2**A, FIG. **2**B, and/or FIG. **3**.

[0163] 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.

[0164] The receiver module **505** may receive information such as packet, data, and/or signaling information regarding what device **500** has received. The received 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.

[0165] The DRX alignment module **510** may be configured to perform a method of discontinuous reception (DRX) in a multicarrier system that utilizes one or more flexible bandwidth carriers. For example, the DRX alignment module **510** may be configured to identify a DRX cycle for a first cell. The DRX alignment module **510** may further be configured to adjust a boundary for a DRX cycle for a second cell such that the boundary for the DRX cycle for the second cell coincides with a boundary for the DRX cycle for the first cell, wherein at least the first cell or the second cell includes one or more flexible bandwidth carriers. In some embodiments, the boundary for the DRX cycle for the first cell and the boundary for the DRX cycle for the second cell may both comprise at least a starting boundary or an ending boundary. In some cases, a period of the DRX cycle for the second cell may be different from a period of the DRX cycle for the first cell.

[0166] In some cases, the DRX alignment module **510** may be further configured to adjust a length of the DRX cycle for the second cell to either increase or decrease a number of monitored subframes with respect to the first cell. In some cases, the DRX alignment module **510** may also identify a periodicity of the DRX cycle for the first cell and adjust a periodicity of the DRX cycle for the second cell at least to coincide or be scaled by a bandwidth scaling factor with respect to the periodicity of the DRX cycle for the first cell. The DRX alignment module **510** may also ignore an initial assigned subframe for a DRX order for the second cell that overlaps an enabling or activation delay for the first cell to further aid in aligning the DRX cycles of the first and second cells. The DRX alignment module **510** may also facilitate adjusting the boundary for the DRX cycle for the second cell by transmitting to and/or receiving at least one or more offsets or cycle lengths. In some embodiments, the DRX alignment module **510** 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 DRX alignment module **510**, and/or the transmitter module **15** may be located at different network entities and may coordinate via the backhaul, air interfaces, etc.

[0167] In some embodiments, the first cell may include a normal bandwidth carrier and the second cell may include one or more flexible bandwidth carriers. In some embodiments, the first cell may include a flexible bandwidth carrier and the second cell may include one or more flexible bandwidth carriers different from the first cell. In some cases, the flexible bandwidth of the first cell may be greater than the flexible bandwidth of the second cell.

[0168] In some embodiments, the first cell may include one or more flexible bandwidth carriers and the second cell may include a normal bandwidth carrier. In some embodiments, the first cell may include one or more flexible bandwidth carriers and the second cell may include one or more flexible bandwidth carriers different from the first cell. In some cases, the flexible bandwidth of the first cell may be less than the flexible bandwidth of the second cell.

[0169] In some embodiments, the first cell may include a bandwidth scaling factor equal to 1 and the second cell includes a bandwidth scaling factor equal to 2 or 4. In other embodiments, the first cell includes a bandwidth scaling factor equal to 2 or 4 and the second cell includes a bandwidth scaling factor equal to 1.

[0170] Turning next to FIG. **5**B, a block diagram illustrates a device **500**-*a* that includes signaling alignment 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 base stations **105** of FIG. **1**, FIG. **2**A, FIG. **2**B, and/or FIG. **3**, the user equipment **115** of FIG. **1**, FIG. **2**A, FIG. **2**B, and/or FIG. **3**, and/or the controller **120**/core network **130** of FIG. **1**; and or aspects of **400**-*a*, **400**-*b*, **400**-*c*, **400**-*d*, **400**-*e*, **400**-*f*, **400**-*g*, **400**-*h*, **400**-*i*, and/or **400**-*j* of FIGS. **4**A, **4**B, **4**C, **4**D, **4**E, **4**F, **4**G, **4**H, **4**I, and/or **4**J.

[0171] The device **500**-*a* may include a receiver module **505**, a first cell DRX identification module **511**, a second cell DRX adjustment module **512**, and a transmitter module **515**. Each of these components may be in communication with each other. In some embodiments, the DRX alignment module **510**-*a*, which may incorporate some or all aspects of the DRX alignment module **510** of FIG. **5**A, may include the first cell DRX identification module **511** and the second cell DRX adjustment 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.

[0172] 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.

[0173] The receiver module **505** may receive information such as packet, data, and/or signaling information regarding what device **500**-*a* has received. The received 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.

[0174] The first cell DRX identification module **511** may be configured to identify a DRX cycle for a first cell in a multicarrier system that utilizes one or more flexible bandwidth carriers. The second cell DRX adjustment module **512** may be configured to adjust a boundary for a DRX cycle for a second cell such that the boundary for the DRX cycle for the second cell coincides with a boundary for the DRX cycle for the first cell. In some embodiments, the boundary for the DRX cycle for the first cell and the boundary for the DRX cycle for the second cell may both comprise at least a starting boundary or an ending boundary.

[0175] As described above in reference to FIGS. **4**A-**4**I, DRX cycle misalignment across cells can cause an increase/ineffective utilization of power resources, particularly by a UE **115**, because the receiver module **505** is required to listen for a longer period of time per DRX cycle to accurately receive messages over the HS-SCCH channel. This is especially the case where a period of the DRX cycle for the second cell is different from a period of the DRX cycle for the first cell. To account for this periodicity difference, the first cell DRX identification module **511** may also identify a periodicity of the DRX cycle for the first cell. The second cell DRX adjustment module **512** may correspondingly adjust a periodicity of the DRX cycle for the second cell at least to coincide or be scaled by a bandwidth scaling factor with respect to the periodicity of the DRX cycle for the first cell, as is described in greater detail with reference to FIGS. **4**B, **4**E, **4**H, and **4**J above.

[0176] In some cases, the second cell DRX adjustment module **512** may be further configured to adjust a length of the DRX cycle for the second cell to either increase or decrease a number of monitored subframes with respect to the first cell. This may be another way to address different periodicities across multiple carriers for DRX cycle alignment. Furthermore, the second cell DRX adjustment module **512** may ignore an initial assigned subframe for a DRX order for the second cell that overlaps an enabling or activation delay for the first cell to further aid in aligning the DRX cycles of the first and second cells, as described in greater detail above with respect to FIGS. **4**C and **4**F.

[0177] In some embodiments, the transmitter module **515** may transmit at least one or more offsets or cycle lengths, or alternatively the receiver module **505** may receive one or more offsets or cycle lengths, depending on whether these modules are located at a base station **105** or a UE **115**, respectively. The offsets or cycles lengths may be determined by the second cell DRX adjustment module **512**, and communicated to the transmitter module **515**.

[0178] In some embodiments, the first cell DRX identification module **511** and/or the second cell DRX adjustment 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 first cell DRX identification module **511**, the second cell DRX adjustment module **512**, and/or the transmitter module **15** may be located at different network entities and may coordinate via the backhaul, air interfaces, etc.

[0179] In some embodiments, the first cell includes a normal bandwidth carrier and the second cell may include one or more flexible or scalable bandwidth carriers. In some embodiments, the first cell may include a flexible bandwidth carrier and the second cell may include one or more flexible bandwidth carriers different from the first cell. In some cases, the flexible bandwidth of the first cell is greater than the flexible bandwidth of the second cell.

[0180] In some embodiments, the first cell includes one or more flexible bandwidth carriers and the second cell includes a normal bandwidth carrier. In some embodiments, the first cell includes one or more flexible bandwidth carriers and the second cell includes one or more flexible bandwidth carriers different from the first cell. In some cases, the flexible bandwidth of the first cell is less than the flexible bandwidth of the second cell.

[0181] In some embodiments, the first cell includes a bandwidth scaling factor equal to 1 and the second cell includes a bandwidth scaling factor equal to 2 or 4. In other embodiments, the first cell includes a bandwidth scaling factor equal to 2 or 4 and the second cell includes a bandwidth scaling factor equal to 1.

[0182] FIG. **6** shows a block diagram of a communications system **600** that may be configured for DRX 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*, **400**-*c*, **400**-*d*, **400**-*e*, **400**-*f*, **400**-*g*, **400**-*h*, **400**-*i*, and/or **400**-*j* of FIGS. **4**A, **4**B, **4**C, **4**D, **4**E, **4**F, **4**G, **4**H, **4**I, and/or **4**J; 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.

[0183] 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*.

[0184] 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.

[0185] 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.

[0186] 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*.

[0187] 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**.

[0188] 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*, **400**-*c*, **400**-*d*, **400**-*e*, **400**-*f*, **400**-*g*, **400**-*h*, **400**-*i*, and/or **400**-*j* of FIGS. **4**A, **4**B, **4**C, **4**D, **4**E, **4**F, **4**G, **4**H, **4**I, and/or **4**J and may not be repeated here for the sake of brevity. The cell DRX identification module **511**-*a* may be an example of the first cell DRX identification module **511** of FIG. **5**B. The cell DRX adjustment module **512**-*a* may be an example of the second cell DRX adjustment module **512** of FIG. **5**B. Furthermore, DRX alignment module **510**-*b*, which may include the cell DRX identification module **511**-*a* and the cell DRX adjustment module **512**-*a*, may be an example of the DRX alignment module **510** of FIG. **5**A and/or the DRX alignment module **510**-*a* of FIG. **5**B.

[0189] 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.

[0190] 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.

[0191] 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*, **400**-*c*, **400**-*d*, **400**-*e*, **400**-*f*, **400**-*g*, **400**-*h*, **400**-*i*, and/or **400**-*j* of FIGS. **4**A, **4**B, **4**C, **4**D, **4**E, **4**F, **4**G, **4**H, **4**I, and/or **4**J, 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.

[0192] 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.

[0193] 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.

[0194] 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.

[0195] 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**.

[0196] 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*, **400**-*c*, **400**-*d*, **400**-*e*, **400**-*f*, **400**-*g*, **400**-*h*, **400**-*i*, and/or **400**-*j* of FIGS. **4**A, **4**B, **4**C, **4**D, **4**E, **4**F, **4**G, **4**H, **4**I, and/or **4**J, and may not be repeated here for the sake of brevity. The cell DRX identification module **511**-*b* may be an example of the first cell DRX identification module **511** of FIG. **5**B. The cell DRX adjustment module **512**-*b* may be an example of the second cell DRX adjustment module **512** of FIG. **5**B. Furthermore, DRX alignment module **510**-*c*, which may include the cell DRX identification module **511**-*b* and the cell DRX adjustment module **512**-*b*, may be an example of the DRX alignment module **510** of FIG. **5**A and/or the DRX alignment module **510**-*a* of FIG. **5**B.

[0197] 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 **77** may be utilized to scale and/or alter chip rates and/or time to generate/decode flexible bandwidth waveforms.

[0198] 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.

[0199] 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 call flows and/or systems as shown in FIGS. **4**A, **4**B, **4**C, **4**D, **4**E, **4**F, **4**G, **4**H, **4**I, and/or **4**J and/or the associated descriptions.

[0200] 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.

[0201] For example, within system **800**, the processor **840** may further include a DRX alignment module **510**-*d* configured to identify a DRX cycle for a first cell. The DRX alignment module **510**-*d* may further be configured to adjust a boundary for a DRX cycle for a second cell such that the boundary for the DRX cycle for the second cell coincides with a boundary for the DRX cycle for the first cell, wherein at least the first cell or the second cell includes one or more flexible bandwidth carriers. The DRX alignment module **510**-*d* may be an example of or may incorporate aspects of the DRX alignment module **510**, **510**-*a*, **510**-*b*, and **510**-*c* of FIGS. **5**A, **5**B, **6**, and/or **7**.

[0202] 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**.

[0203] 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**.

[0204] 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.

[0205] For example, within system **800**, the processor **880** may further include a DRX alignment module **510**-*e* configured to identify a DRX cycle for a first cell. The DRX alignment module **510**-*e* may further be configured to adjust a boundary for a DRX cycle for a second cell such that the boundary for the DRX cycle for the second cell coincides with a boundary for the DRX cycle for the first cell, wherein at least the first cell or the second cell includes one or more flexible bandwidth carriers. The DRX alignment module **510**-*d* may be an example of or may incorporate aspects of DRX alignment module **510**, **510**-*a*, **510**-*b*, and **510**-*c* of FIGS. **5**A, **5**B, **6**, and/or **7**. Furthermore, the DRX alignment module **510**-*e* may coordinate and/or share functionality with the DRX alignment module **510**-*d*.

[0206] Turning to FIG. **9**A, a flow diagram of a method **900** for DRX 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*, **400**-*c*, **400**-*d*, **400**-*e*, **400**-*f*, **400**-*g*, **400**-*h*, **400**-*i*, and/or **400**-*j* of FIGS. **4**A, **4**B, **4**C, **4**D, **4**E, **4**F, **4**G, **4**H, **4**I, and/or **4**J, 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.

[0207] At block **905**, a DRX cycle for a first cell may be identified. At block **910**, a boundary for a DRX cycle for a second cell may be adjusted such that the boundary for the DRX cycle for the second cell coincides with a boundary for the DRX cycle for the first cell, wherein at least the first cell or the second cell comprises at least one of the one or more flexible bandwidth carriers.

[0208] In some embodiments, the boundary for the DRX cycle for the first cell and the boundary for the DRX cycle for the second cell may both comprise at least a starting boundary or an ending boundary. In some cases, a period of the DRX cycle for the second cell may be different from a period of the DRX cycle for the first cell.

[0209] In some cases, the method may further include adjusting a length of the DRX cycle for the second cell to either increase or decrease a number of monitored subframes with respect to the first cell. In some cases, the method may include identifying a periodicity of the DRX cycle for the first cell and adjust a periodicity of the DRX cycle for the second cell at least to coincide or be scaled by a bandwidth scaling factor with respect to the periodicity of the DRX cycle for the first cell. An initial assigned subframe for a DRX order for the second cell that overlaps an enabling or activation delay for the first cell may be ignored to further aid in aligning the DRX cycles of the first and second cells.

[0210] In some embodiments, the method may include adjusting the boundary for the DRX cycle for the second cell by transmitting to and/or receiving at least one or more offsets or cycle lengths.

[0211] In some embodiments, the first cell may include a normal bandwidth carrier and the second cell may include one or more flexible bandwidth carriers. In other embodiments, the first cell may include a flexible bandwidth carrier and the second cell may include one or more flexible bandwidth carriers different from the first cell. In some cases, the flexible bandwidth of the first cell is greater than the flexible bandwidth of the second cell.

[0212] The methods for DRX can also be beneficially implemented when the first cell may include one or more flexible bandwidth carriers and the second cell may include a normal bandwidth carrier. In some cases, the first cell may include one or more flexible bandwidth carriers and the second cell may include one or more flexible bandwidth carriers different from the first cell. The flexible bandwidth of the first cell may be less than the flexible bandwidth of the second cell.

[0213] In yet other cases, the methods described can be implemented where the first cell includes a bandwidth scaling factor equal to 1 and the second cell includes a bandwidth scaling factor equal to 2 or 4. In some cases, the first cell may include a bandwidth scaling factor equal to 2 or 4 and the second cell may include a bandwidth scaling factor equal to 1.

[0214] Turning to FIG. **9**B, a flow diagram of a method **900**-*a* for DRX 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*, **400**-*c*, **400**-*d*, **400**-*e*, **400**-*f*, **400**-*g*, **400**-*h*, **400**-*i*, and/or **400**-*j* of FIGS. **4**A, **4**B, **4**C, **4**D, **4**E, **4**F, **4**G, **4**H, **4**I, and/or **4**J, 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.

[0215] At block **905**-*a*, a DRX cycle for a first cell may be identified. At block **911**, a length of the DRX cycle for the second cell may be adjusted to either increase or decrease a number of monitored subframes with respect to the first cell. At least one of the first or second carriers may include one or more flexible bandwidth carriers. At block **912**, an initial assigned subframe for a DRX order for the second cell that overlaps an enabling or activation delay for the first cell may be ignored.

[0216] In some embodiments, the first cell may include a normal bandwidth carrier and the second cell may include one or more flexible bandwidth carriers. In other embodiments, the first cell may include a flexible bandwidth carrier and the second cell may include one or more flexible bandwidth carriers different from the first cell. In some cases, the flexible bandwidth of the first cell is greater than the flexible bandwidth of the second cell.

[0217] The methods for DRX can also be beneficially implemented when the first cell may include one or more flexible bandwidth carriers and the second cell may include a normal bandwidth carrier. In some cases, the first cell may include one or more flexible bandwidth carriers and the second cell may include one or more flexible bandwidth carriers different from the first cell. The flexible bandwidth of the first cell may be less than the flexible bandwidth of the second cell.

[0218] In yet other cases, the methods described can be implemented where the first cell includes a bandwidth scaling factor equal to 1 and the second cell includes a bandwidth scaling factor equal to 2 or 4. In some cases, the first cell may include a bandwidth scaling factor equal to 2 or 4 and the second cell may include a bandwidth scaling factor equal to 1.

[0219] Turning to FIG. **9**C, a flow diagram of a method **900**-*b* for DRX in a multicarrier system that utilizes one or more flexible bandwidth carriers is provided in accordance with various embodiments. Method **900**-*b* 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*, **400**-*c*, **400**-*d*, **400**-*e*, **400**-*f*, **400**-*g*, **400**-*h*, **400**-*i*, and/or **400**-*j* of FIGS. **4**A, **4**B, **4**C, **4**D, **4**E, **4**F, **4**G, **4**H, **4**I, and/or **4**J, 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**-*b* may be an example of method **900** of FIG. **9**A.

[0220] At block **905**-*a*, a DRX cycle for a first cell may be identified. At block **907**, a periodicity of the DRX cycle for the first cell may be identified. At least one of the first or second carriers may include one or more flexible bandwidth carriers. At block **913**, a periodicity of the DRX cycle for the second cell may be adjusted to at least to coincide or be scaled by a bandwidth scaling factor with respect to the periodicity of the DRX cycle for the first cell

[0221] In some embodiments, the first cell may include a normal bandwidth carrier and the second cell may include one or more flexible bandwidth carriers. In other embodiments, the first cell may include a flexible bandwidth carrier and the second cell may include one or more flexible bandwidth carriers different from the first cell. In some cases, the flexible bandwidth of the first cell is greater than the flexible bandwidth of the second cell.

[0222] The methods for DRX can also be beneficially implemented when the first cell may include one or more flexible bandwidth carriers and the second cell may include a normal bandwidth carrier. In some cases, the first cell may include one or more flexible bandwidth carriers and the second cell may include one or more flexible bandwidth carriers different from the first cell. The flexible bandwidth of the first cell may be less than the flexible bandwidth of the second cell.

[0223] In yet other cases, the methods described can be implemented where the first cell includes a bandwidth scaling factor equal to 1 and the second cell includes a bandwidth scaling factor equal to 2 or 4. In some cases, the first cell may include a bandwidth scaling factor equal to 2 or 4 and the second cell may include a bandwidth scaling factor equal to 1.

[0224] 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.

[0225] 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.

[0226] 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.

[0227] 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).

[0228] 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.

[0229] 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 discontinuous reception (DRX) in a multi-carrier system that utilizes one or more flexible bandwidth carriers, the method comprising:

identifying a DRX cycle for a first cell; and

adjusting a boundary for a DRX cycle for a second cell such that the boundary for the DRX cycle for the second cell coincides with a boundary for the DRX cycle for the first cell, wherein at least the first cell or the second cell comprises at least one of the one or more flexible bandwidth carriers.

2. The method of claim **1**, wherein the boundary for the DRX cycle for the first cell and the boundary for the DRX cycle for the second cell both comprise at least a starting boundary or an ending boundary.

3. The method of claim **1**, wherein a period of the DRX cycle for the second cell is different from a period of the DRX cycle for the first cell.

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

adjusting a length of the DRX cycle for the second cell to either increase or decrease a number of monitored subframes with respect to the first cell.

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

identifying a periodicity of the DRX cycle for the first cell; and adjusting a periodicity of the DRX cycle for the second cell at least to coincide or be scaled by a bandwidth scaling factor with respect to the periodicity of the DRX cycle for the first cell.

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

transmitting to or receiving at a user equipment (UE) at least one or more offsets or cycle lengths to facilitate adjusting the boundary for the DRX cycle for the second cell.

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

ignoring an initial assigned subframe for a DRX order for the second cell that overlaps an enabling or activation delay for the first cell.

8. The method of claim **1**, wherein the first cell comprises a normal bandwidth carrier and the second cell comprises one of the one or more flexible bandwidth carriers.

9. The method of claim **1**, wherein the first cell comprises a flexible bandwidth carrier and the second cell comprises one of the one or more flexible bandwidth carriers different from the first cell.

10. The method of claim **1**, wherein the first cell comprises one of the one or more flexible bandwidth carriers and the second cell comprises a normal bandwidth carrier.

11. The method of claim **1**, wherein the first cell comprises one of the one or more flexible bandwidth carriers and the second cell comprises one of the one or more flexible bandwidth carriers different from the first cell.

12. The method of claim **8**, wherein the first cell comprises a bandwidth scaling factor equal to 1 and the second cell comprises a bandwidth scaling factor equal to 2 or 4.

13. A system for discontinuous reception (DRX) in a multicarrier system that utilizes one or more flexible bandwidth carriers, the system comprising:

means for identifying a DRX cycle for a first cell; and

means for adjusting a boundary for a DRX cycle for a second cell such that the boundary for the DRX cycle for the second cell coincides with a boundary for the DRX cycle for the first cell, wherein at least the first cell or the second cell comprises at least one of the one or more flexible bandwidth carriers.

14. The system of claim **13**, wherein the boundary for the DRX cycle for the first cell and the boundary for the DRX cycle for the second cell both comprise at least a starting boundary or an ending boundary.

15. The system of claim **13**, wherein a period of the DRX cycle for the second cell is different from a period of the DRX cycle for the first cell.

16. The system of claim **13**, further comprising:

means for adjusting a length of the DRX cycle for the second cell to either increase or decrease a number of monitored subframes with respect to the first cell.

17. The system of claim **13**, further comprising:

means for identifying a periodicity of the DRX cycle for the first cell; and

means for adjusting a periodicity of the DRX cycle for the second cell at least to coincide or be scaled by a bandwidth scaling factor with respect to the periodicity of the DRX cycle for the first cell.

18. The system of claim **13**, further comprising:

means for transmitting to or receiving at a user equipment (UE) at least one or more offsets or cycle lengths to facilitate adjusting the boundary for the DRX cycle for the second cell.

19. The system of claim **13**, further comprising:

means for ignoring an initial assigned subframe for a DRX order for the second cell that overlaps an enabling or activation delay for the first cell.

20. The system of claim **13**, wherein the first cell comprises a normal bandwidth carrier and the second cell comprises one of the one or more flexible bandwidth carriers.

21. The system of claim **13**, wherein the first cell comprises a flexible bandwidth carrier and the second cell comprises one of the one or more flexible bandwidth carriers different from the first cell.

22. The system of claim **13**, wherein the first cell comprises one of the one or more flexible bandwidth carriers and the second cell comprises a normal bandwidth carrier.

23. The system of claim **13**, wherein the first cell comprises one of the one or more flexible bandwidth carriers and the second cell comprises one of the one or more flexible bandwidth carriers different from the first cell.

24. The system of claim **20**, wherein the first cell comprises a bandwidth scaling factor equal to 1 and the second cell comprises a bandwidth scaling factor equal to 2 or 4.

25. A computer program product for discontinuous reception (DRX) in a multicarrier system that utilizes one or more flexible bandwidth carriers, the computer program product comprising:

a non-transitory computer-readable medium comprising:

code for identifying a DRX cycle for a first cell; and

code for adjusting a boundary for a DRX cycle for a second cell such that the boundary for the DRX cycle for the second cell coincides with a boundary for the DRX cycle for the first cell, wherein at least the first cell or the second cell comprises at least one of the one or more flexible bandwidth carriers.

26. The computer program product of claim **25**, wherein the boundary for the DRX cycle for the first cell and the boundary for the DRX cycle for the second cell both comprise at least a starting boundary or an ending boundary.

27. The computer program product of claim **25**, wherein a period of the DRX cycle for the second cell is different from a period of the DRX cycle for the first cell.

28. The computer program product of claim **25**, further comprising:

code for adjusting a length of the DRX cycle for the second cell to either increase or decrease a number of monitored subframes with respect to the first cell.

29. The computer program product of claim **25**, further comprising:

code for identifying a periodicity of the DRX cycle for the first cell; and

code for adjusting a periodicity of the DRX cycle for the second cell at least to coincide or be scaled by a bandwidth scaling factor with respect to the periodicity of the DRX cycle for the first cell.

30. The computer program product of claim **25**, further comprising:

code for transmitting to or receiving at a user equipment (UE) at least one or more offsets or cycle lengths to facilitate adjusting the boundary for the DRX cycle for the second cell.

31. The computer program product of claim **25**, further comprising:

code for ignoring an initial assigned subframe for a DRX order for the second cell that overlaps an enabling or activation delay for the first cell.

32. The computer program product of claim **25**, wherein the first cell comprises a normal bandwidth carrier and the second cell comprises one of the one or more flexible bandwidth carriers.

33. The computer program product of claim **25**, wherein the first cell comprises a flexible bandwidth carrier and the second cell comprises one of the one or more flexible bandwidth carriers different from the first cell.

34. The computer program product of claim **25**, wherein the first cell comprises one of the one or more flexible bandwidth carriers and the second cell comprises a normal bandwidth carrier.

35. The computer program product of claim **25**, wherein the first cell comprises one of the one or more flexible bandwidth carriers and the second cell comprises one of the one or more flexible bandwidth carriers different from the first cell.

36. The computer program product of claim **32**, wherein the first cell comprises a bandwidth scaling factor equal to 1 and the second cell comprises a bandwidth scaling factor equal to 2 or 4.

37. A wireless communications device configured for discontinuous reception (DRX) in a multicarrier system that utilizes one or more flexible bandwidth carriers, the device comprising:

at least one processor configured to:

identify a DRX cycle for a first cell; and

adjust a boundary for a DRX cycle for a second cell such that the boundary for the DRX cycle for the second cell coincides with a boundary for the DRX cycle for the first cell, wherein at least the first cell or the second cell comprises at least one of the one or more flexible bandwidth carriers.

38. The wireless communications device of claim **37**, wherein the boundary for the DRX cycle for the first cell and the boundary for the DRX cycle for the second cell both comprise at least a starting boundary or an ending boundary.

39. The wireless communications device of claim **37**, wherein a period of the DRX cycle for the second cell is different from a period of the DRX cycle for the first cell.

40. The wireless communications device of claim **37**, wherein the at least one processor is further configured to:

adjust a length of the DRX cycle for the second cell to either increase or decrease a number of monitored subframes with respect to the first cell.

41. The wireless communications device of claim **37**, wherein the at least one processor is further configured to:

identify a periodicity of the DRX cycle for the first cell; and

adjust a periodicity of the DRX cycle for the second cell at least to coincide or be scaled by a bandwidth scaling factor with respect to the periodicity of the DRX cycle for the first cell.

42. The wireless communications device of claim **37**, wherein the at least one processor is further configured to:

transmit to or receive at a user equipment (UE) at least one or more offsets or cycle lengths to facilitate adjusting the boundary for the DRX cycle for the second cell.

43. The wireless communications device of claim **37**, wherein the at least one processor is further configured to:

ignore an initial assigned subframe for a DRX order for the second cell that overlaps an enabling or activation delay for the first cell.

44. The wireless communications device of claim **37**, wherein the first cell comprises a normal bandwidth carrier and the second cell comprises one of the one or more flexible bandwidth carriers.

45. The wireless communications device of claim **37**, wherein the first cell comprises a flexible bandwidth carrier and the second cell comprises one of the one or more flexible bandwidth carriers different from the first cell.

46. The wireless communications device of claim **37**, wherein the first cell comprises one of the one or more flexible bandwidth carriers and the second cell comprises a normal bandwidth carrier.

47. The wireless communications device of claim **37**, wherein the first cell comprises one of the one or more flexible bandwidth carriers and the second cell comprises one of the one or more flexible bandwidth carriers different from the first cell.

48. The wireless communications device of claim **44**, wherein the first cell comprises a bandwidth scaling factor equal to 1 and the second cell comprises a bandwidth scaling factor equal to 2 or 4.

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