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DIRECCIÓN DE NUEVAS CREACIONES
Procedimiento acelerado de exámenes de patente (PPH)

1	NÚMERO DE SOLICITUD ANTE LA SIC NC2019/0003327		
2	GLOBAL - PPH ☐ PAÍS	3	PCT – PPH ☐ PAÍS
4	PROSUR ☐ PAÍS	5	Alianza del Pacífico (AdP) ☐ PAÍS
6	OFICINA DE PRIMERA PRESENTACIÓN (OPP) ☐	7	OFICINA DE EXAMEN ANTERIOR (OEA) ☒
8	NÚMERO DE SOLICITUD O PUBLICACIÓN DE LA SOLICITUD (OPP) ☐ NÚMERO DE SOLICITUD EN OFICINA DE EXAMEN ANTERIOR (OEA): ☒ NÚMERO DE SOLICITUD PCT: ☐		1. 16801872.9
9	☐ REPRESENTANTE LEGAL ☒ APODERADO		
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PAÍS	Colombia		No. RADICACIÓN O PROTOCOLO DE PODER GENERAL
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Publicación Internacional No. WO/2017/217903		Fecha	2017/12/21
* El solicitante presenta una copia de la(s) reivindicación(es) patentable(s) u otorgable(s) de la solicitud de la Oficina de Primera Presentación que profirió el examen de patentabilidad, junto con una traducción al castellano. ☒ SI ☐ NO			
* El solicitante presenta los resultados de búsqueda de la Oficina de Examen Anterior, junto con una traducción al castellano. ☒ SI ☐ NO			
REQUISITOS PARA EL RECONOCIMIENTO DE LOS RESULTADOS DE EXÁMENES DE PATENTABILIDAD EFECTUADOS A SOLICITUDES EXTRANJERAS			
Para que la Superintendencia de Industria y Comercio pueda reconocer los resultados de exámenes de patentabilidad producidos por otras Oficinas de Propiedad Industrial se debe cumplir con las siguientes condiciones:			
(a) Al momento de solicitar el examen de patentabilidad, si el solicitante pide que se reconozcan exámenes de patentabilidad de otras oficinas extranjeras, deberá aportar junto con el pago de la tasa correspondiente, los siguientes anexos:			
(i) Copia de las resoluciones, fallos o decisiones que han sido relevantes para la determinación de la patentabilidad de la(s) solicitud(es) en la Oficina que haya proferido el examen de patentabilidad que contienen reivindicaciones patentables u otorgables que son la base de la petición, y si es del caso, su traducción al castellano. ☒ SI ☐ NO			
(ii) Copia de todas las reivindicaciones determinadas como patentables u otorgables en la Oficina que profirió el examen de patentabilidad y, si es del caso, su traducción al castellano. ☒ SI ☐ NO			
(iii) Copia de los antecedentes, información o documentos citados por el examinador de la Oficina de Primera Presentación del examen de patentabilidad, en las resoluciones, fallos o decisiones correspondientes, incluyendo la literatura no patente. Los documentos de patente deberán presentarse siempre y cuando no estén disponibles para la Superintendencia de Industria y Comercio mediante el simple acceso a bases de datos gratuitas. ☒ SI ☐ NO			
(iv) Una tabla de correspondencias de las reivindicaciones que han sido determinadas como patentables u otorgables en la solicitud de la Oficina que haya proferido el examen de patentabilidad. ☒ SI ☐ NO			
11	FIRMA DEL SOLICITANTE, DEL APODERADO O DEL REPRESENTANTE LEGAL Junto a cada firma, indicar el nombre del firmante y su calidad (si tal calidad no es obvia al leer el petitorio)		
 CAROLINA DAZA MONTALVO			

10 (iv)	TABLA DE CORRESPONDENCIA DE REIVINDICACIONES		
Reivindicaciones en la solicitud en Colombia (NOTA. LAS REIVINDICACIONES ACÁ INDICADAS CORRESPONDEN A AQUELLAS MODIFICADAS EN MODIFICACIÓN VOLUNTARIA PRESENTADA EL 26 DE ABRIL DEL 2019)		Reivindicaciones otorgables en la Solicitud Europea No. 16801872.9	Explicación sobre la suficiente correspondencia ó Comentarios que explican la correspondencia
1. Un método para habilitar múltiples numerologías en una red, en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la interfaz de radio de multiplexación por división de frecuencia ortogonal (OFDM), como el espaciado de subportadoras, la longitud de los símbolos OFDM, la longitud del prefijo cíclico, la cantidad de símbolos por subtrama o ranura, la longitud de la subtrama y la longitud de la trama, el método es realizado por un equipo de usuario, y comprende: recibir (S110) información del sistema en un canal de difusión con una primera numerología; determinar (S120) un primer espacio de búsqueda a partir de la información del sistema recibida, donde el primer espacio de búsqueda es un espacio de búsqueda común; y		1. Un método para habilitar múltiples numerologías en una red, en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la interfaz de radio de multiplexación por división de frecuencia ortogonal (OFDM), como el espaciado de subportadoras, la longitud de los símbolos OFDM, la longitud del prefijo cíclico, la cantidad de símbolos por subtrama o ranura, la longitud de la subtrama y la longitud de la trama, el método es realizado por un equipo de usuario, UE, y comprende: recibir (S110) información del sistema en un canal de difusión con una primera numerología; determinar (S120) un primer espacio de búsqueda a partir de la información del sistema recibida, donde el primer espacio de búsqueda es un espacio de búsqueda común; y	Igual

recibir (S130) información adicional programada en el primer espacio de búsqueda con una segunda numerología diferente de la primera numerología, en donde la segunda numerología se indica en la información del sistema recibida y la información adicional del sistema comprende referencias a uno o más espacios de búsqueda.	recibir (S130) información adicional programada en el primer espacio de búsqueda con una segunda numerología diferente de la primera numerología, en donde la segunda numerología se indica en la información del sistema recibida y la información adicional del sistema comprende referencias a uno o más espacios de búsqueda.	
2. El método de acuerdo con la reivindicación 1, en el que la etapa de recibir (S110) comprende además detectar información del sistema.	2. El método de acuerdo con la reivindicación 1, en el que la etapa de recibir (S110) comprende además detectar información del sistema.	<i>Igual</i>
3. El método de acuerdo con una cualquiera de las reivindicaciones 1 a 2, que comprende: recibir información de sincronización (S100) para un canal de difusión antes de recibir (S110) en el canal de difusión.	3. El método de acuerdo con una cualquiera de las reivindicaciones 1 a 2, que comprende: recibir información de sincronización (S100) para un canal de difusión antes de recibir (S110) en el canal de difusión.	<i>Igual</i>
4. El método de acuerdo con cualquiera de las reivindicaciones precedentes, en el que la información adicional programada del sistema en el primer espacio de búsqueda es una o más de las siguientes: programación de información de paginación, respuestas de acceso aleatorio, programación de espacios de búsqueda adicionales.	4. El método de acuerdo con cualquiera de las reivindicaciones precedentes, en el que la información adicional programada del sistema en el primer espacio de búsqueda es una o más de las siguientes: programación de información de paginación, respuestas de acceso aleatorio, programación de espacios de búsqueda adicionales.	<i>Igual</i>

5. El método de acuerdo con una cualquiera de las reivindicaciones 1 a 4, en el que la etapa de determinación comprende además determinar un segundo espacio de búsqueda con una tercera numerología.	5. El método de acuerdo con una cualquiera de las reivindicaciones 1 a 4, en el que la etapa de determinación comprende además determinar un segundo espacio de búsqueda con una tercera numerología.	<i>Igual</i>
6. Un método para habilitar múltiples numerologías en una red, en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la interfaz de radio de multiplexación por división de frecuencia ortogonal (OFDM), como el espaciado de subportadoras, la longitud de los símbolos OFDM, la longitud del prefijo cíclico, la cantidad de símbolos por subtrama o ranura, la longitud de la subtrama y la longitud de la trama, el método es realizado por una estación base, y comprende: enviar (S210) información del sistema en un canal de difusión con una primera numerología; y enviar (S220) información adicional en un primer espacio de búsqueda con una segunda numerología diferente de la primera numerología, en donde la segunda numerología se indica en la información del	6. Un método para habilitar múltiples numerologías en una red, en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la interfaz de radio de multiplexación por división de frecuencia ortogonal (OFDM), como el espaciado de subportadoras, la longitud de los símbolos OFDM, la longitud del prefijo cíclico, la cantidad de símbolos por subtrama o ranura, la longitud de la subtrama y la longitud de la trama, el método es realizado por una estación base, BS, y comprende: enviar (S210) información del sistema en un canal de difusión con una primera numerología; y enviar (S220) información adicional en un primer espacio de búsqueda con una segunda numerología diferente de la primera numerología, en donde la segunda numerología se indica en la información del	<i>Igual</i>

sistema recibida y la información adicional del sistema comprende referencias a uno o más espacios de búsqueda.	sistema recibida y la información adicional del sistema comprende referencias a uno o más espacios de búsqueda.	
7. El método de acuerdo con la reivindicación 6, en el que el primer espacio de búsqueda se indica en la información del sistema enviada.	7. El método de acuerdo con la reivindicación 6, en el que el primer espacio de búsqueda se indica en la información del sistema enviada.	<i>Iguales</i>
8. Un equipo de usuario (UE) para habilitar múltiples numerologías en una red, en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la interfaz de radio de multiplexación por división de frecuencia ortogonal (OFDM), como el espaciado de subportadoras, la longitud de los símbolos OFDM, la longitud del prefijo cíclico, la cantidad de símbolos por subtrama o ranura, la longitud de la subtrama y la longitud de la trama, el equipo de usuario UE (1) comprende: un procesador (10) que almacena instrucciones que, cuando son ejecutadas por el procesador, hacen que el UE: reciba (S110) información del sistema en un canal de difusión con una primera numerología;	8. Un equipo de usuario (UE) para habilitar múltiples numerologías en una red, en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la interfaz de radio de multiplexación por división de frecuencia ortogonal (OFDM), como el espaciado de subportadoras, la longitud de los símbolos OFDM, la longitud del prefijo cíclico, la cantidad de símbolos por subtrama o ranura, la longitud de la subtrama y la longitud de la trama, el equipo de usuario UE (1) comprende: un procesador (10); y un programa de computadora (12, 13) que almacena instrucciones que, cuando son ejecutadas por el procesador, hacen que el UE: reciba (S110) información del sistema en un canal de difusión con una primera numerología;	<i>Similares</i> <i>En la modificación voluntaria presentada el 26 de abril de 2019, se eliminó la expresión “y un programa de computadora (12, 13)”, la cual hacía referencia a materia no patentable y así dar claridad a la invención.</i>

determine (S120) un primer espacio de búsqueda a partir de la información del sistema recibida, donde un primer espacio de búsqueda es un espacio de búsqueda común; y reciba (S130) información adicional del sistema en el primer espacio de búsqueda con una segunda numerología diferente de la primera numerología, en donde la segunda numerología se indica en la información del sistema recibida y la información adicional del sistema comprende referencias a uno o más espacios de búsqueda.	determine (S120) un primer espacio de búsqueda a partir de la información del sistema recibida, donde un primer espacio de búsqueda es un espacio de búsqueda común; y reciba (S130) información adicional del sistema en el primer espacio de búsqueda con una segunda numerología diferente de la primera numerología, en donde la segunda numerología se indica en la información del sistema recibida y la información adicional del sistema comprende referencias a uno o más espacios de búsqueda.	
9. Una estación base (BS) para habilitar múltiples numerologías en una red, en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la interfaz de radio de multiplexación por división de frecuencia ortogonal (OFDM), como el espaciado de subportadoras, la longitud de los símbolos OFDM, la longitud del prefijo cíclico, la cantidad de símbolos por subtrama o ranura, la longitud de la subtrama y la longitud de la trama, la BS (2) que comprende:	9. Una estación base (BS) para habilitar múltiples numerologías en una red, en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la interfaz de radio de multiplexación por división de frecuencia ortogonal (OFDM), como el espaciado de subportadoras, la longitud de los símbolos OFDM, la longitud del prefijo cíclico, la cantidad de símbolos por subtrama o ranura, la longitud de la subtrama y la longitud de la trama, la BS (2) que comprende:	<i>Similares</i> <i>En la modificación voluntaria presentada el 26 de abril de 2019, se eliminó la expresión “y un programa de computadora (22, 23)”, la cual hacía referencia a materia no patentable y así dar claridad a la invención.</i>

un procesador (20) que almacena instrucciones que, cuando son ejecutadas por el procesador, hacen que la BS: envíe (S210) información del sistema en un canal de difusión con una primera numerología; y envíe (S220) información adicional en un primer espacio de búsqueda con una segunda numerología diferente de la primera numerología, en donde el primer espacio de búsqueda es un espacio de búsqueda común, en donde la segunda numerología se indica en la información del sistema enviada y la información adicional del sistema comprende referencias a uno o más espacios de búsqueda adicionales.	un procesador (20); y un programa de computadora (22, 23) que almacena instrucciones que, cuando son ejecutadas por el procesador, hacen que la BS: envíe (S210) información del sistema en un canal de difusión con una primera numerología; y envíe (S220) información adicional en un primer espacio de búsqueda con una segunda numerología diferente de la primera numerología, en donde el primer espacio de búsqueda es un espacio de búsqueda común, en donde la segunda numerología se indica en la información del sistema enviada y la información adicional del sistema comprende referencias a uno o más espacios de búsqueda adicionales.	
10. Un medio de almacenamiento no-transitorio legible por computador que almacena instrucciones legibles por computador para habilitar múltiples numerologías en una red, en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la interfaz de radio de multiplexación por división de frecuencia ortogonal (OFDM), como el espaciado de subportadoras, la longitud de los símbolos OFDM, la longitud del prefijo cíclico, la cantidad de símbolos por	10. Un programa de computadora (14, 15) para habilitar múltiples numerologías en una red, en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la multiplexación por división de frecuencias ortogonales, OFDM, interfaz de radio, tales como espaciado entre subportadoras, longitud de símbolo OFDM, longitud de prefijo cíclico, número de símbolos por subtrama o ranura, longitud de subtrama y longitud de trama, el programa de computadora comprende un código de programa de	<i>Esta es una nueva reivindicación que fue incluida en la modificación voluntaria presentada el 26 de abril 26 de 2019, con el fin de eliminar la materia no patentable.</i>

subtrama o ranura, la longitud de la subtrama y la longitud de la trama, las instrucciones legibles por computador que, cuando se ejecutan por un procesador de un equipo de usuario (UE), hacen que el UE: reciba (S110) información del sistema en un canal de difusión con una primera numerología; determine (S120) un primer espacio de búsqueda a partir de la información del sistema recibida, donde un primer espacio de búsqueda es un espacio de búsqueda común; y reciba (S130) información adicional programada en el primer espacio de búsqueda con una segunda numerología diferente de la primera numerología, en donde el primer espacio de búsqueda es un espacio de búsqueda común, en donde la segunda numerología se indica en la información del sistema enviada y la información adicional del sistema comprende referencias a uno o más espacios de búsqueda adicionales.	computadora que, cuando se ejecuta en un equipo de usuario, hace que el usuario equipo para realizar el método de cualquiera de las reivindicaciones 1 a 5.	
11. Un medio de almacenamiento no-transitorio legible por computador que almacena instrucciones legibles por computador para habilitar múltiples numerologías en una red,	11. Un programa de computadora (24, 25) para habilitar múltiples numerologías en una red, en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la multiplexación	<i>Esta es una nueva reivindicación que fue incluida en la modificación voluntaria presentada el 26 de abril de 2019, con el fin de eliminar la materia no patentable.</i>

en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la interfaz de radio de multiplexación por división de frecuencia ortogonal (OFDM), como el espaciado de subportadoras, la longitud de los símbolos OFDM, la longitud del prefijo cíclico, la cantidad de símbolos por subtrama o ranura, la longitud de la subtrama y la longitud de la trama, las instrucciones que, cuando se ejecutan por un procesador de una estación base (BS), hace que la BS: envíe (S210) información del sistema en un canal de difusión con una primera numerología; y envíe (S220) información adicional en un primer espacio de búsqueda con una segunda numerología diferente de la primera numerología, en donde el primer espacio de búsqueda es un espacio de búsqueda común, en donde la segunda numerología se indica en la información del sistema enviada y la información adicional del sistema comprende referencias a uno o más espacios de búsqueda adicionales.	por división de frecuencia ortogonal, OFDM, interfaz de radio, tales como espaciado entre subportadoras, longitud de símbolo OFDM, longitud de prefijo cíclico, número de símbolos por subtrama o ranura, longitud de subtrama y longitud de trama, el programa de computadora comprende un código de programa de computadora que, cuando se ejecuta en una estación base, causa el estación base para realizar el método de la reivindicación 6 o 7.	
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(54) ENABLING MULTIPLE NUMEROLOGIES IN A NETWORK

AKTIVIERUNG MEHRERER NUMEROLOGIEN IN EINEM NETZWERK

PROCÉDÉ POUR PERMETTRE PLUSIEURS NUMÉROLOGIES DANS UN RÉSEAU

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URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2016-08-21]**
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URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_74b/Docs/ [retrieved on 2013-09-28]**
- **QUALCOMM INCORPORATED: "PBCH design considerations", 3GPP DRAFT; R1-1700788 PBCH DESIGN CONSIDERATION, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Spokane, USA; 20170116 - 20170120 16 January 2017 (2017-01-16), XP051208309, Retrieved from the Internet:
URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2017-01-16]**

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Description

TECHNICAL FIELD

[0001] The invention relates to a method for enabling multiple numerologies in a network, as well as a user equipment, a base station, a computer program and a computer program device of the network.

BACKGROUND

[0002] The fifth generation of mobile telecommunications and wireless technology is not yet fully defined but in an advanced draft stage within 3rd Generation Partnership Project (3GPP). It includes work on 5G New Radio (NR) Access Technology. Long term evolution (LTE) terminology is used in this disclosure in a forward looking sense, to include equivalent 5G entities or functionalities although a different term is specified in 5G. A general description of the agreements on 5G NR Access Technology so far is contained in 3GPP technical report (TR) 38.802 v0.3.0 (2016-10), of which a draft version has been published as R1-1610848.

[0003] In 3GPP, there is an ongoing study item that looks into a NR interface for 5G. Terms for denoting this new and next generation technology have not yet converged, so the terms NR and 5G will be used interchangeably.

[0004] One of the first major decisions that the 3GPP work-group RAN1 needs to take for NR concerns is what is often denoted with the terms "numerology" and "frame structure". In 3GPP RAN1, the term numerology is used to determine important numeric parameters that describe some rather fundamental aspects of the OFDM radio interface, such as subcarrier spacing, OFDM symbol length, cyclic prefix length, number of symbols per subframe or slot, subframe length, and frame length. Some of these terms could also fall under the term frame structure, such as e.g. frame length, number of subframe per frame, subframe length, and location and number of symbols in a slot, frame or subframe that carry control information, and location of channels that carry data. In NR a subframe is 1 ms and establishes a 1 ms clock. Transmissions use slots or mini-slots. A slot consists of 7 or 14 symbols, 7 symbols for subcarrier spacings less than or equal to 60 kHz and 14 symbols for subcarrier spacings greater than 60 kHz.

[0005] In addition, the term frame structure can comprise a variety of additional aspects that reflect the structure of frames, subframes and slots, for example the positioning and density of reference signals (pilot signals), placement and structure of control channels, location and length of guard time for uplink to downlink switching (and vice versa) for time division-duplexing (TDD), and time-alignment. Generally, numerology and frame structure encompass a set of fundamental aspects and parameters of the radio interface.

[0006] LTE supports a single sub-carrier spacing of 15

kHz. For some other parameters in LTE, there is some additional flexibility. For example, it is possible to configure the length of the cyclic prefix and the size of the control region within a subframe. Similarly, LTE can support multiple different frame structures, e.g. for frequency division-duplexing (FDD), TDD, and Narrowband Internet of Things (NB-IoT), respectively.

[0007] 3GPP TSG RAN WG1 has recently agreed that that it shall be possible support mixed sub-carrier spacing on the same carrier in NR. The feasibility of mixed sub-carrier spacing was studied e.g. in 3GPP contribution R1-163224, where it was shown that the interference between non-orthogonal sub-carriers can be mitigated successfully.

SUMMARY

[0008] The invention is defined in the independent claims 1, 6, 8, 9, 10 and 11. Embodiments of the invention are defined in the dependent claims. An object of embodiments presented herein is how to enable mixed numerologies in the 5G NR technology.

[0009] According to a first aspect there is presented a method for enabling multiple numerologies in a network.

The method is performed by a user equipment (UE), and comprises receiving system information in a first search space on a broadcast channel with a first numerology, determining a second search space from the received system information, and receiving further information in the second search space with a second numerology.

[0010] The first numerology may be different from the second numerology. From the point of view of the UE executing the method of the first aspect, the case where the first and second numerologies are different is supported but is not a prerequisite for operation of the UE. The UE may as well support and function in a situation the first and second numerologies are equal or equivalent, according to a configuration applicable at a given point in time. Put differently, the second numerology is configurable without being restricted by the first numerology, or without dependence on properties of the first numerology.

[0011] The broadcast channel may be a physical broadcast channel (PBCH).

[0012] The step of receiving system information may further comprise detecting system information. The method may further comprise receiving synchronization information prior to receiving the broadcast channel. Based on the reception of the synchronization information received on one or multiple synchronization channels, the UE may deduce the numerology of the search space or region of the broadcast channel.

[0013] The second numerology may be indicated in the received system information.

[0014] The second search space may be UE specific.

[0015] The second search space may be a common search space.

[0016] The step of determining may further comprise

determining a third search space having a third numerology.

[0017] According to a second aspect there is presented a method for enabling multiple numerologies in a network. The method is performed by a base station (BS), and comprises sending system information in a first search space on a broadcast channel with a first numerology, and sending further information in a second search space with a second numerology.

[0018] The first numerology may be different from the second numerology.

[0019] The broadcast channel may be a physical broadcast channel (PBCH).

[0020] The method may further comprise sending synchronization information for a broadcast channel.

[0021] According to a third aspect there is presented a UE for enabling multiple numerologies in a network. The UE comprises a processor and a computer program product. The computer program product stores instruction that, when executed by the processor, causes the UE to receive system information in a first search space on a broadcast channel with a first numerology, determine a second search space from the received system information, and to receive further information in the second search space with a second numerology.

[0022] According to a fourth aspect there is presented a BS for enabling multiple numerologies in a network. The BS comprises a processor and a computer program product. The computer program product stores instruction that, when executed by the processor, causes the BS to send system information in a first search space on a broadcast channel with a first numerology, and to send further information in a second search space with a second numerology.

[0023] According to a fifth aspect there is presented a UE for enabling multiple numerologies in a network. The UE comprises a communication manager and a determination manager. The communication manager is for receiving system information in a first search space on a broadcast channel with a first numerology, and for receiving further information in the second search space with a second numerology. The determination manager is for determining a second search space from the received system information.

[0024] According to a sixth aspect there is presented a BS for enabling multiple numerologies in a network. The BS comprises a communication manager for sending system information in a first search space on a broadcast channel with a first numerology, and for sending further information in a second search space with a second numerology.

[0025] According to a seventh aspect there is presented a computer program for enabling multiple numerologies in a network. The computer program comprises computer program code which, when run on a user equipment (UE), causes the UE to receive system information in a first search space on a broadcast channel with a first numerology, determine a second search space from the

received system information, and to receive further information in the second search space with a second numerology.

[0026] According to an eighth aspect there is presented a computer program for enabling multiple numerologies in a network. The computer program comprises computer program code which, when run on a BS, causes the BS to send system information in a first search space on a broadcast channel with a first numerology, and to send further information in a second search space with a second numerology.

[0027] According to a ninth aspect there is presented a computer program product comprising a computer program and a computer readable storage means on which the computer program is stored.

[0028] Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the element, apparatus, component, means, step, etc." are to be interpreted openly as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] The invention is now described, by way of example, with reference to the accompanying drawings, on which:

Fig. 1 is a schematic diagram illustrating an environment where embodiments presented herein can be applied;

Fig. 2 is a schematic diagram illustrating frequency multiplexing of sub-band regions with different sub-carrier spacings;

Fig. 3 is a schematic diagram illustrating search spaces according to an embodiment presented herein;

Fig. 4 is a schematic diagram illustrating search spaces according to an embodiment presented herein;

Fig. 5 is a schematic diagram illustrating search spaces according to an embodiment presented herein;

Figs. 6A-6B are flowcharts illustrating methods for embodiments presented herein;

Figs. 7-8 are schematic diagrams illustrating some components of devices presented herein; and

Figs. 9-10 are schematic diagrams showing functional modules of devices presented herein.

DETAILED DESCRIPTION

[0030] It is noted that the invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided by way of example so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout the description.

[0031] Herein the terms user equipment (UE), terminal, handset etc. interchangeably to denote a device that communicates with a network infrastructure. The term should not be construed as to mean any specific type of device, i.e. it applies to them all, and the embodiments described herein are applicable to all devices that use the concerned solution to solve the problems as described. Similarly, a base station (BS) is intended to denote the node in the network infrastructure that communicates with the UE. Different names may be applicable, such as NB, eNB, gNB, and the functionality of the BS may also be distributed in various ways. For example, there could be a radio head terminating parts of the radio protocols and a centralized unit that terminates other parts of the radio protocols. The term BS will refer to all alternative architectures that can implement the concerned invention, and no distinction between such implementations will be made.

[0032] Fig. 2 provides a schematic illustration of frequency multiplexing of three sub-band regions with different numerology. In the illustration, there are three different numerologies provided, such as three different carrier frequency portions that use different subcarrier spacing.

[0033] It should be noted that many other parameters are likely to be dependent, at least in part, on the sub-carrier spacing. For example, the symbol length in OFDM is a function of the sub-carrier spacing. The slot length, which is defined in number of symbols or milliseconds, depends for example on selected numerology. Common to many of these parameters is that a receiver needs to know, or will at least greatly benefit from knowing beforehand, what parameters are used by the transmitter when transmitting a signal to the receiver. For example, a UE benefits from knowing the sub-carrier spacing used by a transmitting BS, so that the UE can reduce the hypotheses of different sub-carrier spacings used by the BS when trying to decode a signal. This applies to many parameters, including but not limited to the ones described above. Some parameters can be either identified by blind decoding, but if there are too many unknown parameters, the identification task will place a heavy processing burden on the UE.

[0034] The term "numerology" will herein denote these parameters or at least some of the parameters. More

precisely, in a system where one of the enumerated parameters is not configurable, numerology may be understood as not including non-configurable parameters. Occasionally, the expression "a numerology" may denote a set of values to be assigned to the configurable parameters.

[0035] Current agreements in RAN1 includes a subcarrier spacing that scales according to $2^m \times 15$ kHz, with m an integer or preferably $m \geq 0$. It is also agreed that a physical resource block consists of 12 subcarriers. A sub-frame duration is also fixed to 1 ms. A slot consists of 7 or 14 symbols, 7 symbols for subcarrier spacings less than or equal to 60 kHz and 14 symbols for subcarrier spacings greater than 60 kHz.

[0036] As already noted, 3GPP TSG RAN WG1 has agreed that 5G NR should support multiple numerologies within a carrier. Having different numerologies within a carrier can be attractive e.g. to simultaneously meet requirements for low latency for one subset of UEs, and at the same time support good coverage for another set of UEs. In more generally terms, different sub-bands on a carrier using different numerologies can then be used for transmissions to and from the different UEs, where the different UEs have different demands on service quality.

[0037] However, problems also arise with this flexibility in supporting multiple numerologies on a carrier. In particular a receiver, such as a UE, would greatly benefit from knowing beforehand what numerology that is to be assumed when trying to decode a signal from a transmitter. One challenge is that, when the UE first finds and connects to a cell, it does not necessarily know what numerology is applied on the carrier in the cell, and in particular, it does not know if there are sub-band portions that apply different numerologies.

[0038] For the UE, it may be difficult or demanding to implement a solution where the UE knows little or nothing about the downlink signal structure, i.e. the numerology, and has to try out a large number of different assumptions through blind decoding before it can decode the signal from the BS. This problem is particularly severe when a UE is to establish a connection with a BS, i.e. when the UE has not yet received much specific information from the BS about how the BS intends to transmit signals to the UE.

[0039] A common and known solution to the problem of informing UEs about cell or carrier parameters is to broadcast such information in system information from the BS to UEs within a coverage area of the BS. By that method, basic parameters such as cell bandwidth, frame structure, cyclic prefix etc. can be made available periodically to all UEs within the proximity of the BS. However, this approach has some significant drawbacks, including:

1. Successful reception of the concerned system information requires that the UE already knows some basic information about the numerology where the system information is transmitted. In LTE, for exam-

ple, the UE is aware of the specified constant sub-carrier spacing of 15 kHz and does not have to hypothesize in this regard. In LTE, based on synchronization information, the UE will also know the timing and the location of certain basic system information, such as master information block (MIB) and then subsequently system information block type 1 (SIB 1), so that it can subsequently gain more information about e.g. the frame structure in the cell.

2. The carrier on which system information is broadcast will be subject to considerable load. Broadcast system information has to be repeated relatively frequently, and if there is intent to provide a significant flexibility by having many configurable numerology parameters, the approach would likely to result in significant overhead.

3. At high frequencies, the realization of signaling by broadcasting methods over a large area can be very difficult, if not impossible, as the propagation conditions may require either beamforming or very prudent coding and modulation to ensure that the broadcast information can be received by UEs regardless of their location.

[0040] Thus, there is a need to provide a solution that can support or enable multiple numerology scenarios, distribution of fundamental parameters without placing excessive load on a broadcast channel, so that a UE can quickly and unambiguously learn what numerologies are supported in different sub-band portions of a carrier. There is also a need for a solution for forward compatibility, so that new numerologies expressed by physical layer parameters and e.g. new channel and frame structure designs can be put to use in sub-band portions of a carrier. By such an approach, the backwards-compatible sub-portion of the carrier can be reduced to a minimum, and new sub-band solutions can be put to use in an efficient way.

[0041] Technologies addressing the aforementioned problems as outlined above are presented.

[0042] Embodiments are presented intended to enable a UE to acquire information about sub-band numerologies on a carrier with minimal overhead including low processing requirements.

[0043] Embodiments are also presented for a BS that signals information to a UE about sub-bands with specific numerologies, wherein the solution provides great flexibility, low overhead and future compatibility required e.g. when new transmission solutions are introduced in later revisions of the network.

[0044] Synchronization signals may be received over a channel or channels with a known numerology. Alternatively, a set of available numerologies is limited, or preferably significantly limited, so that the burden for decoding synchronization signals is manageable. The UE then may decode a physical broadcast channel (PBCH), which may have a numerology that is fixed, or otherwise based on the detection and information deduced from

the synchronization. Information on the PBCH may carry information about common and/or additional search spaces, wherein the information may include information about the numerology applied on these search spaces.

5 Data, such as system information, scheduled on the common search space may further contain references to UE-specific search spaces, and respective numerologies. A first search space may further provide a UE with scheduling information carrying an indication of a second additional search space with another numerology. The scheduling information may in particular indicate the numerology of the second additional search space.

10 **[0045]** The proposed solution can support multiple numerologies of fundamental parameters without placing an excessive load on a broadcast channel, so that a UE can quickly and unambiguously learn what numerologies are supported in different sub-band portions of a carrier. The solution is also forward-compatible, so that new numerologies expressed e.g. by physical layer parameters and e.g. new channel and frame structure design can be put to use in sub-band portions of a carrier, even if they are not present in the first version or versions of a deployment, and the new channel and frame structure is developed in the future. By such an approach, once new channel and frame structures are developed, the old backwards-compatible sub-portion of the carrier can be reduced to a minimum serving only those remaining UEs that does not support the new channel and frame structure, and new sub-band solutions can be put to use in an efficient way.

25 **[0046]** An example of a broadcast channel is a PBCH carrying system information. Often, a PBCH is modelled to carry broadcast messages on a broadcast transport channel (BCH), i.e. the traffic on BCH is mapped on PBCH.

30 **[0047]** First, a UE acquires information about how and where to receive a broadcast channel. The information about how (numerology) and where (physical resources) to receive the broadcast channel can e.g. be based on the reception of synchronization information.

35 **[0048]** Reception of synchronization information provides some very basic information of the carrier cell structure and timing, and in one alternative, the numerology of the PBCH transmission is provided within the synchronization channel or channels that the UE acquires initially. For example, the UE may be required to test a few hypotheses of synchronization channel numerology, and based on the reception of the synchronization channel, the UE can deduce the numerology or set of numerologies that may apply to the reception of the broadcast channel. However, and alternatively, some or all parameters, i.e. numerology, defining where and how to receive the broadcast channel could be hard-coded into the UE, e.g. based on some parameters agreed in a standard specification or the like; the parameters need not be configurable or variable during normal operation of the UE.

40 **[0049]** For example, it could be defined that the UE will use e.g. a sub-carrier spacing of 15 kHz and/or a specific

slot format and/or cyclic prefix and/or specific location of the PBCH when reading the information carried on the PBCH. In an alternative, the sub-carrier spacing and other parameters dependent on the subcarrier spacing are defined and programmed into the UE, such that the parameters are dependent on the carrier frequency. For example, it could be defined or pre-agreed that a carrier implemented below a frequency f_1 has a sub-carrier spacing of $sc1$ for PBCH, a carrier implemented between frequencies f_1 and f_2 , has sub-carrier spacing of $sc2$ for PBCH, and so on.

[0050] The same or a similar approach may also apply to one or several of the following: the timing of the PBCH, i.e. its periodicity, the location of the PBCH on the frequency and time-domain placement, the resource blocks that carry PBCH, and the modulation and coding of the PBCH.

[0051] On the PBCH, the UE can now receive some very fundamental information of the system, i.e. system information. However, to avoid excessive load on the PBCH, which could occur if PBCH also carries numerology information for all sub-bands, the invention uses the following approach. The sub-band carrying PBCH will hereafter also be called control sub-band.

[0052] Information on PBCH may now include a reference to search spaces and/or carrier regions for receiving additional information, such as control channels and data. As used herein, the term search spaces will include also carrier regions. The BCH information may for example include a reference to a common search space and/or one or multiple additional search spaces. The additional search space may be common or UE-specific. The BCH information may further include information on the numerology to be used in the referenced search space or search spaces. The information on the numerology may, for example, provide a reference to a table of different numerologies, wherein the table identifies what numerology the UE should apply when decoding information on the search space or search spaces. Alternatively, the BCH data may include information on whether the search space or search spaces apply the same numerology as BCH, or if the numerology is different. Other information could also be provided, or the format could e.g. be the value of integer m in the expression $2^m \times 15$ kHz, to identify a specific numerology. The information regarding the additional search spaces may also include information about the location of the search space in the time-frequency resource grid.

[0053] The common search space may also be defined to have the same numerology as BCH, to further reduce the signaling on BCH. In the common search space, the UE may be scheduled to receive additional information about one or several additional search spaces or other information.

[0054] In such an embodiment, the information provided in information scheduled at the common search space may include a reference to one or several additional search spaces, in which case the additional search spaces

may use different numerologies. Such information could be scheduled and received on a data region of a frame or subframe, wherein the data is scheduled by a radio network temporary identifier (RNTI) on the common search space.

[0055] A search space may refer to locations (which in LTE are called control channel elements) where a UE can expect to find downlink control channels (PDCCH) that are of relevance for the UE. A common search space is a search space that many, or even all, UEs on a carrier needs to monitor, at least intermittently. Such a common search space may carry e.g. scheduling of paging information (using a paging-RNTI in LTE), or further system information (scheduled by a system information-RNTI in LTE), or e.g. random access responses. In this common search space, the UE may be scheduled to receive information about additional search spaces. The information about additional search spaces may include information about the numerology of the additional search space. In one embodiment, this information is carried in system information mapped onto the data region of a frame, subframe or slot.

[0056] A schematic illustration of an embodiment is provided in Fig. 3. In Fig. 3, the time-relationship and size of different illustrated regions are only schematic. According to the embodiment, the BCH is transmitted from the BS and is received by the UE using a first numerology, numerology1. As illustrated, the BCH information may include a reference to a common search space. The BCH information may further include information as described above on the numerology of the common search space. In Fig. 3, the numerology of the common search space is the same as the numerology of the BCH, i.e. numerology1 on sub-carrier region1. Next, the UE receives, in or associated with the common search space, information about an additional search space. In the illustration, the additional search space is now implemented using a second numerology, numerology2 on sub-carrier region2. Fig. 3 also includes a third search space, which is not assigned to this UE. For illustration purposes, it is shown that this third search space may implement a third numerology, numerology3 on sub-carrier region3.

[0057] In the embodiment illustrated in Fig. 3, a reference to the additional, second search space is provided in the common search space. However, a reference to an additional, second search space may also be provided directly in the information carried on BCH, as illustrated in Fig. 4.

[0058] In Fig. 4, it is exemplified that also the common search space may implement a different numerology, numerology2 on sub-carrier region2, than the numerology of the BCH, numerology1 on sub-carrier region1. It should further be noted that all the illustrated regions (search spaces and BCH) may occur periodically, or even in every subframe or slot (not illustrated). The periodicity may be different for the relevant search spaces.

[0059] A benefit of providing information about the numerology of the additional search space or spaces from

via the common search space is that the information can be provided on a shared channel, scheduled by assignments, such as downlink control information (DCI) on PDCCH, as explained below. The UE searches for (data) scheduling assignments on the common search space. When it identifies a scheduling assignment relating to an RNTI intended for this purpose, the UE finds an allocation of downlink resources, i.e., a scheduling command and corresponding scheduling of downlink data. For example, this data can be control information, e.g. identified as system information, carried on the data region of a frame, subframe or slot. The downlink data region may carry information about the additional search space and its numerology, as explained before or other information. This is illustrated in Fig. 5.

[0060] In one solution, the scheduling assignment is directed to a plurality of UEs, using an RNTI that is common to the plurality of UE's, such as a System Information RNTI (SI-RNTI). In another solution, the UE is directed to the additional search space using an assignment directed specifically to this UE, i.e. using e.g. the UEs Cell-RNTI (C-RNTI), wherein the C-RNTI is allocated to this UE. In this latter solution, the UE may first need to establish a connection to the network, by which it can receive such UE specific control information about the additional search space or spaces via dedicated signaling, such as Radio Resource Control (RRC) signaling. The latter approach may reduce the need for repetitive control information on the carrier, as UE's are assigned to receive the aforementioned control information only at times when specifically needed.

[0061] A network 4, wherein embodiments described herein can be implemented is presented in Fig. 1. A UE 1 is wirelessly connectable to a BS 2. The BS 2 is connected to a core network (CN) 3.

[0062] A method, according to an embodiment, for enabling multiple numerologies in a network is presented with reference to Fig. 6A. The method is performed by a UE, and comprises receiving S110 system information in a first search space on a broadcast channel with a first numerology, determining S120 a second search space from the received system information, and receiving S130 further information in the second search space with a second numerology.

[0063] The first numerology may be different from the second numerology.

[0064] The broadcast channel may be a physical broadcast channel (PBCH).

[0065] The step of receiving may further comprise detecting system information.

[0066] The method may further comprise receiving S100 synchronization information for a broadcast channel prior to the step of receiving S110.

[0067] The second numerology may be indicated in the received system information.

[0068] The second search space may be UE-specific.

[0069] The second search space may be a common search space.

[0070] The step of determining S120 may further comprise determining a third search space having a third numerology.

[0071] A method for enabling multiple numerologies in a network is presented with reference to Fig. 6B. The method is performed by a BS, and comprises sending S210 system information in a first search space on a broadcast channel with a first numerology, and sending S220 further information in a second search space with a second numerology.

[0072] The method may further comprise sending S200 synchronization information for a broadcast channel.

[0073] A UE for enabling multiple numerologies in a network is presented with reference to Fig. 7. The UE 1 comprises a processor 10, and a computer program product 12, 13. The computer program product stores instruction that, when executed by the processor, causes the UE to receive S110 system information in a first search space on a broadcast channel with a first numerology, determine S120 a second search space from the received system information, and to receive S130 further information in the second search space with a second numerology.

[0074] A BS for enabling multiple numerologies in a network is presented with reference to Fig. 8. The BS 2 comprises a processor 20, and a computer program product 22, 23. The computer program product stores instruction that, when executed by the processor, causes the BS to send S210 system information in a first search space on a broadcast channel with a first numerology, and to send S220 further information in a second search space with a second numerology.

[0075] A UE for enabling multiple numerologies in a network is presented with reference to Fig. 9. The UE 1 comprises a communication manager 91 and a determination manager 90. The communication manager is for receiving S110 system information in a first search space on a broadcast channel with a first numerology, and for receiving S130 further information in the second search space with a second numerology. The determination manager is for determining S120 a second search space from the received system information.

[0076] A BS for enabling multiple numerologies in a network is presented with reference to Fig. 10. The BS 2 comprises a communication manager 101 for sending S210 system information in a first search space on a broadcast channel with a first numerology, and for sending S220 further information in a second search space with a second numerology.

[0077] A computer program 14, 15 for enabling multiple numerologies in a network is presented. The computer program comprises computer program code which, when run on a UE, causes the UE 1 to receive S110 system information in a first search space on a broadcast channel with a first numerology, determine (S120) a second search space from the received system information, and to receive S130 further information in the second search

space with a second numerology.

[0078] A computer program 24, 25 for enabling multiple numerologies in a network is presented. The computer program comprises computer program code which, when run on a BS, causes the BS 2 to send S210 system information in a first search space on a broadcast channel with a first numerology, and to send S220 further information in a second search space with a second numerology.

[0079] A computer program product 12, 13 (Fig. 7), 22, 23 (Fig. 8) comprising a computer program 14, 15 (Fig. 7), 24, 25 (Fig. 8) and a computer readable storage means on which the computer program 14, 15, 24, 25 is stored, is also presented.

[0080] Fig. 7 is a schematic diagram showing some components of the UE 1. The processor 10 may be provided using any combination of one or more of a suitable central processing unit, CPU, multiprocessor, microcontroller, digital signal processor, DSP, application specific integrated circuit etc., capable of executing software instructions of a computer program 14 stored in a memory. The memory can thus be considered to be or form part of the computer program product 12. The processor 10 may be configured to execute methods described herein with reference to Fig. 6A.

[0081] The memory may be any combination of read and write memory, RAM, and read only memory, ROM. The memory may also comprise persistent storage, which, for example, can be any single one or combination of magnetic memory, optical memory, solid state memory or even remotely mounted memory.

[0082] A second computer program product 13 in the form of a data memory may also be provided, e.g. for reading and/or storing data during execution of software instructions in the processor 10. The data memory can be any combination of read and write memory, RAM, and read only memory, ROM, and may also comprise persistent storage, which, for example, can be any single one or combination of magnetic memory, optical memory, solid state memory or even remotely mounted memory. The data memory may e.g. hold other software instructions 15, to improve functionality for the UE 1.

[0083] The UE 1 may further comprise an input/output (I/O) interface 11 including e.g. a user interface. The WD 1 may further comprise a receiver configured to receive signaling from other nodes, and a transmitter configured to transmit signaling to other nodes (not illustrated). Other components of the UE 1 are omitted in order not to obscure the concepts presented herein.

[0084] Fig. 9 is a schematic diagram showing functional blocks of the UE 1. The modules may be implemented as only software instructions such as a computer program executing in the cache server or only hardware, such as application specific integrated circuits, field programmable gate arrays, discrete logical components, transceivers, etc. or as a combination thereof. In an alternative embodiment, some of the functional blocks may be implemented by software and other by hardware. The

modules correspond to the steps in the methods illustrated in Fig. 6A, comprising a determination manager unit 90 and a communication manager unit 91. In the embodiments where one or more of the modules are implemented by a computer program, it shall be understood that these modules do not necessarily correspond to process modules, but can be written as instructions according to a programming language in which they would be implemented, since some programming languages do not typically contain process modules.

[0085] The determination manager 90 is for enabling multiple numerologies in a network. This module corresponds to the determine step S1210 of Fig. 6A. This module can e.g. be implemented by the processor 10 of Fig. 7, when running the computer program.

[0086] The communication manager 91 is for enabling multiple numerologies in a network. This module corresponds to the receive step S100, the receive step S110 and the receive step S130 of Fig. 6A. This module can e.g. be implemented by the processor 10 of Fig. 7, when running the computer program.

[0087] Fig. 8 is a schematic diagram showing some components of the base station 2. A processor 20 may be provided using any combination of one or more of a suitable central processing unit, CPU, multiprocessor, microcontroller, digital signal processor, DSP, application specific integrated circuit etc., capable of executing software instructions of a computer program 24 stored in a memory. The memory can thus be considered to be or form part of the computer program product 22. The processor 20 may be configured to execute methods described herein with reference to Fig. 6B.

[0088] The memory may be any combination of read and write memory, RAM, and read only memory, ROM. The memory may also comprise persistent storage, which, for example, can be any single one or combination of magnetic memory, optical memory, solid state memory or even remotely mounted memory.

[0089] A second computer program product 23 in the form of a data memory may also be provided, e.g. for reading and/or storing data during execution of software instructions in the processor 20. The data memory can be any combination of read and write memory, RAM, and read only memory, ROM, and may also comprise persistent storage, which, for example, can be any single one or combination of magnetic memory, optical memory, solid state memory or even remotely mounted memory. The data memory may e.g. hold other software instructions 25, to improve functionality for the BS 2.

[0090] The BS 2 may further comprise an input/output, I/O, interface 21 including e.g. a user interface. The BS 2 may further comprise a receiver configured to receive signaling from other nodes, and a transmitter configured to transmit signaling to other nodes (not illustrated). Other components of the BS 2 are omitted in order not to obscure the concepts presented herein.

[0091] Fig. 10 is a schematic diagram showing functional blocks of the BS 2. The modules may be imple-

mented as only software instructions such as a computer program executing in the cache server or only hardware, such as application-specific integrated circuits, field programmable gate arrays, discrete logical components, transceivers, etc. or as a combination thereof. In an alternative embodiment, some of the functional blocks may be implemented by software and other by hardware. The modules correspond to the steps in the methods illustrated in Fig. 6B, comprising a communication manager unit 101. In the embodiments where one or more of the modules are implemented by a computer program, it shall be understood that these modules do not necessarily correspond to process modules, but can be written as instructions according to a programming language in which they would be implemented, since some programming languages do not typically contain process modules.

[0092] The communication manager 101 is for enabling multiple numerologies in a network. This module corresponds to the send step S200, the send step S210, and the send step S220 of Fig. 6B. This module can e.g. be implemented by the processor 20 of Fig. 8, when running the computer program.

[0093] The invention has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the invention, as defined by the appended patent claims.

Claims

1. A method for enabling multiple numerologies in a network, wherein numerology refers to a set of numeric parameters describing aspects of the orthogonal frequency-division multiplexing, OFDM, radio interface, such as subcarrier spacing, OFDM symbol length, cyclic prefix length, number of symbols per sub frame or slot, sub frame length, and frame length, the method being performed by a user equipment, UE, and comprising:

receiving (S110) system information on a broadcast channel with a first numerology; determining (S120) a first search space from the received system information, wherein the first search space is a common search space; and receiving (S130) further system information scheduled in the first search space with a second numerology different from the first numerology, wherein the second numerology is indicated in the received system information and the further system information comprises references to one or more additional search spaces.

2. The method according to claim 1, wherein the step of receiving (S110) further comprises detecting sys-

tem information.

3. The method according to any one of claims 1 to 2, comprising:

receiving (S100) synchronization information for a broadcast channel prior to receiving (S110) on the broadcast channel.

4. The method according to any of the preceding claims, wherein the further system information scheduled in the first search space is one or more of the following: scheduling of paging information, random access responses, scheduling of additional search spaces.

5. The method according to any one of claims 1 to 4, wherein the step of determining further comprises determining a second search space with a third numerology.

6. A method for enabling multiple numerologies in a network, wherein numerology refers to a set of numeric parameters describing aspects of the orthogonal frequency-division multiplexing, OFDM, radio interface, such as subcarrier spacing, OFDM symbol length, cyclic prefix length, number of symbols per sub frame or slot, sub frame length, and frame length, the method being performed by a base station, BS, and comprising:

sending (S210) system information on a broadcast channel with a first numerology; and sending (S220) further system information scheduled in a first search space with a second numerology different from the first numerology, wherein the first search space is a common search space, wherein the second numerology is indicated in the sent system information and the further system information comprises references to one or more additional search spaces.

7. The method according to claim 6, wherein the first search space is indicated in the sent system information.

8. A user equipment, UE, for enabling multiple numerologies in a network, wherein numerology refers to a set of numeric parameters describing aspects of the orthogonal frequency-division multiplexing, OFDM, radio interface, such as subcarrier spacing, OFDM symbol length, cyclic prefix length, number of symbols per sub frame or slot, sub frame length, and frame length, the UE (1) comprising:

a processor (10); and

a computer program (12, 13) storing instructions that, when executed by the processor, cause the UE to:

receive (S110) system information on a broadcast channel with a first numerology; determine (S120) a first search space from the received system information, wherein the second search space is a common search space; and receive (S130) further system information in the first search space with a second numerology different from the first numerology, wherein the second numerology is indicated in the received system information and the further system information comprises references to one or more additional search spaces.

9. A base station, BS, for enabling multiple numerologies in a network, wherein numerology refers to a set of numeric parameters describing aspects of the orthogonal frequency-division multiplexing, OFDM, radio interface, such as subcarrier spacing, OFDM symbol length, cyclic prefix length, number of symbols per sub frame or slot, sub frame length, and frame length, the BS (2) comprising:

a processor (20); and a computer program (22, 23) storing instructions that, when executed by the processor, cause the BS to:

send (S210) system information on a broadcast channel with a first numerology; and send (S220) further system information in a first search space with a second numerology different from the first numerology, wherein the first search space is a common search space, wherein the second numerology is indicated in the sent system information and the further system information comprises references to one or more additional search spaces.

10. A computer program (14, 15) for enabling multiple numerologies in a network, wherein numerology refers to a set of numeric parameters describing aspects of the orthogonal frequency-division multiplexing, OFDM, radio interface, such as subcarrier spacing, OFDM symbol length, cyclic prefix length, number of symbols per sub frame or slot, sub frame length, and frame length, the computer program comprising computer program code which, when run on a user equipment, causes the user equipment to perform the method of any of claims 1 to 5.

11. A computer program (24, 25) for enabling multiple numerologies in a network, wherein numerology refers to a set of numeric parameters describing aspects of the orthogonal frequency-division multiplexing, OFDM, radio interface, such as subcarrier spacing, OFDM symbol length, cyclic prefix length, number of symbols per sub frame or slot, sub frame length, and frame length, the computer program comprising computer program code which, when run on a base station, causes the base station to perform the method of claim 6 or 7.

15 Patentansprüche

1. Verfahren zum Ermöglichen mehrfacher Numerologien in einem Netzwerk, wobei sich die Numerologie auf einen Satz numerischer Parameter bezieht, die Aspekte der Funkschnittstelle des orthogonalen Frequenzmultiplexverfahrens (OFDM-Funkschnittstelle) wie Unterträgerabstand, OFDM-Symbollänge, zyklische Präfixlänge, Anzahl von Symbolen pro Unterrahmen oder Schlitz, Unterrahmenlänge und Rahmenlänge beschreiben, wobei das Verfahren von einer Benutzereinrichtung (UE) durchgeführt wird und Folgendes umfasst:

Empfangen (S110) von Systeminformationen auf einem Broadcast-Kanal mit einer ersten Numerologie; Bestimmen (S120) eines ersten Suchraums aus den empfangenen Systeminformationen, wobei der erste Suchraum ein gemeinsamer Suchraum ist; und Empfangen (S130) weiterer Systeminformationen, die im ersten Suchraum geplant sind, mit einer zweiten Numerologie, die sich von der ersten Numerologie unterscheidet, wobei die zweite Numerologie in den empfangenen Systeminformationen angegeben ist und die weiteren Systeminformationen Referenzen auf einen oder mehrere zusätzliche Suchräume umfassen.

2. Verfahren nach Anspruch 1, wobei der Schritt des Empfangens (S110) ferner das Erkennen von Systeminformationen umfasst.
3. Verfahren nach einem der Ansprüche 1 bis 2, das Folgendes umfasst:
- Empfangen (S100) von Synchronisationsinformationen für einen Broadcast-Kanal vor dem Empfangen (S110) auf dem Broadcast-Kanal.
4. Verfahren nach einem der vorstehenden Ansprüche,

wobei die weiteren Systeminformationen, die in dem ersten Suchraum geplant sind, eines oder mehrere der Folgenden sind: Planung von Paging-Information, Direktzugriffsantworten, Planung zusätzlicher Suchräume.

5. Verfahren nach einem der Ansprüche 1 bis 4, wobei der Schritt des Bestimmens ferner das Bestimmen eines zweiten Suchraums mit einer dritten Numerologie umfasst.

6. Verfahren zum Ermöglichen mehrfacher Numerologien in einem Netzwerk, wobei sich die Numerologie auf einen Satz numerischer Parameter bezieht, die Aspekte der Funkschnittstelle des orthogonalen Frequenzmultiplexverfahrens (OFDM-Funkschnittstelle) wie Unterträgerabstand, OFDM-Symbollänge, zyklische Präfixlänge, Anzahl von Symbolen pro Unterrahmen oder Schlitz, Unterrahmenlänge und Rahmenlänge beschreiben, wobei das Verfahren durch eine Basisstation (BS) durchgeführt wird und Folgendes umfasst:

Senden (S210) von Systeminformationen auf einem Broadcast-Kanal mit einer ersten Numerologie; und

Senden (S220) weiterer Systeminformationen, die in einem ersten Suchraum geplant sind, mit einer zweiten Numerologie, die sich von der ersten Numerologie unterscheidet, wobei der erste Suchraum ein gemeinsamer Suchraum ist, wobei die zweite Numerologie in den gesendeten Systeminformationen angegeben ist und die weiteren Systeminformationen Verweise auf einen oder mehrere zusätzliche Suchräume umfasst.

7. Verfahren nach Anspruch 6, wobei der erste Suchraum in den gesendeten Systeminformationen angegeben wird.

8. Benutzereinrichtung, UE, zum Ermöglichen mehrfacher Numerologien in einem Netzwerk, wobei sich die Numerologie auf einen Satz numerischer Parameter bezieht, die Aspekte der Funkschnittstelle des orthogonalen Frequenzmultiplexverfahrens (OFDM-Funkschnittstelle), wie Unterträgerabstand, OFDM-Symbollänge, zyklische Präfixlänge, Anzahl von Symbolen pro Unterrahmen oder Schlitz, Unterrahmenlänge und Rahmenlänge beschreiben, wobei die UE (1) Folgendes umfasst:

einen Prozessor (10); und
ein Computerprogramm (12, 13) zum Speichern von Anweisungen, die, wenn sie durch den Prozessor ausgeführt werden, die UE zu Folgen-

dem veranlassen:

Empfangen (S110) von Systeminformationen auf einem Broadcast-Kanal mit einer ersten Numerologie;

Bestimmen (S120) eines ersten Suchraums aus den empfangenen Systeminformationen, wobei der zweite Suchraum ein gemeinsamer Suchraum ist; und

Empfangen (S130) weiterer Systeminformationen im ersten Suchraum mit einer zweiten Numerologie, die sich von der ersten Numerologie unterscheidet, wobei die zweite Numerologie in den empfangenen Systeminformationen angegeben ist und die weiteren Systeminformationen Referenzen auf einen oder mehrere zusätzliche Suchräume umfassen.

9. Basisstation, BS, um mehrere Numerologien in einem Netzwerk zu ermöglichen, wobei sich die Numerologie auf einen Satz numerischer Parameter bezieht, die Aspekte der Funkschnittstelle des orthogonalen Frequenzmultiplexverfahrens (OFDM-Funkschnittstelle) wie Unterträgerabstand, OFDM-Symbollänge, zyklische Präfixlänge, Anzahl von Symbolen pro Unterrahmen oder Schlitz, Unterrahmenlänge und Rahmenlänge beschreiben, wobei die BS (2) Folgendes umfasst:

einen Prozessor (20); und

ein Computerprogramm (22, 23) zum Speichern von Anweisungen, die, wenn sie durch den Prozessor ausgeführt werden, die BS zu Folgendem veranlassen:

Senden (S210) von Systeminformationen auf einem Broadcast-Kanal mit einer ersten Numerologie; und

Senden (S220) weiterer Systeminformationen in einem ersten Suchraum mit einer zweiten Numerologie, die sich von der ersten Numerologie unterscheidet, wobei der erste Suchraum ein gemeinsamer Suchraum ist, wobei die zweite Numerologie in der gesendeten Systeminformation angegeben ist und die weitere Systeminformation Verweise auf einen oder mehrere zusätzliche Suchräume umfasst.

10. Computerprogramm (14, 15) zum Ermöglichen mehrerer Numerologien in einem Netzwerk, wobei sich die Numerologie auf einen Satz numerischer Parameter bezieht, die Aspekte der Funkschnittstelle des orthogonalen Frequenzmultiplexverfahrens (OFDM-Funkschnittstelle) wie Unterträgerabstand, OFDM-Symbollänge, zyklische Präfix-

länge, Anzahl von Symbolen pro Unterrahmen oder Schlitz, Unterrahmenlänge und Rahmenlänge beschreiben, wobei das Computerprogramm einen Computer-Programmcodes umfasst, der, wenn er auf einer Benutzereinrichtung ausgeführt wird, die Benutzereinrichtung veranlasst, das Verfahren nach einem der Ansprüche 1 bis 5 durchzuführen.

11. Computerprogramm (24, 25) zum Ermöglichen mehrerer Numerologien in einem Netzwerk, wobei sich die Numerologie auf einen Satz numerischer Parameter bezieht, die Aspekte der Funkschnittstelle des orthogonalen Frequenzmultiplexverfahrens (OFDM-Funkschnittstelle) wie Unterträgerabstand, OFDM-Symbollänge, zyklische Präfixlänge, Anzahl von Symbolen pro Unterrahmen oder Schlitz, Unterrahmenlänge und Rahmenlänge beschreiben, wobei das Computerprogramm einen Computer-Programmcodes umfasst, der, wenn er auf einer Basisstation ausgeführt wird, die Basisstation veranlasst, das Verfahren nach Anspruch 6 oder 7 durchzuführen.

Revendications

1. Procédé pour permettre de multiples numéologies dans un réseau, dans lequel une numéologie désigne un ensemble de paramètres numériques décrivant des aspects de l'interface radio à multiplexage par répartition orthogonale de la fréquence, OFDM, tels qu'un espacement de sous-porteuse, une longueur de symbole OFDM, une longueur de préfixe cyclique, un nombre de symboles par sous-trame ou créneau, une longueur de sous-trame et une longueur de trame, le procédé étant mis en oeuvre par un équipement utilisateur, UE, et comprenant :

la réception (S110) d'informations système sur un canal de diffusion avec une première numéologie ;
la détermination (S120) d'un premier espace de recherche à partir des informations système reçues, dans lequel le premier espace de recherche est un espace de recherche commun ; et
la réception (S130) d'informations système supplémentaires planifiées dans le premier espace de recherche avec une deuxième numéologie différente de la première numéologie, dans lequel la deuxième numéologie est indiquée dans les informations système reçues et les informations système supplémentaires comprennent des références à un ou plusieurs espaces de recherche additionnels.

2. Procédé selon la revendication 1, dans lequel l'étape de réception (S110) comprend en outre la détection d'informations système.

3. Procédé selon l'une quelconque des revendications 1 à 2, comprenant :

la réception (S100) d'informations de synchronisation pour un canal de diffusion avant réception (S110) sur le canal de diffusion.

4. Procédé selon l'une quelconque des revendications précédentes, dans lequel les informations système supplémentaires planifiées dans le premier espace de recherche sont une ou plusieurs parmi les suivantes : planification d'informations de radiorecherche, réponse d'accès aléatoire, planification d'espaces de recherche additionnels.

5. Procédé selon l'une quelconque des revendications 1 à 4, dans lequel l'étape de détermination comprend en outre la détermination d'un deuxième espace de recherche avec une troisième numéologie.

6. Procédé pour permettre de multiples numéologies dans un réseau, dans lequel une numéologie désigne un ensemble de paramètres numériques décrivant des aspects de l'interface radio à multiplexage par répartition orthogonale de la fréquence, OFDM, tels qu'un espacement de sous-porteuse, une longueur de symbole OFDM, une longueur de préfixe cyclique, un nombre de symboles par sous-trame ou créneau, une longueur de sous-trame et une longueur de trame, le procédé étant mis en oeuvre par une station de base, BS, et comprenant :

l'envoi (S210) d'informations système sur un canal de diffusion avec une première numéologie ; et

l'envoi (S220) d'informations système supplémentaires planifiées dans un premier espace de recherche avec une deuxième numéologie différente de la première numéologie, dans lequel le premier espace de recherche est un espace de recherche commun, dans lequel la deuxième numéologie est indiquée dans les informations système envoyées et les informations système supplémentaires comprennent des références à un ou plusieurs espaces de recherche additionnels.

7. Procédé selon la revendication 6, dans lequel le premier espace de recherche est indiqué dans les informations système envoyées.

8. Équipement utilisateur, UE, pour permettre de multiples numéologies dans un réseau,

dans lequel une numérologie désigne un ensemble de paramètres numériques décrivant des aspects de l'interface radio à multiplexage par répartition orthogonale de la fréquence, OFDM, tels qu'un espacement de sous-porteuse, une longueur de symbole OFDM, une longueur de préfixe cyclique, un nombre de symboles par sous-trame ou créneau, une longueur de sous-trame et une longueur de trame, l'UE (1) comprenant :

un processeur (10) ; et
un programme informatique (12, 13) stockant des instructions qui, lorsqu'elles sont exécutées par le processeur, amènent l'UE à :

recevoir (S110) des informations système sur un canal de diffusion avec une première numérologie ;
déterminer (S120) un premier espace de recherche à partir des informations système reçues, dans lequel le deuxième espace de recherche est un espace de recherche commun ; et
recevoir (S130) des informations système supplémentaires dans le premier espace de recherche avec une deuxième numérologie différente de la première numérologie, dans lequel la deuxième numérologie est indiquée dans les informations système reçues et les informations système supplémentaires comprennent des références à un ou plusieurs espaces de recherche additionnels.

9. Station de base, BS, pour permettre de multiples numérolologies dans un réseau, dans lequel une numérologie désigne un ensemble de paramètres numériques décrivant des aspects de l'interface radio à multiplexage par répartition orthogonale de la fréquence, OFDM, tels qu'un espacement de sous-porteuse, une longueur de symbole OFDM, une longueur de préfixe cyclique, un nombre de symboles par sous-trame ou créneau, une longueur de sous-trame et une longueur de trame, la BS (2) comprenant :

un processeur (20) ; et
un programme informatique (22, 23) stockant des instructions qui, lorsqu'elles sont exécutées par le processeur, amènent la BS à :

envoyer (S210) des informations système sur un canal de diffusion avec une première numérologie ; et
envoyer (S220) des informations système supplémentaires dans un premier espace de recherche avec une deuxième numérologie différente de la première numérologie,

dans lequel le premier espace de recherche est un espace de recherche commun, dans lequel la deuxième numérologie est indiquée dans les informations système envoyées et les informations système supplémentaires comprennent des références à un ou plusieurs espaces de recherche additionnels.

10. Programme informatique (14, 15) pour permettre de multiples numérolologies dans un réseau, dans lequel une numérologie désigne un ensemble de paramètres numériques décrivant des aspects de l'interface radio à multiplexage par répartition orthogonale de la fréquence, OFDM, tels qu'un espacement de sous-porteuse, une longueur de symbole OFDM, une longueur de préfixe cyclique, un nombre de symboles par sous-trame ou créneau, une longueur de sous-trame et une longueur de trame, le programme informatique comprenant un code de programme informatique qui, lorsqu'il est exécuté sur un équipement utilisateur, amène l'équipement utilisateur à mettre en oeuvre le procédé selon l'une quelconque des revendications 1 à 5.

11. Programme informatique (24, 25) pour permettre de multiples numérolologies dans un réseau, dans lequel une numérologie désigne un ensemble de paramètres numériques décrivant des aspects de l'interface radio à multiplexage par répartition orthogonale de la fréquence, OFDM, tels qu'un espacement de sous-porteuse, une longueur de symbole OFDM, une longueur de préfixe cyclique, un nombre de symboles par sous-trame ou créneau, une longueur de sous-trame et une longueur de trame, le programme informatique comprenant un code de programme informatique qui, lorsqu'il est exécuté sur une station de base, amène la station de base à mettre en oeuvre le procédé selon la revendication 6 ou 7.

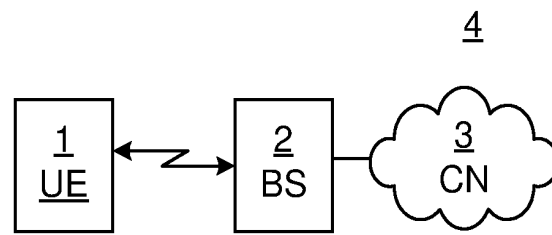


Fig. 1

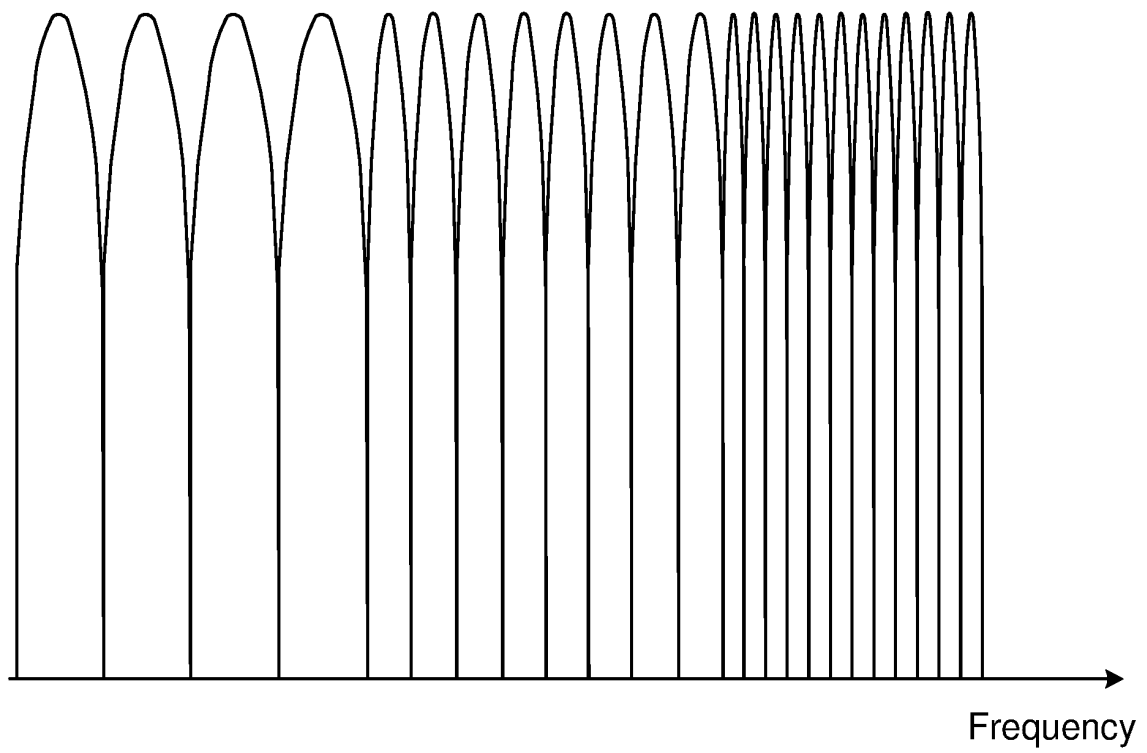


Fig. 2

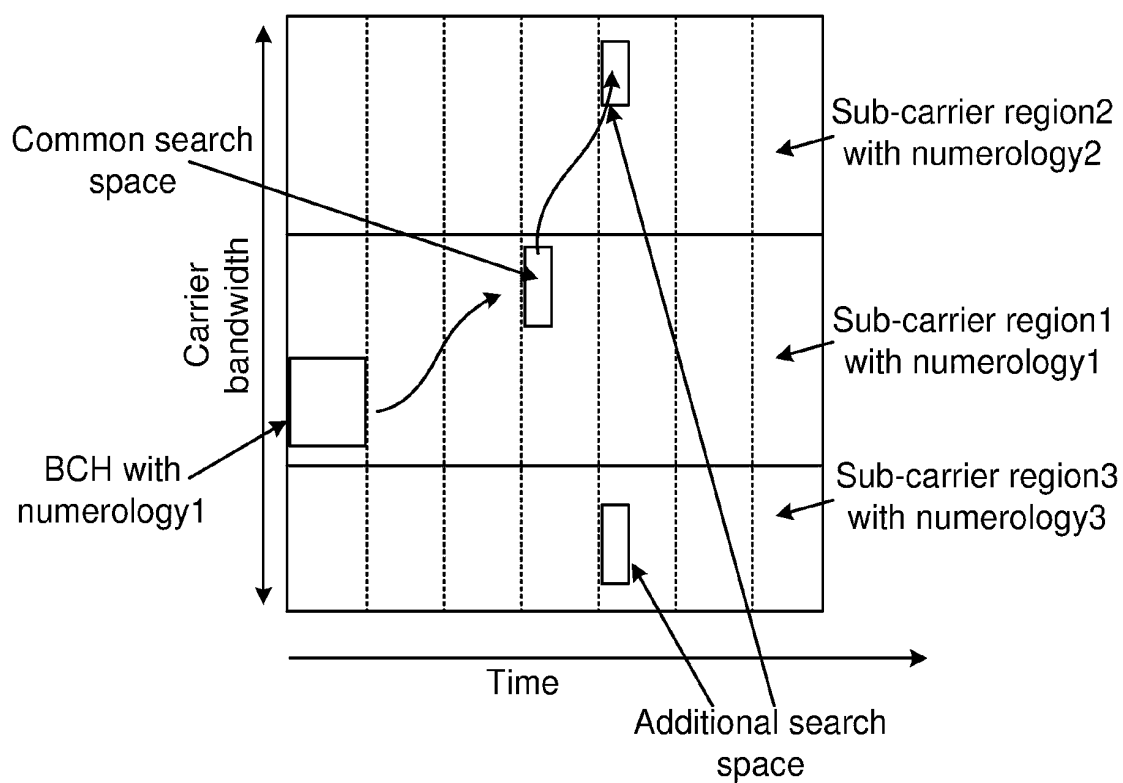


Fig. 3

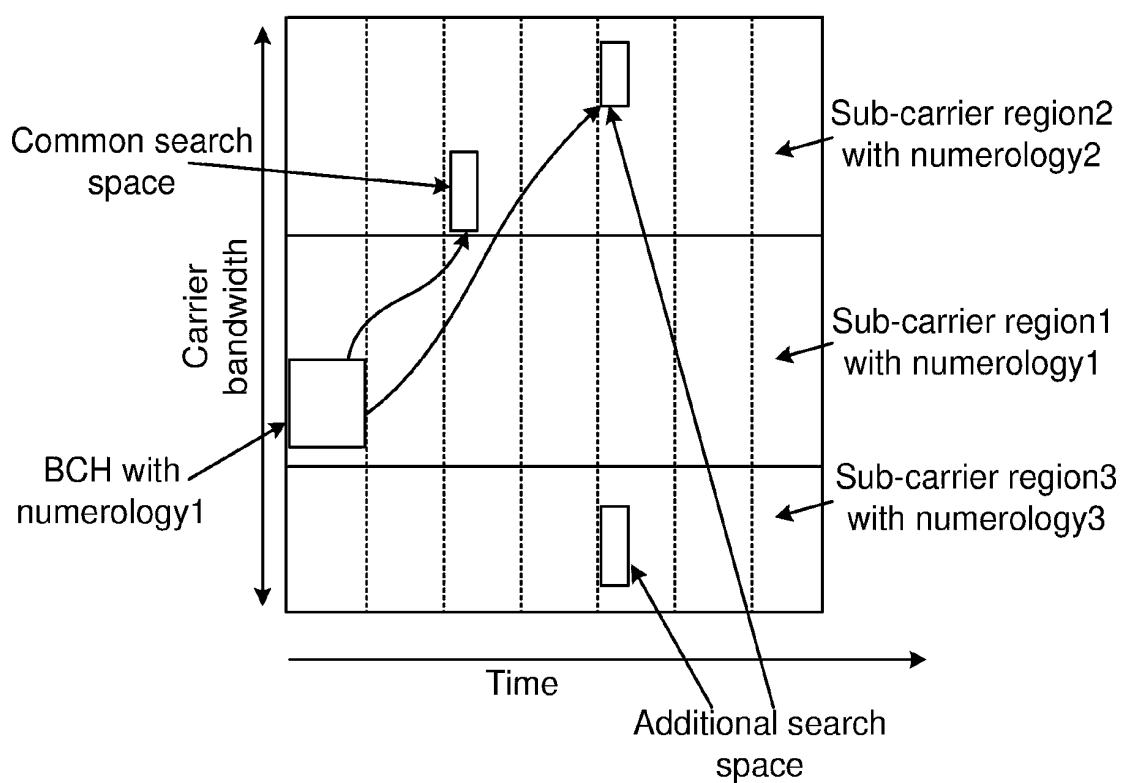


Fig. 4

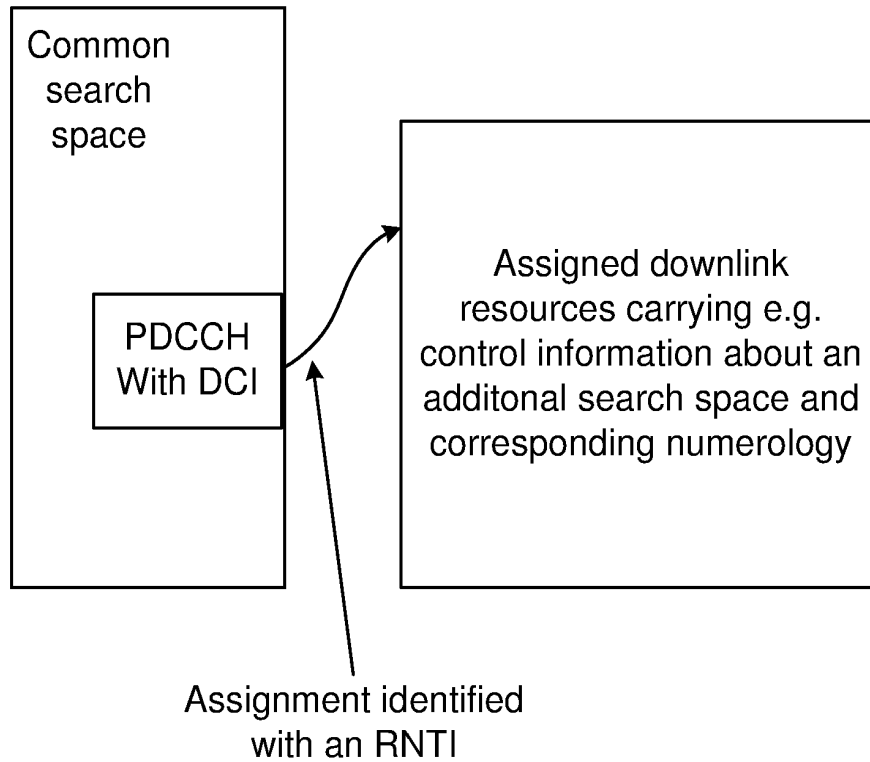


Fig. 5

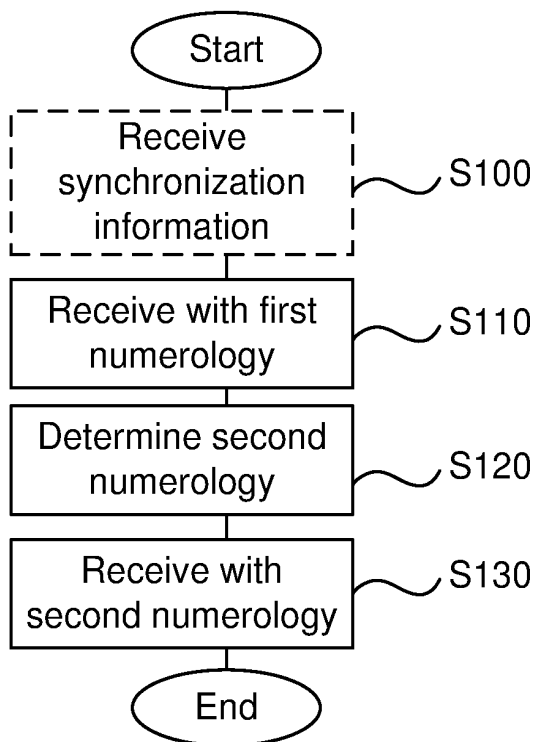


Fig. 6A

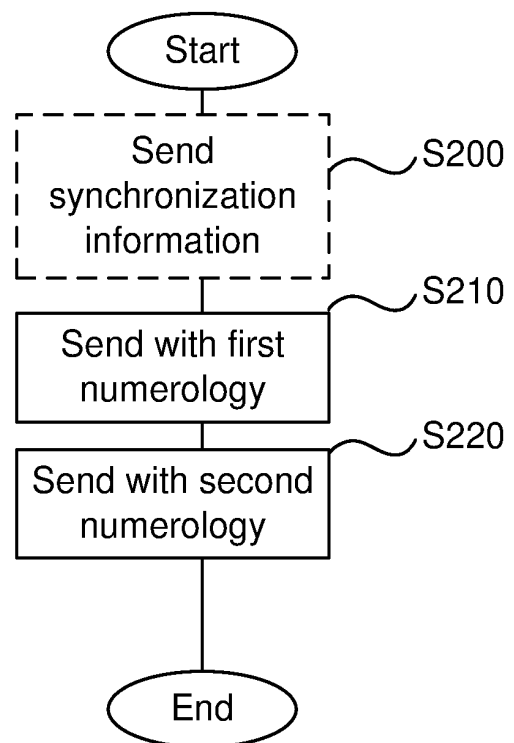


Fig. 6B

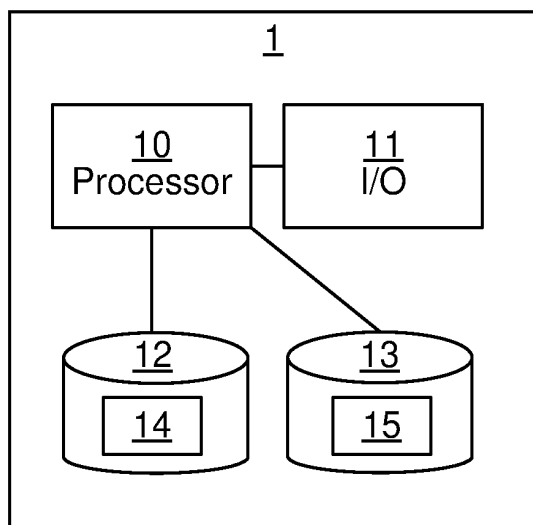


Fig. 7

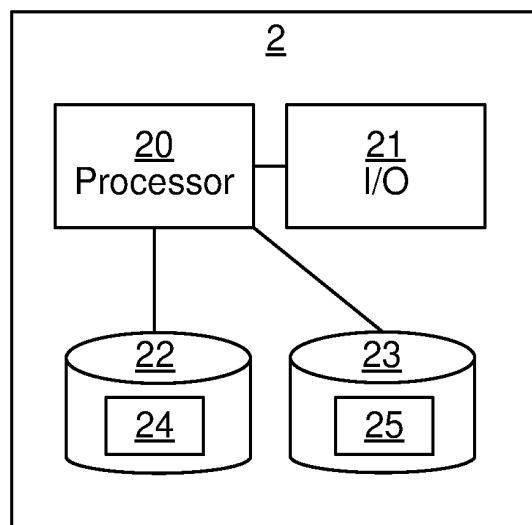


Fig. 8

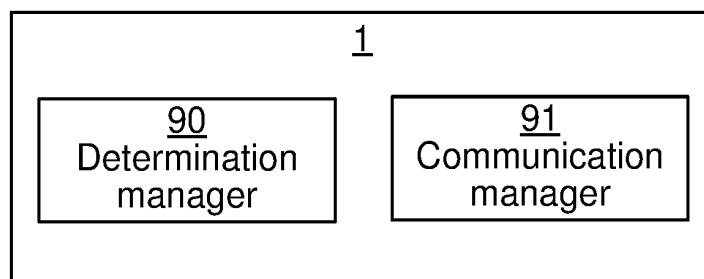


Fig. 9

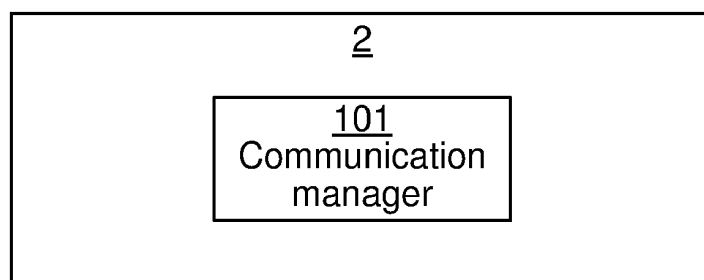


Fig. 10

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Gaceta 2017/51)

(54)

PERMITIR MÚLTIPLES NUMEROLOGIAS EN UNA RED

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SE 112 29 Estocolmo (SE) • LARSSON, Daniel SE-226 47 Estocolmo (SE) (74) Representante: Ericsson Patent Development Torshamnsgatan 21-23 164 80 Estocolmo (SE) (56) Referencias citadas: WO-A1-2016/130175 2014/165678	ASPECTOS DE CANAL DE CONTROL PARA COBERTURA MEJORADA MTC UE, PROYECTO DE SOCIEDAD DE 3ª GENERACION (3GPP), CENTRO DE COMPETENCIA MOVIL; 650, ROUTE DES LUCIOLES; F-06921 SOPHIA-ANTIPOLIS CED, vol. RAN WG1, no. Guangzhou, China; 20131007 – 20131011 28 de septiembre de 2013 (2013-09-28), XP050717733, Recuperado del Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_74b/Docs/ [recuperado el 2013-09-28] • QUALCOMM INCORPORATED: “Consideraciones de diseño PBCH”, 3GPP DRAFT; R1-1700788 CONSIDERACION DE DISEÑO PBCH, PROYECTO DE SOCIEDAD DE 3ª GENERACION (3GPP), CENTRO DE COMPETENCIA MOVIL; 650, ROUTE DES LUCIOLES; F-06921 SOPHIA-ANTIPOLIS CEDEX; FRANCIA, vol. RAN WG1, no. Spokane, EE.UU.; 20170116 – 20170120 16 de enero de 2017 (2017-01-16), XP051208309, Recuperado del Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [recuperado el 2017-01-16]
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REIVINDICACIONES

1. Un método para habilitar múltiples numerologías en una red, en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la interfaz de radio de multiplexación por división de frecuencia ortogonal (OFDM), como el espaciado de subportadoras, la longitud de los símbolos OFDM, la longitud del prefijo cíclico, la cantidad de símbolos por subtrama o ranura, la longitud de la subtrama y la longitud de la trama, el método es realizado por un equipo de usuario, UE, y comprende:
recibir (S110) información del sistema en un canal de difusión con una primera numerología;
determinar (S120) un primer espacio de búsqueda a partir de la información del sistema recibida, donde el primer espacio de búsqueda es un espacio de búsqueda común; y
recibir (S130) información adicional programada en el primer espacio de búsqueda con una segunda numerología diferente de la primera numerología, en donde la segunda numerología se indica en la información del sistema recibida y la información adicional del sistema comprende referencias a uno o más espacios de búsqueda.
2. El método de acuerdo con la reivindicación 1, en el que la etapa de recibir (S110) comprende además detectar información del sistema.
3. El método de acuerdo con una cualquiera de las reivindicaciones 1 a 2, que comprende:
recibir información de sincronización (S100) para un canal de difusión antes de recibir (S110) en el canal de difusión.

4. El método de acuerdo con cualquiera de las reivindicaciones precedentes, en el que la información adicional programada del sistema en el primer espacio de búsqueda es una o más de las siguientes: programación de información de paginación, respuestas de acceso aleatorio, programación de espacios de búsqueda adicionales.

5. El método de acuerdo con una cualquiera de las reivindicaciones 1 a 4, en el que la etapa de determinación comprende además determinar un segundo espacio de búsqueda con una tercera numerología.

6. Un método para habilitar múltiples numerologías en una red, en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la interfaz de radio de multiplexación por división de frecuencia ortogonal (OFDM), como el espaciado de subportadoras, la longitud de los símbolos OFDM, la longitud del prefijo cíclico, la cantidad de símbolos por subtrama o ranura, la longitud de la subtrama y la longitud de la trama, el método es realizado por una estación base, BS, y comprende:
enviar (S210) información del sistema en un canal de difusión con una primera numerología; y
enviar (S220) información adicional en un primer espacio de búsqueda con una segunda numerología diferente de la primera numerología, en donde la segunda numerología se indica en la información del sistema recibida y la información adicional del sistema comprende referencias a uno o más espacios de búsqueda.

7. El método de acuerdo con la reivindicación 6, en el que el primer espacio de búsqueda se indica en la información del sistema enviada.

8. Un equipo de usuario (UE) para habilitar múltiples numerologías en una red,

en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la interfaz de radio de multiplexación por división de frecuencia ortogonal (OFDM), como el espaciado de subportadoras, la longitud de los símbolos OFDM, la longitud del prefijo cíclico, la cantidad de símbolos por subtrama o ranura, la longitud de la subtrama y la longitud de la trama, el equipo de usuario UE (1) comprende:

un procesador (10); y un programa de computadora (12, 13) que almacena instrucciones que, cuando son ejecutadas por el procesador, hacen que el UE:

reciba (S110) información del sistema en un canal de difusión con una primera numerología;

determine (S120) un primer espacio de búsqueda a partir de la información del sistema recibida, donde un primer espacio de búsqueda es un espacio de búsqueda común; y

reciba (S130) información adicional del sistema en el primer espacio de búsqueda con una segunda numerología diferente de la primera numerología, en donde la segunda numerología se indica en la información del sistema recibida y la información adicional del sistema comprende referencias a uno o más espacios de búsqueda.

9. Una estación base (BS) para habilitar múltiples numerologías en una red, en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la interfaz de radio de multiplexación por división de frecuencia ortogonal (OFDM), como el espaciado de subportadoras, la longitud de los símbolos OFDM, la longitud del prefijo cíclico, la cantidad de símbolos por subtrama o ranura, la longitud de la subtrama y la longitud de la trama,

la BS (2) que comprende:

un procesador (20); y un programa de computadora (22, 23) que almacena instrucciones que, cuando son ejecutadas por el procesador, hacen que la BS:

envíe (S210) información del sistema en un canal de difusión con una primera numerología; y

envíe (S220) información adicional en un primer espacio de búsqueda con una segunda numerología diferente de la primera numerología, en donde el primer espacio de búsqueda es un espacio de búsqueda común, en donde la segunda numerología se indica en la información del sistema enviada y la información adicional del sistema comprende referencias a uno o más espacios de búsqueda adicionales.

10. Un programa de computadora (14, 15) para habilitar múltiples numerologías en una red, en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la multiplexación por división de frecuencias ortogonales, OFDM, interfaz de radio, tales como espaciado entre subportadoras, longitud de símbolo OFDM, longitud de prefijo cíclico, número de símbolos por subtrama o ranura, longitud de subtrama y longitud de trama, el programa de computadora comprende un código de programa de computadora que, cuando se ejecuta en un equipo de usuario, hace que el usuario equipo para realizar el método de cualquiera de las reivindicaciones 1 a 5.

11. Un programa de computadora (24, 25) para habilitar múltiples numerologías en una red, en donde la numerología se refiere a un conjunto de parámetros numéricos que describen aspectos de la multiplexación por división de frecuencia ortogonal, OFDM, interfaz de radio, tales como espaciado entre subportadoras, longitud de símbolo OFDM, longitud de prefijo cíclico, número de símbolos por subtrama o ranura, longitud de subtrama y longitud de trama, el programa de computadora comprende un código de programa de computadora que, cuando se ejecuta en una estación base, causa el estación base para realizar el método de la reivindicación 6 o 7.

Agenda item: 5.1.1.2
Source: Qualcomm Incorporated
Title: PBCH design considerations
Document for: Discussion/Decision

1. Introduction

This contribution provides our high-level synchronization design for the NR. More specifically, we present a unified PBCH design for all NR frequency bands. Our companion contributions, listed below, cover other aspects of the synchronization design:

- [1] presents our synchronization raster design
- [2] presents our proposed synchronization signal bandwidth and multiplexing
- [3] presents our views on the synchronization periodicity
- [4] presents synchronization signal design and considerations
- [5] presents PBCH channel coding considerations

2. Overview

It is important to discuss the design requirements for the synchronization signals before going into more detailed discussion on sequence and signal design. More specifically, we summarize our views on such design requirements and considerations for synchronization signals (SS) and physical broadcast channels in Table 1.

Table 1: Synchronization signal design requirements

Aspects	Below 6GHz Requirements	Above 6GHz Requirements
Use cases	- Initial access - Mobility/RRM - Beam tracking - Frequency tracking loop for narrow band mode	
Synchronization signal frequency raster	The larger the synchronization signal frequency raster, the lower the initial access latency. Furthermore, the synchronization raster should allow synchronization signal sub-carriers to be aligned with subcarriers of data/control channels (discussed in [1])	
Initial access vs. mobility synchronization signals	- Periodicity is the same for both initial access and mobility SS - Waveform is the same for both initial access and mobility SS - SS block may not always contain PBCH e.g., measurement RS (MRS) may be in the locations of PBCH instead [6]. MRS is for additional beam tracking and measurement	
Time footprint	- SS block should fit into slots of different numerologies up to 60kHz slot - SS block should not overlap with uplink common burst (ULCB) and downlink common burst (DLCB) for simple implementation and desired L1 latency e.g., 250us. ▪ SS block should not overlap ULCB for not blocking uplink transmission. ▪ Theoretically it is possible to use DLCB for SS block but it is much cleaner not to touch DLCB for smooth common control RS processing and PDCCH processing. In particular, if SS block overlaps with DLCB, UE has to adjust PDCCH search space for the slots containing SS block.	

Synchronization signal bandwidth (MHz)	Less than 5MHz	Less than 40MHz
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As RAN1 suggested, we should aim to have a unified NR synchronization design across different frequency bands. In this contribution we provide our proposal where we have a unified design for the synchronization signal waveforms and the SS block, while the bandwidth and subcarrier spacing of the synchronization signals may be band-dependent.

More specifically, the NR frequency bands may be classified into two categories:

- **Band category A:** Synchronization signal has synchronization signal bandwidth 4.32MHz and synchronization signal SCS of 30KHz
- **Band category B:** Synchronization signal has synchronization signal bandwidth 34.56MHz and synchronization signal SCS of 240KHz

The synchronization signal bandwidth, synchronization signal frequency raster and numerology are summarized in Table 2, which are discussed in [1].

Table 2: Synchronization signal bandwidth and numerology

Parameter	Band Cat A	Band Cat B
Minimum carrier bandwidth (MHz)	5	80
Synchronization signal bandwidth (MHz)	4.32	34.56
Sub-carrier spacing (kHz)	30	240

A synchronization signal block consists of one OFDM symbol for the primary synchronization signal (PSS) and one OFDM symbol for the secondary synchronization signal (SSS). Furthermore, the synchronization signal block may contain two OFDM symbols for the physical broadcast channel (PBCH). The synchronization signals and the physical broadcast channel within a synchronization signal block are time-multiplexed as provided Figure 1.

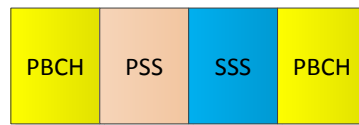


Figure 1: Unified NR synchronization signal block design

The synchronization signal sequences are identical across frequency bands. However, the subcarrier spacing of the synchronization signals is band-dependent per Table 2, as discussed in [1]. Table 3 provides our design consideration for both synchronization signals and PBCH within a synchronization signal block. The design of synchronization signals are discussed in [4].

Table 3: Design parameters of one Synchronization signal block

Design parameters	PSS	SSS	PBCH
The maximum number of sub-carriers	144	144	144
The number of OFDM symbols	1	1	2
Sequence length (or the number of used sub-carriers)	127	Up to 128 depending on SSS design	Up to 128

2. NR PBCH Design Considerations

2.1 Numerology, Bandwidth and Multiplexing

The cells transmit PBCH to provide UE with the minimum system information containing essential information and configurations to obtain the system information blocks for initial acquisition procedures. In an initial acquisition procedure, UE first searches for the synchronization signals to synchronize with the cell and then decode PBCH. Since UE has no knowledge on system bandwidth after decoding synchronization signals, similar to legacy LTE PBCH, it is preferred to transmit PBCH at the same synchronization frequency location used to transmit the synchronization signals. Furthermore, PBCH could have the same numerology and bandwidth as the synchronization signals.

Proposal 1: Transmit PBCH at the same synchronization frequency location used to transmit the synchronization signals. Furthermore, PBCH has the same channel bandwidth and numerology as synchronization signals as follows

Parameter	Band Cat A	Band Cat B
Minimum carrier bandwidth (MHz)	5	80
Synchronization signal bandwidth (MHz)	4.32	34.56
Synchronization sub-carrier spacing (kHz)	30	240

A synchronization signal block consists of one OFDM symbol for the primary synchronization signal (PSS) and one OFDM symbol for the secondary synchronization signal (SSS). Furthermore, the synchronization signal block may contain two OFDM symbols for the physical broadcast channel (PBCH) which are identical: one PBCH symbol in the beginning of SS block and the other in the end of SS block. Such two identical PBCH symbols, which are separated by PSS and SSS, allow UE refine the carrier frequency offset (CFO) estimation without first decoding PBCH. More specifically, UE can coarsely estimate the CFO based on synchronization signals and further refine the estimate by two looks of PBCH. The FTL loop based on synchronization signals and PBCH is expected to be good enough for UE to decode PBCH as well as common search space successfully in a narrow band mode e.g., RRC IDLE or RRC CONNECTED INACTIVE states. The pull-in range for FTL is $[-5\text{kHz}, 5\text{kHz}]$ for 30kHz SS/PBCH subcarrier spacing (below 6GHz) and $[-40\text{kHz}, 40\text{kHz}]$ for 240kHz SS/PBCH subcarrier spacing (above 6GHz).

Proposal 2: For synchronization signal (SS) block containing PBCH, the synchronization signals and two identical PBCH symbols are time-multiplexed in such synchronization signal block. Furthermore, one PBCH symbol is in the beginning of SS block and the other is in the end of SS block.

2.2 PBCH Transmission Diversity

The encoding and modulation of PBCH payload (e.g., MIB) could follow the same techniques used in LTE PBCH. From transmission perspective, the PBCH could be transmitted over multiple antenna ports for transmit diversity and coverage enhancement. In LTE, PBCH could be transmitted over single port or multiple antenna ports (e.g., 2 ports and 4 ports). At the UE side, UE performs blind detection on the number of antenna ports, which could cause unnecessary PBCH decoding latency and complexity.

For NR, it is preferred to have the information on the number of antenna ports to be available to UE for reduction in PBCH decoding latency and complexity. For example, the PBCH could be transmitted over two antenna ports only using SFBC. Another transmit diversity option is small CDD (SCDD). In addition, for high reliability, PBCH could be repeated over multiples of synchronization periodicity.

Proposal 3: For PBCH transmission, the number of antenna ports used for PBCH transmission should be available to UE for reduction in PBCH decoding latency and complexity.

2.3 PBCH redundancy versions and SS block timing indication

Similar to LTE, PBCH can explicitly carry part of system timing (e.g. SFN). Then remaining timing information – such as LSB bits of SFN and/or SS block index – can be conveyed implicitly through PBCH RV (redundancy version).

Proposal 4: SS block index is indicated in NR-PBCH through the RV number.

It is desirable to permit the UE to combine PBCH transmissions from different SS blocks: indeed, multiple beams (even within burst) can excite a cluster and deliver useful signal to the UE. Moreover, multibeam sync design should permit the BS the flexibility in beam shape and beam sweep pattern, and the BS may indeed use wider or even pseudo-omni beams through a burst.

2.4 DMRS for PBCH demodulation

In LTE, cell-specific reference signal (CRS) is broadcast and works as DMRS for demodulating PBCH. However, in NR, CRS might not be broadcast for network power saving and in keeping with lean design principles. The key question is what signal could be utilized as demodulation RS for decoding NR PBCH. In this proposal, we propose to use the secondary synchronization signal (SSS) as DMRS for PBCH demodulation. Although SSS and PBCH are always transmitted in the same synchronization signal block, they should be sent over the same antenna ports so that SSS could be used as demodulation RS for PBCH.

Proposal 5: For PBCH demodulation, SSS can be used as a reference signal for PBCH. In particular, SSS and PBCH are transmitted over the same antenna port(s).

3. System Information Delivery

PBCH payload contains MIB which provides common control resource set/common search space configuration or provides common control resource set configuration to derive common search space [7]. After decoding the common search space, UE can obtain the minimum system information blocks (MSIB) which contains RACH configurations. Other information elements to be conveyed in MIB can be

- System frame number (SFN)
- Duplexing mode (TDD vs. FDD)
- (FFS) SI value tag

Proposal 6: PBCH payload contains MIB which provides common control resource set/common search space configuration or provides common control resource set configuration to derive common search space.

4. PBCH Performance Evaluation

4.1 Simulation Assumptions

Below we provide preliminary PBCH link-level with SFBC, on CDL-C scaled to 30ns DS. Two-port SSS is used as DMRS for PBCH, where each port transmits the LTE SSS sequences and the two ports are CDMed [4]. SSS thus occupies 124 tones. PBCH occupies the same tones as SSS in OFDM symbols containing PBCH (see Figure 1).

4.2 Simulation Results

Figure 2 gives PBCH BLER for one-shot decoding. BLER is computed for the best beam among the 14 beams swept in an SS burst (see Table 4, AP virtualization). Here, post-beamforming SNR is defined as the SNR seen in 12 RBs (@ 240 kHz SCS), averaged over time and the two UE antenna ports. These results show that PBCH can carry 48 to 72 bits (including CRC). The BLER can further improve with soft combining across SS blocks within a burst and/or across bursts (within the BCH TTI.)

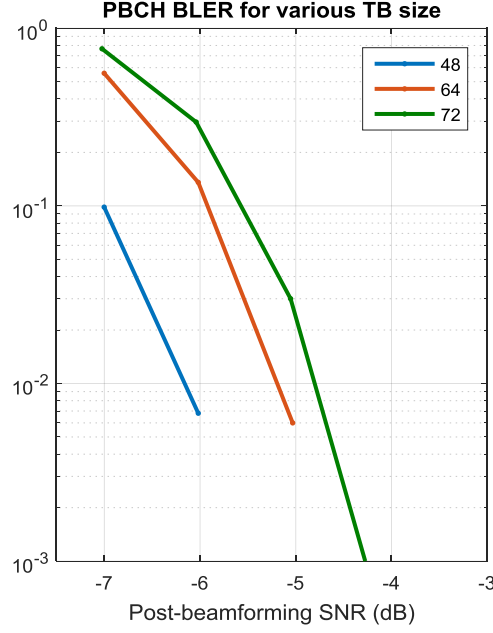


Figure 2: PBCH one-shot decode performance for various TB sizes

5. Conclusion

This contribution has discussed single beam design aspects of PBCH for NR. More specifically, we have the following proposals:

Proposal 1: Transmit PBCH at the same synchronization frequency location used to transmit the synchronization signals. Furthermore, PBCH has the same channel bandwidth and numerology as synchronization signals as follows

Parameter	Band Cat A	Band Cat B
Minimum carrier bandwidth (MHz)	5	80
Synchronization signal bandwidth (MHz)	4.32	34.56
Synchronization sub-carrier spacing (kHz)	30	240

Proposal 2: For synchronization signal (SS) block containing PBCH, the synchronization signals and two identical PBCH symbols are time-multiplexed in such synchronization signal block. Furthermore, one PBCH symbol is in the beginning of SS block and the other is in the end of SS block.

Proposal 3: For PBCH transmission, the number of antenna ports used for PBCH transmission should be available to UE for reduction in PBCH decoding latency and complexity.

Proposal 4: SS Block index is indicated in NR-PBCH through the RV number.

Proposal 5: For PBCH demodulation, SSS can be used as a reference for two-port PBCH. In particular, SSS and PBCH are transmitted over the same antenna ports.

Proposal 6: PBCH payload contains MIB which provides common control resource set/common search space configuration or provides common control resource set configuration to derive common search space.

6. References

- [1]. R1-1700785, “Synchronization signal frequency raster consideration” Qualcomm Incorporated
 - [2]. R1-1700784, “Synchronization signal bandwidth and multiplexing consideration” Qualcomm Incorporated
 - [3]. R1-1700786, “Synchronization signal periodicity consideration,” Qualcomm Incorporated
 - [4]. R1-1700787, “Synchronization signal sequence design consideration” Qualcomm Incorporated
 - [5]. R1-1700837, “PBCH channel coding,” Qualcomm Incorporated
 - [6]. R1-1700793, “DL based Mobility measurement consideration,” Qualcomm Incorporated
 - [7]. R1-1700816, “Common control resource set and UE-specific control resource set,” Qualcomm Incorporated
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Appendix

Table 4: Link-level evaluation assumptions

	Below 6GHz	Above 6GHz
Carrier Frequency	4 GHz	30 GHz
Channel Model	CDL-C, with delay scaling of 100, 300 and 1000 ns ASA = 5 degree, ASD = 30 degree, ZSA = 5 degree, ZSD = 1 degree The CDL table is translated so that the strongest cluster's AoD and AoA occur at a random angle for both the antenna panels of TRP and UE in the local coordinate. The value of the random angle is selected to be uniformly distributed from +30 to -30 degree. The random value is chosen independently for both AoD and AoA	CDL-C, with delay scaling of 30 ns
Subcarrier Spacing(s)	30 KHz	240 KHz
SNR range	> -8dB	[post-beamforming] > -7dB
UE speed	3 km/h	3 km/hr, 100 km/hr
Search window	The time window to search (correlate) NR-PSS = periodicity of NR-SS transmission = 5 msec.	
Antenna Configuration at the TRP	(1,1,2) with omni-directional antenna element	(4,8,2), with directional antenna element (HPBW=65°, directivity 8dB)
Antenna Configuration at the UE	(1,1,2) with omni-directional antenna element	(2,4,2), with directional antenna element (HPBW=90°, directivity 5dB)
Antenna port virtualization		BS beam sweep: sweeping 14 directions in Azimuth, directed towards 100 degree in Elevation UE beam pattern: pseudo-omni
Frequency Offset	zero	
Phase Rotation Model		Follow the PN model of [R1-165005]
Number of interfering TRPs	0 TRP	

Source: Ericsson
Title: Control channel aspects for enhanced coverage MTC UE
Agenda Item: 7.2.2.2.4
Document for: Discussion and Decision

1 Introduction

One of the objectives of the recently started Rel-12 work item on “Low cost & enhanced coverage MTC UE for LTE” [1] is to specify coverage improvements corresponding to 15 dB for FDD. The specified coverage improvement techniques should also be applicable for TDD.

In contribution [2] we discuss the required link budget improvement for each physical signal/channel in FDD. For PDCCH with DCI format 1A, the required improvement is found to be around 13.6 dB (assuming 4 dB loss from single Rx) for the new low-complexity UE type with a single receive antenna and 9.6 dB for other LTE UEs. Since the PDCCH common search space needs to be received by all UE types, a 13.6 dB coverage improvement on PDCCH (with the payload corresponding to DCI format 1A) needs to be the design target.

If fast physical layer HARQ is supported also in extended coverage mode feedback on decoding is needed. Current coverage of PUCCH and PUSCH is not sufficient to provide this feedback without improvements.

In this contribution we give an overview of options on how to achieve the needed coverage enhancements.

2 Overview of legacy operation

The downlink control channels, PDCCH and EPDCCH, are today used to convey scheduling information to the UE both for UE specific and broadcast signalling. When considering coverage extension of scheduling functionality, a number of different control channel use cases need to be considered which currently are handled by the common or UE specific search space.

When a UE detects a new cell it first reads the MIB on PBCH which contains the necessary information to decode the PDCCH common search space. The PDCCH transmitted in subframe #5 in even radio frames is then subsequently used to find the format and resource allocation used for the SIB 1 transmission. Based on the parameter *schedulingInfoList* carried by SIB 1, the subframes where the other SIBs may be transmitted becomes known. The UE must in these subframes detect if an SI message is sent and the corresponding format and resource.

The UE must also monitor the common search space for P-RNTI in subframes valid for paging. After a PRACH transmission the UE monitors common search space for a pre-configured time for a RA-RNTI to detect the network response. After sending MSG3 the UE monitors both common and UE-specific search space for contention resolution.

A UE in connected mode monitors both common and dedicated search space unless in DRX. Finally, MBMS service area info updates is also notified over the downlink control channel.

Observation:

- *A new common search space for extended coverage is needed to maintain system functionality.*

Proposal:

- *Introduce a new common search space at least carrying the P-RNTI, M-RNTI and C-RNTI.*
 - o *FFS on need for other functionality depend on RACH and SI procedure design*

3 Discussion on DCI coverage

In this section we discuss the possibility to extend the coverage of DCI messages. We keep the discussion general at this point and do not make an assumption on whether EPDCCH or PDCCH is the physical channel used for the transmission. A few possibilities are then available:

- Reduce the amount of DCI information
- Relax the required error rate
- Increase the amount of resources, either
 - Physical resources (e.g. in time, across subframes)
 - Transmission power (power resources)

3.1 Reduced DCI size

The link budget calculations made during the study item [3] assumed a bandwidth of 10 MHz. For this bandwidth a format 1A DCI constitutes 43 bits including CRC. Format 1A gives scheduling flexibility in modulation and coding, HARQ process mapping and other things that may not be needed for a device in bad coverage, so with optimizations a few bits could probably be removed. If and what bits that can be removed depends on the design of the uplink and downlink data channels. Reduction of payload bits implies definition of a new DCI format and thus comes at the cost in complexity of supporting additional DCI formats and loss of flexibility in scheduling. For instance, a restriction in resource allocation should be clearly motivated to not unnecessarily put restrictions on the scheduling flexibility.

An additional way to reduce the message size is to reduce the CRC size. This could be motivated if the search space is significantly reduced such that false detection rate does not go up significantly. With significantly larger aggregation levels the number of blind decodes per subframe may very well decrease just due to lack of potential resources. It should be noted that if message sizes are reduced this may also bring an increase in the false detection probability. False detection has a negative impact on UE power consumption and may increase the overall interference in the system. Reducing the search space also reduces the flexibility of scheduling which may increase overhead, power consumption and latency.

Observation:

- ***Reduced CRC size can only be motivated if a smaller search space is defined.***

Broadcast information such as SI-message scheduling can be conveyed using DCI format 1C which has been payload optimized, e.g. for 10 MHz this result in only 27 bits. This gives some guidance on how much a DCI can be reduced with maintained flexibility. If any potential loss in coding gain is excluded this bit reduction results in a 2-dB energy gain compared to format 1A. Format 1C has a limited maximum TBS size of 2216 bits, this TBS size may be sufficient for operation in extended coverage mode however the format lacks an indication between uplink and downlink and HARQ indicator.

Proposal:

- ***Introduce support for PDSCH and PUSCH scheduling with a DCI format smaller than format 1A***
 - ***FFS whether format 1C can be reused***

3.2 Relaxed error probabilities

An “artificial” way of improving a link budget calculation is to change the assumed required quality. For PDCCH the assumption has been that an error rate of 1% should be achieved. Of course it is possible to operate a system with a higher error rate on the scheduling control channel with a higher number of missed assignments as a result. If the error rate assumption was changed to 10%, the link budget would improve with 2-3 dB. Of course a higher error rate would also result in a higher overhead, not only on the control

channel but also on the data channel due to retransmissions. A suitable error rate target must consider latency and overhead, also taking the ratio between data channel and control channel into account. It is hence not directly obvious that a relaxed error target will reduce the resource consumption.

Observation:

- ***Resource consumption for different target error rate depends on the needed control channel resources and the size of the granted resource.***

3.3 Increased (E)PDCCH resources

To improve detection probability the total received message energy needs to be increased. From a standards perspective this is most easily done using power boosting since this can be done transparently for the user.

Power boosting however comes with some limitations. Common search space is sent on PDCCH which has a short duration in time and large span in frequency, and this limits the amount of power adjustments in these OFDM symbols. The EPDCCH has a more suitable design for power boosting.

It should also be noted that the difference is small for a UE in need of a coverage enhancement between boosting power on a narrow bandwidth with a high power spectral density (PSD) and using a larger bandwidth with a lower PSD, since such a UE is noise limited and hence cannot benefit from ICIC gains. PSD boosting also makes other parts of the spectrum difficult to use for other users since the remaining available power resource is reduced.

Common search space on PDCCH carrying scheduling information using format 1C would need about a 10 dB improvement even if we assume some relaxation on the detection probability, to ~10%, providing ~2 dB. This implies that 80 CCEs would be needed if PDCCH is used.

For 10 MHz with 3 symbols for PDCCH a total of about 40 CCEs are available, dependent on PHICH configuration. It is hence obvious that a new or extended common search space design is needed for coverage limited UEs.

Observation:

- ***Current common search space on PDCCH is not sufficient to provide the coverage extension needed even with power boosting.***

The received energy per information bit can be increased by extending the transmission duration in time. This can be achieved with small modifications to the current EPDCCH structure by spanning a DCI message across multiple adjacent subframes, at the cost of increased latency. An aggregation level of 80 could for example be achieved by allocating all eCCEs in a 2 PRB bandwidth over one radio frame. Decoding performance depends on factors such as DCI size as well as channel estimation performance (which could actually be improved compared to the single subframe EPDCCH transmission, if interpolation across subframes is allowed) and link simulations are needed to assess the aggregation levels needed to achieve the targeted coverage. To facilitate also low cost MTC UEs in need of coverage enhancement a limited bandwidth EPDCCH common search space should be supported. If frequency diversity is found to be more important than channel estimation improvement from cross subframe interpolation frequency hopping can be included.

Proposal:

- ***Introduce support for both common and UE specific search space spanning multiple subframes using a EPDCCH-like design.***
 - o ***FFS on the aggregation level needed***
- ***Support a bandwidth limited common search space to facilitate low cost devices.***

Combining all techniques listed is expected to provide the required coverage enhancement summarized in Table 1.

Table 1: Summary of approximate coverage enhancement need and potential

Required coverage enhancement for normal LTE UE	9.6 dB
Required coverage enhancement for low-complexity UE type	13.6 dB
Change from format 1A to 1C	2 dB gain
Relaxed requirements (not preferred)	(2 dB gain)
Power boosting	0-6 dB gain
Larger aggregation levels	6-12 dB gain

Discussion on UCI coverage

For PUCCH format 1a, the required improvement is found to be 8.5 dB. The WID [1] suggests that the coverage improvement should be realized through repetition and/or PSD boosting.

PUCCH is used to convey various lower layer control information from the UE to eNodeB. The necessity to support transmission of this information in the studied scenario was discussed during the study item phase. In summary:

- **CSI:** It is not obvious that CSI will be very useful at least in the worst case scenario where the maximum coverage enhancement is needed. A UE operating in enhanced coverage mode is expected to experience a very bad channel quality. It should also be noted that the CSI reporting will be very slow in case it is repeated many times to improve the coverage. This is not necessarily a problem since the radio channel is also expected to vary very slowly in the studied scenario. However, it is probably sufficient to transmit the CSI inband on UL-SCH if a CSI is needed at all. Link adaptation can also be based on the measured required number of (H)ARQ transmissions for successful transmission. Hence there does not seem to be a strong need for CSI transmission over PUCCH.
- **HARQ-ACK:** The HARQ-ACK feedback loop will also be very slow in case of a large repetition factor. If only one PDSCH TTI is transmitted in every HARQ (re)transmission, the associated PUCCH resource cost for transmitting the HARQ-ACK feedback will be large. However, assuming that TTI bundling (repetition) is used for PDSCH, the associated HARQ-ACK feedback can be kept on a reasonable level. On the other hand, it may be sufficient to rely on an appropriate amount of PDSCH TTI bundling in combination with RLC ARQ (soft combining of RLC transmissions could possibly be considered) and eliminate the feedback for the physical layer HARQ protocol. Then there would not be a need to support HARQ-ACK feedback transmission on PUCCH.
- **SR:** The UE needs to be able to request uplink resources. It is possible for the UE to do this via PRACH if it would not be able to do this by transmitting SR over PUCCH. Requesting resources via SR might be more efficient in the general case, but in the studied scenario the packet inter-arrival time is expected to be low and PRACH may be sufficiently efficient. The need for D-SR depends on possible periodicities of SR and if MTC devices are expected to remain in RRC connected mode between packet arrivals.

Hence it might be possible to do reasonably well without PUCCH support in enhanced coverage mode. At least in the worst case scenario where the maximum coverage enhancement is needed, PUCCH-related functionality can be seen as non-critical optimizations. We note that PUCCH repetition may be particularly challenging in the TDD case; however, if repetition of existing formats is shown to be feasible it can be considered.

Proposal:

- *Coverage enhanced formats for CSI over PUCCH are not introduced.*
- *FFS if downlink transmission formats require HARQ for efficient operation*
- *Ask RAN2 for guidance on the need to support D-SR for extended coverage mode.*

4 Conclusions

In this contribution we list some options on how to improve coverage of the downlink control channel. We observe that changes are needed to the current operation of both common and UE specific search space compared to what is in Rel-11. Based on these observations we make a few proposals:

Proposals:

- *Introduce a new common search space at least carrying the P-RNTI, M-RNTI and C-RNTI.*
 - o *FFS on need for other functionality depend on RACH and SI procedure design*
- *Introduce support for PDSCH and PUSCH scheduling with a DCI format smaller than format 1A*
 - o *FFS whether format 1C can be reused*
- *Introduce support for both common and UE specific search space spanning multiple subframes using a EPDCCH-like design.*
 - o *FFS on the aggregation level needed*
- *Support a bandwidth limited common search space to facilitate low cost devices .*
- *Coverage enhanced formats for CSI over PUCCH are not introduced.*
- *FFS if downlink transmission formats require HARQ for efficient operation*
- *Ask RAN2 for guidance on the need to support D-SR for extended coverage mode.*

References

- [1] RP-130848, "New WI: Low cost & enhanced coverage MTC UE for LTE"
- [2] R1-133420, "Coverage enhancement targets for MTC UE", Ericsson, ST-Ericsson
- [3] TR 36.888, "Study on provision of low-cost MTC UEs based on LTE", V12.0.0 (2013-06)

Source: Panasonic
Title: Use of multiple numerologies in NR
Agenda Item: 8.1.3.1
Document for: Discussion

1 Introduction

In RAN1#85, following was agreed on multiplexing different numerologies.

Agreements:

- Forward compatibility of NR shall ensure smooth introduction of future services and features with no impact on the access of earlier services and UEs
 - Multiplexing different numerologies within a same NR carrier bandwidth (from the network perspective) is supported
 - ✧ FDM and/or TDM multiplexing can be considered

In addition, following on the synchronization signal were agreed.

Agreements:

- For a NR carrier (from network perspective) using multiple numerologies, at least the following is for further study
 - multiple frequency/time portions using different numerologies share a synchronization signal
 - ✧ Note: The synchronization signal refers to the signal itself and the time-frequency resource used to transmit the synchronization signal

This document discusses how to use multiple numerologies as the system.

2 Discussion

We discuss the assumed UE types as NR and then discuss multiple numerologies usage from the synchronization signal to the traffic channels. This would allow the systematic view of multiple numerology usage.

Assumed UE types of different use cases

Some kind of UE type assumption is required in order to determine how and what numerologies/channels are supported. As the first step, we assume following.

- UE supporting only eMBB
- UE supporting only mMTC
- UE supporting both eMBB and URLLC
- UE supporting both eMBB and V2X

UE supporting only eMBB is rather extension of current smart phone or PC usage.

UE supporting only mMTC intends lower cost by reduced bandwidth.

Although UE supports only URLLC would be desirable from usage scenario perspective, we currently assume it also support eMBB as URLLC would requires wideband reception/transmission for the reliable communication and higher performance encoding/decoding capability for shorter latency. We recognize this needs some more discussion.

UE supporting V2X also supports eMBB as we expect V2N or V2I would be based on eMBB. If V2I is modification from URLLC, V2X UE also supports URLLC. V2X supports sidelink.

Proposal 1: Following types of UEs are supported in NR.

- UE supporting only eMBB
- UE supporting only mMTC
- UE supporting both eMBB and URLLC
- UE supporting both eMBB and V2X

Synchronization signals like PSS/SSS

As the synchronization signals, we identified following types of signals.

- Synchronization signals for below 6GHz frequency with licensed band for eMBB and URLLC
- Synchronization signals for millimetre frequency with licensed band for eMBB and URLLC
- Synchronization signals for below 6GHz frequency with unlicensed band for eMBB
- Synchronization signals for millimetre frequency with unlicensed band for eMBB
- Synchronization signals for below 6GHz frequency with coverage extension of mMTC
- Synchronization signals for below 6GHz frequency for sidelink

The reason of the distinction between below 6GHz and millimetre frequency is to support higher phase noise and higher Doppler in millimetre frequency. Then, we assume different subcarrier spacing usage between them. For example, below 6GHz would utilize 15 kHz and millimetre would utilize 60 kHz subcarrier spacing. Synchronization signal design also follows such difference.

The reason of the distinction between licensed and unlicensed band is the synchronization signal in licensed band can be periodically transmitted to minimize the overhead. Such periodic transmission would improve the receiver performance by energy combining of multiple signals. On the other hand, unlicensed band does not allow such periodic transmission as the time/frequency resource needs to be shared with the other usages. Therefore, similar to LAA, the synchronization signal to allow one-shot detection is required. Such signal would require rather wideband transmission for the reliability of one shot detection. Instead of the frequency diversity of one-shot wideband transmission, synchronization signal in licensed band can obtain time diversity because of the periodic transmission.

We assume URLLC is used for licensed band in order to have predictable time/frequency resource availability. Therefore, URLLC with unlicensed band is not considered.

Although we listed separate type as synchronization signal with coverage extension of mMTC, we are not yet sure whether separate signal is required. Similar to eMTC and LTE relation, synchronization signal for below 6GHz frequency with licensed band could be reused. As to allow NB-IoT in NR carrier bandwidth seems common understanding in NR session, mMTC could be more similarity with eMTC in LTE regarding supported bit rate and reliance on NR design like sharing the synchronization signal from eMBB.

Synchronization signal for sidelink is necessary as it is transmitted by UE. Even if the side link is operated by GNSS like GPS as the synchronization source, it needs to support the operation when GNSS is not available such as under the tunnels.

Note that to have the commonality among all channels is desirable.

According to above discussion, we propose following.

Proposal 2: To have following types of synchronization signals

- Synchronization signals for below 6GHz frequency with licensed band for eMBB and URLLC
- Synchronization signals for millimetre frequency with licensed band for eMBB and URLLC
- Synchronization signals for below 6GHz frequency with unlicensed band for eMBB
- Synchronization signals for millimetre frequency with unlicensed band for eMBB
- FFS: Synchronization signals for below 6GHz frequency with coverage extension of mMTC
- Synchronization signals for below 6GHz frequency for sidelink

MIB and SIB1

After UE detects the synchronization signal, UE receives MIB (=PBCH) like signal, which is minimum amount of the broadcast information. The subcarrier spacing of MIB is fixed relation to the synchronization signal. For example, if 15 kHz subcarrier spacing is used for the synchronization signal, MIB also uses 15 kHz subcarrier spacing. If 60 kHz subcarrier spacing is used for the synchronization signal, MIB also uses 60 kHz subcarrier spacing.

Whether to separate MIB and SIB1 or to merge MIB and SIB1 is FFS. In order to minimize the constant fixed time frequency resource usage, to minimize MIB size and separate SIB1 is desirable. On the other hand, to split MIB and SIB1 means the cell detection procedure delay increases. This trade-off needs to be evaluated further. The amount of SIB would follow the discussion outcome of RAN2, like minimum system information and on-demand system information [2].

After the reception of MIB, for UE receiver, FFT bandwidth and frequency position for SIB1 and SIBx reception need to be known. If MIB and SIB1 are merged, FFT bandwidth and frequency position for remaining SIBs reception need to be known to UE. In case of MIB and SIB1 split, the centre carrier used by UE may be same between MIB and SIB1. In case of mMTC, SIB1 may be frequency hopped and the centre carrier position also varies based on the hopping pattern. These FFT bandwidth and frequency position could be used for other reception like paging, random access response, unicast DCI and PDSCH.

After MIB reception or after SIB1 reception, the numerology and time/frequency resource of DCI common search space needs to be known to UE. Then, the other system information can be signalled by DCI common search space.

Proposal 3: Subcarrier spacing used for MIB is known by synchronization signal to UE.

Proposal 4: Whether and how to split between MIB and SIB1 is FFS.

Proposal 5: After the reception of MIB, for UE receiver, FFT bandwidth and frequency position for system information reception is known. These FFT bandwidth and frequency position could be used for other reception like paging, random access response, unicast DCI and PDSCH.

Proposal 6: After the reception of MIB and/or SIB1, the numerology and time/frequency resource of DCI common search space is known to UE.

Beam and PCI

In millimetre frequency context, to extend the coverage by beamforming is one of the required technique. The system should support following two operations.

Case 1) each beam has dedicated PCI and dedicated MIB/SIB1.

Case 2) multiple beams share the same PCI and share MIB/SIB1.

Case 1 is something similar to sector operation. Case 2 is something similar to CSI-RS id based distinction. Which case is used is up to the network operation and the system should support both cases. Note that one beam may be limited time/frequency resource usage only as the beam could sweep analogue manner and/or digital manner.

Proposal 7: Related to beamforming, following two cases are supported. Each beam may use only limited time/frequency resource.

Case 1) each beam has dedicated PCI and dedicated MIB/SIB1.

Case 2) multiple beams share the same PCI and share MIB/SIB1.

DCI common search space

From UE side, DCI common search space time/frequency location is known after MIB or SIB1 reception. On the other hand, from the network perspective, the time frequency resource used by DCI common search space is not required to be utilized by only certain numerology. If other than UE's expected numerology is used, the blind decoding attempt by UE is just failed. Therefore, dynamic numerology change is also possible for time/frequency resource used by DCI common search space.

Proposal 8: Although numerology and time/frequency resource of DCI common search space is known to UEs, this time frequency resource is not always required to be utilized by the UE's assumed numerology. Only when DCI common search space is utilized by the UE, the network needs to utilize UE's assumed numerology.

Reference signals for MIB/SIB1/system information

Reference signals used for MIB reception are fixed resources. For the minimization of constant resource perspective, this reference should be used for mobility tracking and AFC/AGC purpose. But probably it would not be sufficient. Therefore, some more constant reference signals are required. How much such cell specific reference signals are required need to be evaluated.

Proposal 9: Reference signals for MIB/SIB1/system information can be used for the mobility tracking, AFC and AGC. If necessary, more constant reference for such purpose is increased but should be minimized.

Random access procedure

Numerology and time/frequency resource used by random access channels are informed by system information. Even if preamble-less based random access channel is used, numerology and time/frequency resource used by random access channels are informed by system information. This resource needs to be reserved constantly. Dynamic sharing the resource among numerologies would be difficult. Numerology and time/frequency resource used by random access responses are also informed by the system information. If UE specific numerology and time/frequency resource are used by random access channels, these are configured by UE specific procedure.

Proposal 10: Numerology and time/frequency resource used by non-UE specific random access procedures are informed by system information.

UE specific DCI search space

By the random access procedure, UE specific ID is known to UE. After that, UE specific DCI search space is known to UE (using also the configuration informed by system information). Similar to DCI common search space, although numerology and time/frequency resource of DCI common search space is known to UEs, from the network perspective, this time frequency resource is not always required to be utilized by the UE's assumed numerology. Therefore, dynamic numerology change is possible for time/frequency resource used by UE specific DCI search space.

Proposal 11: Although numerology and time/frequency resource of UE specific search space is known to UEs, from the network perspective, this time frequency resource is not always required to be utilized by the UE's assumed numerology.

Minimum TTI, PRB size and subcarrier spacing

Using higher subcarrier spacing has more symbols in the same time. For example, 60 kHz subcarrier spacing has 4 times OFDM symbols compared with 15 kHz subcarrier spacing in case CP length is also scaled linearly. The minimum PRB size and TTI size are determined to the relation to the traffic size granularity. Therefore, the number of REs in one PRB needs to be roughly constant regardless of the numerology change. N times subcarrier spacing with 1/N minimum TTI length and N times frequency bandwidth of PRB size allows the minimum granularity of the scheduling roughly same. Therefore, to take such approach is reasonable.

If such approach is taken, higher subcarrier spacing can be used for latency reduction.

Proposal 12: In order to have constant granularity of assigned data size, basically, N times subcarrier spacing with 1/N minimum TTI length and N time's frequency bandwidth of PRB size is used.

Proposal 13: Higher subcarrier spacing can be used also for the latency reduction in addition to millimetre frequency usage.

Subcarrier spacing used by DCI and PDSCH

Current our thinking of subcarrier spacing relation of downlink channels is following.

Table 1: Subcarrier spacing relation among DL channels

	Synchronization channels	System information including MIB, random access response, paging	UE specific DCI	PDSCH	Usage
Case 1	15 kHz	15 kHz	15 kHz	15 kHz	eMBB and mMTC for below 6GHz frequency
Case 2	15 kHz	15 kHz	60 kHz	60 kHz	eMBB for below 6GHz frequency with latency reduction
Case 3	15 or 30 or 60 kHz	30 or 60 kHz	30 or 60 kHz	30 or 60 kHz	V2X for below 6GHz frequency
Case 4	60 to 240 kHz order	60 to 240 kHz order	60 to 240 kHz order	60 to 240 kHz order	eMBB and URLLC for millimetre frequency

Case 1 is used for eMBB and mMTC for below 6GHz frequency.

Case 2 is used for eMBB for below 6GHz frequency with latency reduction. Another usage is URLLC. UE specific DCI and PDSCH could be the same OFDM symbol in order to reduce the latency. Therefore, the same subcarrier spacing is used. For UE with latency reduction of eMBB, UE could receive case 1 and case 2 simultaneously for UE specific DCI and PDSCH.

Case 3 usage could be used for V2X for below 6GHz frequency. In order to support higher velocity, higher subcarrier spacing could be useful. Case 3 is FFS.

Case 4 is used for eMBB and URLLC for millimetre frequency.

Proposal 14: To consider table 1 as starting point of subcarrier relations of downlink channels.

Subcarrier spacing used by UCI and PUSCH

Current our thinking of subcarrier spacing relation of uplink channels is following.

Table 2: Subcarrier spacing relation among UL channels

	UCI	PUSCH	Usage
Case 1	15 kHz	15 kHz	eMBB and mMTC for below 6GHz frequency
Case 2	60 kHz	60 kHz	eMBB for below 6GHz frequency with latency reduction
Case 3	30 or 60 kHz	30 or 60 kHz	V2X for below 6GHz frequency
Case 4	3.75 kHz	3.75 kHz	mMTC with large coverage extension
Case 5	60 to 240 kHz order	60 to 240 kHz order	eMBB and URLLC for millimetre frequency

Case 1 is used for eMBB and mMTC for below 6GHz frequency.

Case 2 is used for eMBB for below 6GHz frequency with latency reduction

Case 3 could be used for V2X for below 6GHz frequency. In order to support higher velocity, higher subcarrier spacing could be useful. Case 3 is FFS.

Case 4 is used for mMTC with large coverage extension.

Case 5 is used for eMBB and URLLC for millimetre frequency.

The selection between case 1 and 4 is dynamically signalled by DCI for mMTC.

Random access channel would be specific subcarrier spacing depending on the design.

Proposal 15: To consider table 2 as starting point of subcarrier relations of uplink channels.

Dynamic Broadcasting of numerology partition indication

Based on the discussion above, we have not identified the need of the dynamic broadcasting of numerology partition. Broadcasting of numerology partition restricts future usage of numerology partition as only possible indicatable partitions are supported also in future. In addition, dynamic broadcasting of numerology partition indication requires constant downlink resource. If dynamic broadcasting of numerology partition indication reception is failed by UE, further reception of the channels is failed. Therefore, reliable transmission to all UEs in the cell is required, which is very costly transmission, especially for beam forming usage. Therefore, we propose following.

As broadcasting of dynamic information, resource usage for uplink or downlink might be required although these also be possible by unicast manner. The relation to these channels needs further discussion.

Proposal 16: Dynamic broadcasting of numerology partition indication is not required.

Resource usage

Based on the discussion, the constant transmission of downlink would be following

- synchronization signals, MIB/SIB1, reference signals for the reception of MIB/SIB1 in case of licensed carrier

The following would be required to be constant usage with semi-static configuration

- system information

The following would be possible to be dynamically shared among numerology although UE assumes certain time/frequency resources

- paging, random access response, common DCI search space, UE specific search space

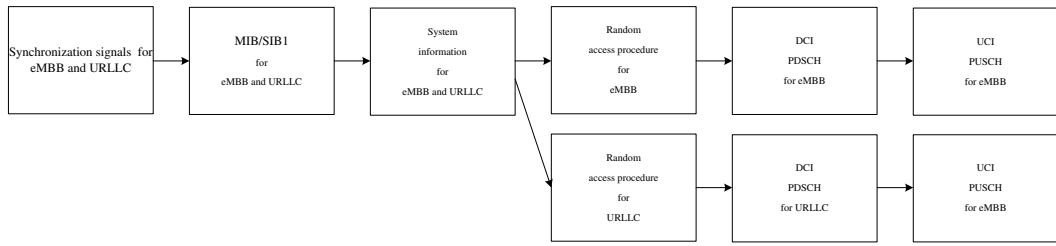
The following would be possible to be dynamically shared among numerology.

- PDSCH, PUSCH, UCI

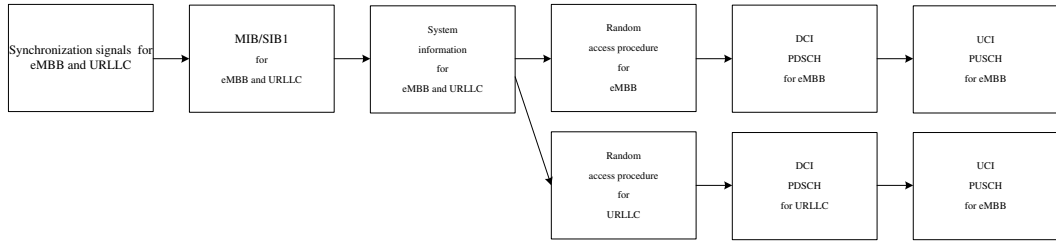
Relation of the channels

Summary of the relation among channels are shown below.

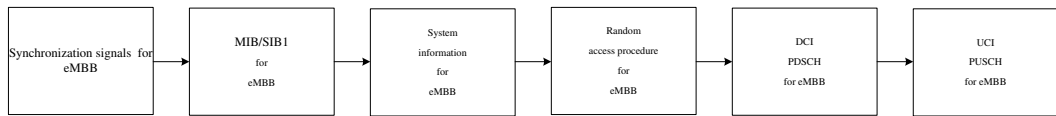
Below 6GHz frequency with licensed band



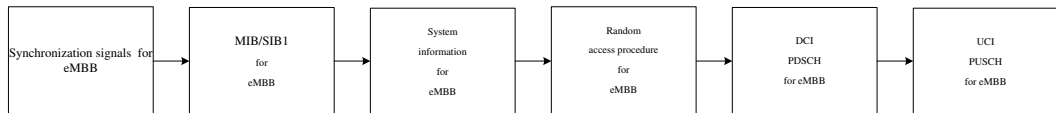
For millimetre wave frequency with licensed band for eMBB and URLLC



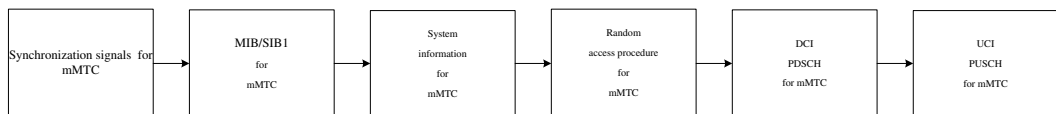
For below 6GHz frequency with unlicensed band for eMBB



For millimetre wave frequency with unlicensed band for eMBB

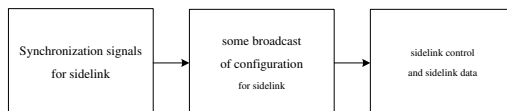


For below 6GHz frequency with coverage extension of mMTC: FFS



Synchronization signals for coverage extension of mMTC is shared with eMBB, MIB would be also shared.

For below 6GHz frequency for sidelink



3 Conclusion

This document discusses how to use multiple numerologies as the system. We propose following.

Proposal 1: Following types of UEs are supported in NR.

- UE supporting only eMBB
- UE supporting only mMTC
- UE supporting both eMBB and URLLC
- UE supporting both eMBB and V2X

Proposal 2: To have following types of synchronization signals

- Synchronization signals for below 6GHz frequency with licensed band for eMBB and URLLC
- Synchronization signals for millimetre frequency with licensed band for eMBB and URLLC
- Synchronization signals for below 6GHz frequency with unlicensed band for eMBB
- Synchronization signals for millimetre frequency with unlicensed band for eMBB
- FFS: Synchronization signals for below 6GHz frequency with coverage extension of mMTC
- Synchronization signals for below 6GHz frequency for sidelink

Proposal 3: Subcarrier spacing used for MIB is known by synchronization signal to UE.

Proposal 4: Whether and how to split between MIB and SIB1 is FFS.

Proposal 5: After the reception of MIB, for UE receiver, FFT bandwidth and frequency position for system information reception is known. These FFT bandwidth and frequency position could be used for other reception like paging, random access response, unicast DCI and PDSCH.

Proposal 6: After the reception of MIB and/or SIB1, the numerology and time/frequency resource of DCI common search space is known to UE.

Proposal 7: Related to beamforming, following two cases are supported. Each beam may use only limited time/frequency resource.

Case 1) each beam has dedicated PCI and dedicated MIB/SIB1.

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Proposal 12: In order to have constant granularity of assigned data size, basically, N times subcarrier spacing with 1/N minimum TTI length and N time's frequency bandwidth of PRB size is used.

Proposal 13: Higher subcarrier spacing can be used also for the latency reduction in addition to millimetre frequency usage.

Proposal 14: To consider table 1 as starting point of subcarrier relations of downlink channels.

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Case 2	15 kHz	15 kHz	60 kHz	60 kHz	eMBB for below 6GHz frequency with latency reduction
Case 3	15 or 30 or 60 kHz	30 or 60 kHz	30 or 60 kHz	30 or 60 kHz	V2X for below 6GHz frequency
Case 4	60 to 240 kHz order	60 to 240 kHz order	60 to 240 kHz order	60 to 240 kHz order	eMBB and URLLC for millimetre frequency

Proposal 15: To consider table 2 as starting point of subcarrier relations of uplink channels.

	UCI	PUSCH	Usage
Case 1	15 kHz	15 kHz	eMBB and mMTC for below 6GHz frequency
Case 2	60 kHz	60 kHz	eMBB for below 6GHz frequency with latency reduction
Case 3	30 or 60 kHz	30 or 60 kHz	V2X for below 6GHz frequency
Case 4	3.75 kHz	3.75 kHz	mMTC with large coverage extension
Case 5	60 to 240 kHz order	60 to 240 kHz order	eMBB and URLLC for millimetre frequency

Proposal 16: Dynamic broadcasting of numerology partition indication is not required.

4 Reference

[1] RP-160671, " New SID Proposal: Study on New Radio Access Technology", NTT DOCOMO

[2] R2-16xxxx, Report of email discussion on [94#40] [NR] System information