(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
20 June 2019 (20.06.2019)

WIPO | PCT

(10) International Publication Number
WO 2019/115861 A1

(51) International Patent Classification:
H04W 72/04 (2009.01) *H04W 72/12* (2009.01)
H04L 5/00 (2006.01) *H04W 72/08* (2009.01)
H04L 27/26 (2006.01) *H04L 27/00* (2006.01)
H04W 16/14 (2009.01)

(21) International Application Number:
PCT/FI2018/050820

(22) International Filing Date:
08 November 2018 (08.11.2018)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/599,043 15 December 2017 (15.12.2017) US

(71) Applicant: NOKIA TECHNOLOGIES OY [FI/FI]; Karaportti 3, 02610 Espoo (FI).

(72) Inventors: TIIROLA, Esa; Kaapelitie 4, 90620 Oulu (FI). HOOLI, Kari; Kaapelitie 4, 90620 Oulu (FI).

(74) Agent: NOKIA TECHNOLOGIES OY et al.; Ari Aarnio, IPR Department, Karakaari 7, 02610 Espoo (FI).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) Title: INTERLACE STRUCTURES

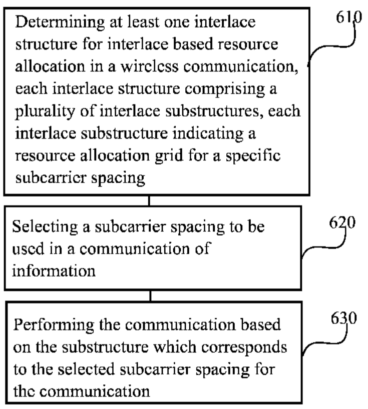

FIGURE 6

(57) Abstract: According to an example aspect of the present invention, there is provided an apparatus comprising at least one processing core, at least one memory including computer program code, the at least one memory and the computer program code being configured to, with the at least one processing core, cause the apparatus at least to determine at least one interlace structure for interlace based resource allocation in a wireless communication, each interlace structure comprising a plurality of interlace substructures, each substructure indicating a resource allocation grid for a specific subcarrier spacing, and wherein a given interlace structure comprises a constant cluster bandwidth among the plurality of substructures, a constant number of interlaces among the plurality of substructures, and a varying number of subcarriers per interlace among the plurality of substructures, to select a subcarrier spacing to be used in a communication of information.

WO 2019/115861 A1

INTERLACE STRUCTURES

FIELD

The present disclosure relates to wireless communication.

BACKGROUND

Wireless communication involves communication of information encoded using a suitable modulation. One or plural carriers may be employed. In a simple example, a sine-wave carrier may be modulated by introducing frequency shifts in the wave. The introduction of such frequency shifts has the effect that the shape of the carrier in frequency space becomes wider in that pure sinewave is a sharp peak in frequency space, whereas a modulated carrier has a non-zero bandwidth in frequency space. Using multiple carriers spreads energy used in transmission over a wider spectrum band.

SUMMARY OF THE INVENTION

According to some aspects, there is provided the subject-matter of the independent claims. Some embodiments are defined in the dependent claims.

According to a first aspect of the present invention, there is provided an apparatus comprising at least one processing core, at least one memory including computer program code, the at least one memory and the computer program code being configured to, with the at least one processing core, cause the apparatus at least to determine at least one interlace structure for interlace based resource allocation in a wireless communication, each interlace structure comprising a plurality of interlace substructures, each substructure indicating a resource allocation grid for a specific subcarrier spacing, and wherein a given interlace structure comprises a constant cluster bandwidth among the plurality of substructures, a constant number of interlaces among the plurality of substructures, and a varying number of subcarriers per interlace among the plurality of substructures, wherein the number of subcarriers per interlace depends on the subcarrier spacing and is, for each of the plurality of substructures, a multiple of a physical resource block size in subcarriers, to select a subcarrier spacing to be used in a communication of information, and to perform the communication based on the substructure which corresponds to the selected subcarrier spacing for the communication.

Various embodiments of the first aspect may further comprise at least one of the features in the following bulleted list:

- in each interlace substructure, each physical resource block comprises 12 subcarriers

- the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to apply spectrum sharing or the listen before talk principle in the transmitting of the information
- the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to conditionally apply a requirement to occupy between 80% and 100% of a declared nominal channel bandwidth for the communication of the information
- the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to perform the communication using a partial interlace comprised in the substructure corresponding to the selected subcarrier spacing
- a number of clusters comprised in the partial interlace is reduced by a power of two compared to the number of clusters in a full interlace.
- the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to determine the number of clusters for the partial interlace such that a number of subcarriers comprised in the partial interlace form an integer number of at least one physical resource block.
- the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to process an allocation where clusters of a given interlace that are comprised in the partial interlace are allocated based on a given resource allocation scheme, and where the part of the given interlace that is not comprised in the partial interlace is allocated based on a different resource allocation scheme.
- the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to process an allocation wherein clusters of a given interlace comprised in the partial interlace are allocated for a first user equipment, and subcarriers on clusters of the given interlace that are not comprised in the partial interlace are allocated for a second user equipment.
- the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to determine that the apparatus need not occupy between 80% and 100% of the declared nominal channel bandwidth, and to responsively apply the partial interlace.
- the apparatus is or is comprised in a user equipment and the transmission is an uplink transmission on an unlicensed band.
- the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to determine the at least one interlace structure by determining a first interlace structure having 240 kHz as the cluster bandwidth, six interlaces, and 12 clusters per interlace, wherein the first interlace

structure comprises a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1152 subcarriers in total and 16 physical resource blocks per interlace, a second substructure corresponding to a subcarrier spacing of 30 kHz and having 576 subcarriers in total and 8 physical resource blocks per interlace, a third substructure corresponding to a subcarrier spacing of 60 kHz and having 288 subcarriers in total and 4 physical resource blocks per interlace, a fourth substructure corresponding to a subcarrier spacing of 120 kHz and having 144 subcarriers in total and 2 physical resource blocks per interlace, and a fifth substructure corresponding to a subcarrier spacing of 240 kHz and having 72 subcarriers in total, and 1 physical resource block per interlace.

- the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to determine the at least one interlace structure by determining a second interlace structure having 120 kHz as the cluster bandwidth, 12 interlaces and 12 clusters per interlace, wherein the second interlace structure comprises a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1152 subcarriers in total and 8 physical resource blocks per interlace, a second substructure corresponding to a subcarrier spacing of 30 kHz and having 576 subcarriers in total and 4 physical resource blocks per interlace, a third substructure corresponding to a subcarrier spacing of 60 kHz and having 288 subcarriers in total and 2 physical resource blocks per interlace, and a fourth substructure corresponding to a subcarrier spacing of 120 kHz and having 144 subcarriers in total and 1 physical resource block per interlace.
- the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to determine the at least one interlace structure by determining a third interlace structure having 240 kHz as the cluster bandwidth, 6 interlaces and 13 clusters per interlace, wherein the third interlace structure comprises a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1248 subcarriers in total and 17,333 physical resource blocks per interlace, a second substructure corresponding to a subcarrier spacing of 30 kHz and having 624 subcarriers in total and 8.667 physical resource blocks per interlace, a third substructure corresponding to a subcarrier spacing of 60 kHz and having 312 subcarriers in total and 4.333 physical resource blocks per interlace, a fourth substructure corresponding to a subcarrier spacing of 120 kHz and having 156 subcarriers in total and 2.167 physical resource blocks per interlace, and a fifth substructure corresponding to a subcarrier spacing of 120 kHz and having 78 subcarriers in total and 1.083 physical resource blocks per interlace.
- the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to determine the at least one interlace

structure by determining a fourth interlace structure having 180 kHz as the cluster bandwidth, 10 interlaces and 10 clusters per interlace, wherein the fourth interlace structure comprises a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1200 subcarriers in total and 10 physical resource blocks per interlace, a second substructure corresponding to a subcarrier spacing of 30 kHz and having 600 subcarriers in total and 5 physical resource blocks per interlace, and a third substructure corresponding to a subcarrier spacing of 60 kHz and having 300 subcarriers in total and 2,5 physical resource blocks per interlace.

- the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to determine the at least one interlace structure by determining a fifth interlace structure having 360 kHz as the cluster bandwidth, five interlaces and 10 clusters per interlace, wherein the fifth interlace structure comprises a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1200 subcarriers in total and 20 physical resource blocks per interlace, a second substructure corresponding to a subcarrier spacing of 30 kHz and having 600 subcarriers in total and 10 physical resource blocks per interlace, and a third substructure corresponding to a subcarrier spacing of 60 kHz and having 300 subcarriers in total and 5 physical resource blocks per interlace.
- the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to determine the at least one interlace structure by determining a sixth interlace structure having 120 kHz as the cluster bandwidth, 13 interlaces and 12 clusters per interlace, wherein the sixth interlace structure comprises a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1248 subcarriers in total and 8 physical resource blocks per interlace, a second substructure corresponding to a subcarrier spacing of 30 kHz and having 624 subcarriers in total and 4 physical resource blocks per interlace, a third substructure corresponding to a subcarrier spacing of 60 kHz and having 312 subcarriers in total and 2 physical resource blocks per interlace, and a fourth substructure corresponding to a subcarrier spacing of 120 kHz and having 156 subcarriers in total and 1 physical resource block per interlace.

According to a second aspect of the present invention, there is provided a method comprising determining at least one interlace structure for interlace based resource allocation in a wireless communication, each interlace structure comprising a plurality of interlace substructures, each substructure indicating a resource allocation grid for a specific subcarrier spacing, and wherein a given interlace structure comprises a constant cluster bandwidth among the plurality of substructures, a constant number of interlaces among the plurality of substructures, and a varying number of subcarriers per interlace among the plurality of substructures, wherein the number of subcarriers per interlace depends on the subcarrier spacing and is, for each of the plurality of substructures, a multiple of a physical resource block size in subcarriers, selecting a subcarrier spacing to be used in a communication of information, and performing the communication based on the substructure which corresponds to the selected subcarrier spacing for the communication.

Various embodiments of the second aspect may further comprise at least one feature corresponding to a feature in the preceding bulleted list laid out in connection with the first aspect.

According to a third aspect of the present invention, there is provided an apparatus comprising means for determining at least one interlace structure for interlace based resource allocation in a wireless communication, each interlace structure comprising a plurality of interlace substructures, each substructure indicating a resource allocation grid for a specific subcarrier spacing, and wherein a given interlace structure comprises a constant cluster bandwidth among the plurality of substructures, a constant number of interlaces among the plurality of substructures, and a varying number of subcarriers per interlace among the plurality of substructures, wherein the number of subcarriers per interlace depends on the subcarrier spacing and is, for each of the plurality of substructures, a multiple of a physical resource block size in subcarriers, means for selecting a subcarrier spacing to be used in a communication of information, and means for performing the communication based on the substructure which corresponds to the selected subcarrier spacing for the communication.

According to a fourth aspect of the present invention, there is provided a non-transitory computer readable medium having stored thereon a set of computer readable instructions that, when executed by at least one processor, cause an apparatus to at least determine at least one interlace structure for interlace based resource allocation in a wireless communication, each interlace structure comprising a plurality of interlace substructures, each substructure indicating a resource allocation grid for a specific subcarrier spacing, and wherein a given interlace structure comprises a constant cluster bandwidth among the plurality of substructures, a constant number of interlaces among the plurality of substructures, and a varying number of subcarriers per interlace among the plurality of substructures, wherein the number of subcarriers per interlace depends on the subcarrier spacing and is, for each of the plurality of substructures, a multiple of a physical resource block size in subcarriers, select a subcarrier spacing to be used in a communication of information, and perform the communication based on the substructure which corresponds to the selected subcarrier spacing for the communication.

According to a fifth aspect of the present invention, there is provided a computer program configured to cause a method in accordance with at the second aspect to be performed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 illustrates an example system in accordance with at least some embodiments of the present invention;

FIGURE 2A illustrates a set of five interlace substructures;

FIGURE 2B Illustrates clusters in PRBs;

FIGURE 3A illustrates measurement windows;

FIGURE 3B illustrates one example of partial interlace allocations;

FIGURE 4 illustrates an example apparatus capable of supporting at least some embodiments of the present invention;

FIGURE 5 illustrates signalling in accordance with at least some embodiments of the present invention, and

FIGURE 6 is a flow graph of a method in accordance with at least some embodiments of the present invention.

EMBODIMENTS

Embodiments described in the present document relate to uplink resource allocation in uplink transmissions. Scalable interlace structures are described which facilitate transmission of information in the uplink direction using wide transmission bandwidth, which may enable a higher transmission power without increasing power spectral density, PSD. Such scalable interlace structures may be used, for example, in block interleaved orthogonal frequency division multiple access, which is also known as block interleaved frequency division multiple access, B-IFDMA. This type of resource allocation can be used, for example, with DFT-S-OFDM or OFDM waveforms.

FIGURE 1 illustrates an example system in accordance with at least some embodiments of the present invention. Mobile 110, which may comprise, for example, a user equipment, mobile phone, smartphone, tablet device, laptop computer, desktop computer or another device configured to act as a user equipment of a cellular or non-cellular communication system, is in wireless communication with base station 120 and, optionally, also base station 130.

To achieve interoperability, mobile 110 and base stations 120 and/or 130 may be configured to operate in accordance with a same communication technology, such as, for example, a cellular or non-cellular technology. Examples of cellular communication technologies include wideband code division multiple access, WCDMA, long term evolution, LTE, and fifth generation, 5G, also known as new radio, NR. Examples of non-cellular communication technologies include wireless local area network, WLAN, and worldwide interoperability for microwave access, WiMAX, technologies. However, in some embodiments, the base stations may also operate under plural radio access technologies, RATs, such as LTE and 5G.

Radio link 112 connects mobile 110 with base station 120, and optional radio link 113 connects mobile 110 with base station 130. While two radio links are illustrated in FIGURE 1, the invention may be applicable also in situations where mobile 110 is engaged in a communication session which uses a single radio link, or one that uses more than two radio links. Radio links 112 and/or 113 may be arranged in accordance with a same communication technology as mobile 110 and base stations 120 and 130, to achieve interoperability. As said, base stations 120 and 130, as well as mobile 110, may be capable of communicating also with other communication technologies. The expression “base station” is a terminological choice by which it is not intended to limit the present disclosure to any specific technology. Depending on a communication technology used, the expression “access point” may be used alternatively to “base station”. The expression “access node” may comprise either a base station or an access point. Following 3GPP terminology, base station may be called as eNB in LTE or gNB in NR.

Inter-base station link 123 enables the base stations to exchange information directly. For example, handover related information may be communicated over inter-base station link 123. This link may be referred to as an X2 interface, for example, depending on the technology in use. Some technologies do not have an inter-base station link, and systems built according to such technologies may allow base stations to communicate with each other via a core network or via a base station controller device, for example.

Interface 124 connects base station 120 to network node 140. Interface 134 connects base station 130 with network node 140. Network node 140 may comprise, for example, a base station controller or a core network node, such as, for example, a mobility management entity, gateway or switch. Network node 140 may be interfaced with further nodes, which are not illustrated in FIGURE 1, via interface 141. Inter-base station link 123, interface 124, interface 134 and/or interface 141 may comprise wire-line connections, for example. While base station 120 and base station 130 are in the example of FIGURE 1 connected to the same network node 140, in general not all base stations need be connected to a same node. In the absence of inter-base station link 123, base station 120 and base station 130 may communicate via network node 140, or more generally via a core network, for example.

Radio links 112 and/or 113 may be comprised in an active communication session of mobile 110. Mobile 110 may receive information via either or both radio links on downlink parts of the link or links, and/or mobile 110 may transmit information on uplink parts of the link or links. To maintain a radio link, mobile 110 may participate in power control procedures for the radio link, and mobile 110 may be configured to monitor radio link quality of the radio link.

Radio links 112 and/or 113 may operate on frequency bands reserved for use by the communication system comprising base stations 120 and 130, or, alternatively or in addition, these links may operate on frequency bands that are also used by further systems. For example, the radio links 112 and/or 113 may be partially or completely on an unlicensed band or a shared spectrum band, which is shared by nodes of at least one further system. An example of such a further system is an IEEE 802.11, which is also known as wireless local area network, or “Wi-Fi”. Examples of unlicensed bands include frequency bands at 5 GHz, 37 GHz or 60 GHz frequencies. An example of a shared spectrum band is 3.5 GHz frequencies in USA.

When sharing an unlicensed band with other systems, use of frequency resources of the unlicensed band by the co-existing systems may be facilitated by keeping transmissions spectrally relatively flat. Power spectral density, PSD, describes how power of a transmitted signal is spread over frequency. Keeping transmission spectrally flat corresponds to keeping PSD relatively constant. This avoids power peaks in frequency use, which could cause interference in other systems. In other words, maintaining a constant PSD provides a technical effect in that sharing a frequency band between plural users and systems is more successful.

In the present context, the term “interlace” refers to a set of B-IFDMA clusters which are equally spaced along a spectrum. For example, an interlace may comprise ten clusters equally spaced along a spectrum. A cluster may comprise one or more adjacent subcarriers. An interlace may be allocated for uplink or downlink transmission from a user equipment, for example. Such transmission may take place over an unlicensed spectrum band, for example. Such transmission may take place over a spectrum band that is used by other systems as well. In the present context, the term “cluster” refers to a constituent of an interlace, for example, an interlace may comprise ten or twelve clusters, the clusters being equally spaced in frequency space. One cluster may comprise one or more adjacent physical resource blocks, PRBs, or a fraction of a PRB.

In the context of new radio, NR, Type 0 resource allocation uses a resource block group, RBG, level granularity in resource allocation and uses a bitmap based indication of allocated RBGs. On the other hand, NR Type 1 resource allocation indicates an index of the starting PRB and the number of PRBs allocated in the allocation. Type 1 operates, in NR, with a one-PRB granularity in allocating resources.

In the present context, the term “pin” refers to subcarriers comprised in one cluster of an interlace. For example, 16 pins per cluster refers to a case where a cluster has 16 adjacent subcarriers. In case of OFDM waveform, modulation symbols are mapped on subcarriers, where modulation symbols may be outcome of phase shift keying or quadrature amplitude modulation for example. In case of DFT-S-OFDM waveform, a set of modulation symbols are spread, or precoded or transformed, with DFT before mapping to the subcarriers. Term virtual subcarrier may be used in the context of DFT-S-OFDM (that is, frequency domain generation of the single carrier signal) instead of subcarrier to emphasize the differences between OFDM and DFT-S-OFDM. DFT-spreading introduces correlation between the involved frequency pins, which can be seen as a considerable difference compared to an OFDM waveform where subcarriers are uncorrelated in the transmitter side. In the present context, term subcarrier is used to refer to OFDM and/or DFT-S-OFDM scenarios. This can be justified by the fact that from resource allocation point there may be no differences between OFDM and DFT-S-OFDM at least in the context of configuring interlace structure(s) and allocating one or multiple interlaces or partial interlaces using configured interlace structure(s), or substructure(s).

In the present context, the term “sub-carrier spacing”, SCS, defines the distance, in frequency, between adjacent sub-carriers.

In the present context, the term “interlace structure” refers to a framework for managing frequency resources using interlaces, wherein each interlace may be allocated to transmitters in whole or in part. An interlace structure may comprise plural interlace substructures. An interlace substructure defines, for a specific sub-carrier spacing, the number of interlaces in use, the number of clusters, the cluster bandwidth, and the total number of subcarriers per interlace. Further, the number of pins per cluster follows from the number of subcarriers per interlace, when this is divided by the number of clusters. Each interlace substructure may further indicate at least one of the following: a number of physical resource blocks per interlace, spacing between adjacent clusters, and a total bandwidth of resource allocation.

Embodiments of the present invention seek to provide interlace structures which enable dynamic use of frequency resources while maintaining a constant PSD. To maintain the constant PSD and enable use of different sub-carrier spacings, plural interlace substructures are defined. In at least some of these plural interlace substructures, the cluster bandwidth is the same, the number of interlaces is the same, and the number of subcarriers per interlace is a multiple of the physical resource block size. Where the physical resource block size is 12 subcarriers, for example, the number of subcarriers per interlace is a multiple of 12. As will be seen herein below, using interlace structures essentially conforming to these principles, a spectrum band may be efficiently used, which corresponds to spreading transmitted energy evenly over a large part of the spectrum band, which again corresponds to maintaining constant PSD over the spectrum band. In effect, this amounts to scaling the number of subcarriers per interlace to maintain constant bandwidth usage.

FIGURE 2A illustrates an interlace structure comprising a set of five interlace substructures. The illustrated interlace substructures conform to the following design:

SCS (kHz)	# of interl	pins/cluster	pins/interl	PRBs/interl	cluster BW	# total SC
15	6	16	192	16	240 kHz	1152
30	6	8	96	8	240 kHz	576
60	6	4	48	4	240 kHz	288
120	6	2	24	2	240 kHz	144
240	6	1	12	1	240 kHz	72

Table 1: First option for interlace substructures as function of SCS.

In the interlace structure of Table 1, all interlace substructures further share the following characteristics: clusters/interlace = 12, spacing between adjacent clusters 1,44 MHz, total BW 17,28 MHz, BW occupancy (@20MHz) 80,4% of the nominal bandwidth of 20 MHz and spectrum usage efficiency 86% (@20MHz).

In the following table, a second interlace structure is presented:

SCS (kHz)	# of interl	pins/cluster	pins/interl	PRBs/interl	cluster BW	# total SC
15	12	8	96	8	120 kHz	1152
30	12	4	48	4	120 kHz	576
60	12	2	24	2	120 kHz	288
120	12	1	12	1	120 kHz	144

Table 2: Second option for interlace substructures as function of SCS

In the interlace structure of Table 2, all interlace substructures further share the following characteristics: clusters/interlace = 12, spacing between adjacent clusters 1,44 MHz, total BW 17,28 MHz, BW occupancy (@20MHz) 80% of the nominal bandwidth of 20 MHz and spectrum usage efficiency 86% (@20MHz).

Both the first and second options have reasonably high spectrum usage efficiencies of about 90 percent, but not excessively high in order to match the spectrum mask of a 20 MHz carrier. Both options fulfil an 80% bandwidth occupancy rule defined by ETSI for 5GHz band.

The following table lays out a third interlace structure:

SCS (kHz)	# of interl	pins/cluster	pins/interl	PRBs/interl	cluster BW	# total SC
15	6	16	208	17,333	240 kHz	1248
30	6	8	104	8,667	240 kHz	624
60	6	4	52	4,333	240 kHz	312
120	6	2	26	2,167	240 kHz	156
240	6	1	13	1,083	240 kHz	78

Table 3: Third option for interlace substructures as function of SCS

In the interlace structure of Table 3, all interlace substructures further share the following characteristics: clusters/interlace = 13, spacing between adjacent clusters 1,44 MHz, total BW 18,72 MHz, BW occupancy 88% of the nominal bandwidth of 20 MHz and spectrum usage efficiency 94% (@20MHz). The option of Table 3 is a modification of the interlace structure of Table 1, such that the number of clusters is increased from 12 to 13. This results in improved spectral efficiency, however the number of subcarriers per interlace is no longer a multiple of the PRB size in subcarriers.

The following table lays out a fourth interlace structure:

SCS (kHz)	# of interl	pins/cluster	pins/interl	PRBs/interl	cluster BW	# total SC
15	10	12	120	10	180 kHz	1200
30	10	6	60	5	180 kHz	600
60	10	3	30	2,5	180 kHz	300

Table 4: Fourth option for interlace substructures as function of SCS

In the interlace structure of Table 4, all interlace substructures further share the following characteristics: clusters/interlace = 10, spacing between adjacent clusters 1,8 MHz, total BW 18 MHz, BW occupancy 82% of the nominal bandwidth of 20 MHz and spectrum usage efficiency 90% (@20MHz). The option of Table 4 has a challenge in that the number of subcarriers per interlace is not a multiple of the PRB size when SCS is 60 kHz. However, this problem may be mitigated by using an even number of interlaces with 60 kHz SCS.

The following table lays out a fifth interlace structure:

SCS (kHz)	# of interl	pins/cluster	pins/interl	PRBs/interl	cluster BW	# total SC
15	5	24	240	20	360 kHz	1200
30	5	12	120	10	360 kHz	600
60	5	6	60	5	360 kHz	300

Table 5: Fifth option for interlace substructures as function of SCS

In the interlace structure of Table 5, all interlace substructures further share the following characteristics: clusters/interlace = 10, spacing between adjacent clusters 1,8 MHz, total BW 18 MHz, BW occupancy 83% of the nominal bandwidth of 20 MHz and spectrum usage efficiency 90% (@20MHz). The option of Table 5 is a variant of Table 4, where the number of interlaces is reduced to 5.

The following table lays out a sixth interlace structure:

SCS (kHz)	# of interl	pins/cluster	pins/interl	PRBs/interl	cluster BW	# total SC
15	13	8	96	8	120 kHz	1248
30	13	4	48	4	120 kHz	624
60	13	2	24	2	120 kHz	312
120	13	1	12	1	120 kHz	156

Table 6: Sixth option for interlace substructures as function of SCS

In the interlace structure of Table 6, all interlace substructures further share the following characteristics: clusters/interlace = 12, spacing between adjacent clusters 1,56 MHz, total BW 18,72 MHz, BW occupancy 86% of the nominal bandwidth of 20 MHz and spectrum usage efficiency 94% (@20MHz). The option of Table 6 is a variant of Table 2, where the number of interlaces is increased from 12 to 13.

An interlace may be allocated to a user equipment, UE, for transmitting, for example in the uplink or in a device-to-device, D2D, link. A D2D link connects two user equipment directly to each other in the sense that a signal transmitted by one UE is received in another UE without the signal being re-transmitted after being transmitted by the one UE but before reception in the another UE. On the other hand, alternatively to a whole interlace, a part of an interlace may be allocated. To use partial interlaces, a number of allocated clusters may be reduced by dividing by a power of two to support allocation of multiple fractions of a single interlace. For example, partial interlaces comprising ½ or ¼ of the clusters of a full interlace may be supported. Such a partial allocation is possible when the number of clusters in a whole interlace is a multiple of 4. A partial interlace comprising ½ of the clusters of a full interlace may be supported with an even number of clusters in a whole interlace. A partial interlace may comprise a subset of consecutive clusters of a whole interlace. A location of an allocated cluster set may be defined with reference to a predefined PRB grid used for PUSCH resource allocation, for example.

For example, allocations of partial interlaces may be useful when a UE does not need to comply with a bandwidth occupancy rule, for example when regulations of the region or the band do not require it, or when the UE may temporarily transmit with a narrower signal BW. In these situations, interlaced allocation may be used to increase max transmit power and/or cell coverage, for small payload transmission in a resource usage efficient manner.

Partial interlaces may be allocated, for example, to UEs that are not on an edge of a cell, and do not require maximum transmit power. For example, under United States FCC rules the maximum allowed transmit power is as follows: full interlace allocation: 21,8 dBm, ½ interlace allocation: 18,8 dBm, ¼ interlace allocation: 15,8 dBm and allocation of one PRB (non-interlaced): 11 dBm.

Partial interlaces may be used to increase multiplexing capacity when the number of allocated subcarriers on a partial interlace remain sufficient for the intended payload. With partial interlaces, interlaced allocations can be restricted into a sub-portion of the bandwidth. This is another benefit of partial interlaces: they provide more flexible coexistence with PRB/RBG type of PUSCH resource allocations. In the absence of a BW occupancy rule, it can be more attractive to allocate PUSCH resources in a PRB/RBG manner for large UL-SCH payload transmissions, allowing the use of channel aware scheduling and resulting in more efficient channel estimation, with allocation more localized in frequency since the transmission is spread out over fewer clusters. FIGURE 3B illustrates one example of partial interlace allocations based on the first option for interlace substructures. In the example, UE #1, UE#2, UE#5, and UE#7 use ½ interlace allocation while UE#3, UE#4, UE#6, and UE#8 use ¼ interlace allocation. The clusters not part of the used partial interlaces may be allocated for PUSCH with allocation Type 0 or Type 1.

The parameters for partial interlace substructures based on Table 1 are tabulated on Table 7. It can be noted that partial interlaces are not supported for 240 kHz SCS and ¼ partial interlace is not supported for 120 kHz SCS as the RE allocation would be less than 1 PRB.

SCS (kHz)	Interlace allocation	# of clusters per allocation	Max # of multiplexed UEs	# of pins per cluster	3 or PRBs per allocation
15	Full	12	6	16	16
	1 / 2	6	12	16	8
	1 / 4	3	24	16	4
30	Full	12	6	8	8
	1 / 2	6	12	8	4
	1 / 4	3	24	8	2
60	Full	12	6	4	4
	1 / 2	6	12	4	2
	1 / 4	3	24	4	1
120	Full	12	6	2	2
	1 / 2	6	12	2	1
240	Full	12	6	1	1

Table 7: Parameters for partial interlace allocation for interlace substructures of Table 1

In some embodiments, the number of subcarriers per cluster is selected in such a way that N adjacent clusters of different interlaces, N depending on the subcarrier spacing, fill complete PRB(s), thus allowing smooth coexistence between interlace based resource allocation and other possible resource allocation schemes. This kind of operation may be beneficial in scenarios where the UL transmission does not fulfil a bandwidth occupancy rule, but an interlaced structure is used to increase the transmit power while maintaining efficient resource utilization.

In one embodiment, clusters of a given interlace that are comprised in a partial interlace are allocated based on a given resource allocation scheme, and where the part of the given interlace that is not comprised in the partial interlace is allocated based on a different resource allocation scheme. The different resource allocation scheme may comprise allocating resources of another interlace, in addition to allocating resources of the given interlace. Furthermore, in one embodiment, the different allocation scheme does not operate with a concept of clusters. However, in another embodiment, the different allocation scheme operates on cluster and comprises allocating those subcarriers of the clusters of the given interlace that are not comprised in the partial interlace based on the different resource allocation scheme.

FIGURE 2B illustrates multiplexing interlace-based transmission and PRB/PRG transmissions. FIGURE 2B shows that it is possible to multiplex interlace based transmission and PRB/RBG (resource block group) type of transmissions in the same symbol although the resource allocation granularity is different. For example, with 30 kHz subcarrier spacing, subcarriers of 3 adjacent clusters corresponds to 2 PRBs. Correspondingly, resources corresponding to interlaces #0-2 could be used for interlace based resource allocation, for example a control channel. Resources corresponding to interlaces #3-11 could be used based on a different resource allocation type, resource allocation type 0 (bitmap) for example for PUSCH and could occupy also resources outside the interlace grid. In an embodiment, the multiplexing is performed with connection of partial interlaces discussed above, and the embodiments presented there apply also to the multiplexing of interlace based resource allocation and other type of resource allocations.

Each frequency domain cluster may have a separate demodulation reference signal, DMRS. As shown in Table 1, the number of subcarriers/cluster may vary between 1 and 16, based on subcarrier spacing, in the option of Table 1. The following multiplexing schemes can be used: 1) TDM between DMRS and data (symbols). This is the only option with high SCS (such as 240 kHz). 2) FDM between DMRS and data (subcarriers). This is a relevant option with low SCS, and mini-slot, which is also known as non-slot based scheduling, or 3) a combination of TDM and FDM. The DMRS density may vary according to scenario e.g. between ½ (PUCCH, small payload) and 1/7 (PUCCH).

FIGURE 3A illustrates measurement windows. Shown is the interlace structure with reference to a 1 MHz measurement window, for example according to ETSI/FCC rules. The spacing between clusters is 1.2 MHz (the empty spectrum between two adjacent clusters), which means that when only one interlace is allocated, there is at most one cluster within the 1 MHz measurement window. This means that maximum transmit power for one cluster allocation is 10 dBm + 10*log10(12) = 20.8 dBm (ETSI rules) or, alternatively, 11 dBm + 10*log10(12) = 21.8 dBm (FCC rules). The logarithms are obtained of 12, since there are 12 clusters per interlace in these numerical examples.

It can be noted that this is quite close to the maximum allowed transmit power used on licensed bands, 23 dBm, which is a typical value used for the maximum UE transmit power. On the other hand, when the signal bandwidth is limited to 18 MHz, the maximum transmit power according to the considered PSD rule may be either 22.6 dBm (10 dB/MHz) or 23.6 dBm (11 dB/MHz). Hence, the maximum transmit power supported by the proposed interlace structure is only 1.7 dB (10*log10(12/18)) less than the maximum transmit power for a signal bandwidth with 18 MHz bandwidth.

Overall, at least some of the following advantages may be obtained:

- The proposed solution supports numerical options defined for NR Phase I

- Compatibility with ETSI bandwidth occupancy rule, 80% of 20 MHz
- Allowing to maximize the transmit power under constrained maximum power spectral density, such as 10 dBm/MHz, with a reasonable number of allocated resources.
- Good multiplexing capacity
- Scalable resource allocation
- Support for a mixed resource allocation both based on interlaces and PRB/RBG allocation, and
- Resource size of each interlace is multiple of 12, compatible with NR PRB

To compare interlaced and PRB/RBG allocations, the necessary continuous PRB allocations to reach a targeted transmit power under an 11 dBm/MHz PSD limit are shown on Table 8. For example, 18.8 dBm transmit power with 30 kHz SCS requires allocation of 17 PRBs. At same time, allocation of ½ partial interlace consumes 4 PRBs. Therefore, interlaced resource allocation may be more efficient when the payload is just couple of tens or hundreds of bits but relatively high transmission power is required or preferred.

	Targeted transmit power		
	21,8 dBm	18,8 dBm	15,8 dBm
SCS 15 kHz	67	34	17
SCS 30 kHz	34	17	9
SCS 60 kHz	17	9	5
SCS 120 kHz	9	5	3
SCS 240 kHz	5	3	2

Table 8: Necessary continuous PRB allocations to reach a targeted Tx power under 11 dBm/MHz PSD limit

FIGURE 4 illustrates an example apparatus capable of supporting at least some embodiments of the present invention. Illustrated is device 400, which may comprise, for example, a mobile communication device such as mobile 110 or base station 120 of FIGURE 1. Comprised in device 400 is processor 410, which may comprise, for example, a single- or multi-core processor wherein a single-core processor comprises one processing core and a multi-core processor comprises more than one processing core. Processor 410 may comprise, in general, a control device. Processor 410 may comprise more than one processor. Processor 410 may be a control device. A processing core may comprise, for example, a Cortex-A8 processing core manufactured by ARM Holdings or a Steamroller processing core produced by Advanced Micro Devices Corporation. Processor 410 may comprise at least one Qualcomm Snapdragon and/or Intel Atom processor. Processor 410 may comprise at least one application-specific integrated circuit, ASIC. Processor 410 may comprise at least one field-programmable gate array, FPGA. Processor 410 may be means for performing method steps in device 400. Processor 410 may be configured, at least in part by computer instructions, to perform actions.

Device 400 may comprise memory 420. Memory 420 may comprise random-access memory and/or permanent memory. Memory 420 may comprise at least one RAM chip. Memory 420 may comprise solid-state, magnetic, optical and/or holographic memory, for example. Memory 420 may be at least in part accessible to processor 410. Memory 420 may be at least in part comprised in processor 410. Memory 420 may be means for storing information. Memory 420 may comprise computer instructions that processor 410 is configured to execute. When computer instructions configured to cause processor 410 to perform certain actions are stored in memory 420, and device 400 overall is configured to run under the direction of processor 410 using computer instructions from memory 420, processor 410 and/or its at least one processing core may be considered to be configured to perform said certain actions. Memory 420 may be at least in part comprised in processor 410. Memory 420 may be at least in part external to device 400 but accessible to device 400.

Device 400 may comprise a transmitter 430. Device 400 may comprise a receiver 440. Transmitter 430 and receiver 440 may be configured to transmit and receive, respectively, information in accordance with at least one cellular or non-cellular standard. Transmitter 430 may comprise more than one transmitter. Receiver 440 may comprise more than one receiver. Transmitter 430 and/or receiver 440 may be configured to operate in accordance with global system for mobile communication, GSM, wideband code division multiple access, WCDMA, 5G, long term evolution, LTE, IS-95, wireless local area network, WLAN, Ethernet and/or worldwide interoperability for microwave access, WiMAX, standards, for example.

Device 400 may comprise a near-field communication, NFC, transceiver 450. NFC transceiver 450 may support at least one NFC technology, such as NFC, Bluetooth, Wibree or similar technologies.

Device 400 may comprise user interface, UI, 460. UI 460 may comprise at least one of a display, a keyboard, a touchscreen, a vibrator arranged to signal to a user by causing device 400 to vibrate, a speaker and a microphone. A user may be able to operate device 400 via UI 460, for example to accept incoming telephone calls, to originate telephone calls or video calls, to browse the Internet, to manage digital files stored in memory 420 or on a cloud accessible via transmitter 430 and receiver 440, or via NFC transceiver 450, and/or to play games.

Device 400 may comprise or be arranged to accept a user identity module 470. User identity module 470 may comprise, for example, a subscriber identity module, SIM, card installable in device 400. A user identity module 470 may comprise information identifying a subscription of a user of device 400. A user identity module 470 may comprise cryptographic information usable to verify the identity of a user of device 400 and/or to facilitate encryption of communicated information and billing of the user of device 400 for communication effected via device 400.

Processor 410 may be furnished with a transmitter arranged to output information from processor 410, via electrical leads internal to device 400, to other devices comprised in device 400. Such a transmitter may comprise a serial bus transmitter arranged to, for example, output information via at least one electrical lead to memory 420 for storage therein. Alternatively to a serial bus, the transmitter may comprise a parallel bus transmitter. Likewise processor 410 may comprise a receiver arranged to receive information in processor 410, via electrical leads internal to device 400, from other devices comprised in device 400. Such a receiver may comprise a serial bus receiver arranged to, for example, receive information via at least one electrical lead from receiver 440 for processing in processor 410. Alternatively to a serial bus, the receiver may comprise a parallel bus receiver.

Device 400 may comprise further devices not illustrated in FIGURE 4. For example, where device 400 comprises a smartphone, it may comprise at least one digital camera. Some devices 400 may comprise a back-facing camera and a front-facing camera, wherein the back-facing camera may be intended for digital photography and the front-facing camera for video telephony. Device 400 may comprise a fingerprint sensor arranged to authenticate, at least in part, a user of device 400. In some embodiments, device 400 lacks at least one device described above. For example, some devices 400 may lack a NFC transceiver 450 and/or user identity module 470.

Processor 410, memory 420, transmitter 430, receiver 440, NFC transceiver 450, UI 460 and/or user identity module 470 may be interconnected by electrical leads internal to device 400 in a multitude of different ways. For example, each of the aforementioned devices may be separately connected to a master bus internal to device 400, to allow for the devices to exchange information. However, as the skilled person will appreciate, this is only one example and depending on the embodiment various ways of interconnecting at least two of the aforementioned devices may be selected without departing from the scope of the present invention.

It should be appreciated that future networks may utilize network functions virtualization, NFV, which is a network architecture concept that proposes virtualizing network node functions into “building blocks” or entities that may be operationally connected or linked together to provide services. A virtualized network function, VNF, may comprise one or more virtual machines running computer program codes using standard or general type servers instead of customized hardware. Cloud computing or data storage may also be utilized. In radio communications, this may mean operations to be carried out, at least partly, in a central/centralized unit, CU, (for example a server, host or node) operationally coupled to distributed unit, DU, (for example a radio head/node). It is also possible that node operations will be distributed among a plurality of servers, nodes or hosts. It should also be understood that the distribution of labour between core network operations and radio access node operations may vary depending on implementation. In an embodiment, the server may generate a virtual network through which the server communicates with the radio node / radio access node. In general, virtual networking may involve a process of combining hardware and software network resources and network functionality into a single, software-based administrative entity, a virtual network. Such virtual network may provide flexible distribution of operations between the server and the radio head/node. In practice, any digital signal processing task may be performed in either the CU or the DU and the boundary where the responsibility is shifted between the CU and the DU may be selected according to implementation.

Therefore, in an embodiment, a CU-DU architecture is implemented. In such case the apparatus/device of Figure 4 may be comprised in a central unit (for example a control unit, an edge cloud server, a server) operatively coupled (for example via a wireless or wired network) to a distributed unit (for example. a remote radio head/node). That is, the central unit (for example an edge cloud server) and the radio access node may be stand-alone apparatuses communicating with each other via a radio path or via a wired connection. Alternatively, they may be located in a same entity communicating via a wired connection, etc. It should be understood that the edge cloud or edge cloud server may serve a plurality of radio nodes or a radio access networks. In an embodiment, at least some of the described processes may be performed by the central unit. In another embodiment, the apparatus may be instead comprised in the distributed unit, and at least some of the described processes may be performed by the distributed unit.

In an embodiment, the execution of at least some of the functionalities of the apparatus may be shared between two physically separate devices (DU and CU) forming one operational entity. Therefore, the apparatus may be seen to depict the operational entity comprising one or more physically separate devices for executing at least some of the described processes. In an embodiment, such CU-DU architecture may provide flexible distribution of operations between the CU and the DU. In practice, any digital signal processing task may be performed in either the CU or the DU and the boundary where the responsibility is shifted between the

CU and the DU may be selected according to implementation. In an embodiment, the apparatus controls the execution of the processes, regardless of the location of the apparatus and regardless of where the processes/functions are carried out.

FIGURE 5 illustrates signalling in accordance with at least some embodiments of the present invention. On the vertical axes are disposed, on the left, mobile 110 of FIGURE 1, and on the right, base station 120 of FIGURE 1. Time advances from the top toward the bottom.

In phase 510, mobile 110 requests an allocation of resources for uplink transmission. In case phase 510 takes place using non-interlaced transmission over a licensed band, a secondary UL cell on an unlicensed band may be configured using dedicated higher layer signalling. Another example is that phase 510 comprises physical random access transmission, PRACH, which utilizes a specific non-interlaced format. On the other hand, phase 510 may itself be based on an interlaced transmission, which may be determined based on higher-layer signalling. Such higher-layer signalling may be dedicated or cell-specific signalling, for example. When phase 510 is an interlaced transmission, it may be e.g. a PRACH, or SR transmission. In phase 520, base station 120 selects an interlace allocation for mobile 110 or a cell for mobile 110. This allocation, as described herein above, may comprise an entire interlace or a fraction of an interlace, for example an interlace from one of the interlace substructures of Table 1. An interlace substructure may be selected in mobile 110, possibly based on an indication that mobile 110 receives from the network. For example, a base station such as a gNB may explicitly indicate the substructure by broadcasted or UE-specific signalling. This indication may comprise an indication of a subcarrier spacing corresponding to the interlace substructure, for example. The indication may be based on a frequency band of a cell, with a predefined SCS. The cell may be UE-specifically configured by the gNB, for example, in a case where phase 510 takes place over an unlicensed band.

In phase 530, base station 120 informs mobile 110 of the allocation, and responsively in phase 540 mobile 110 performs an uplink transmission in accordance with the allocation, by using the resources defined by the allocation. Later, mobile 110 may switch to using a different interlace allocation from a different interlace substructure. If the allocation communicated in phase 530 was from an interlace substructure of Table 1, also the different interlace allocation may be from an interlace substructure of Table 1. When switching to the different interlace substructure, the number of overall interlaces available does not change, and the cluster size in kilohertz remains the same. The number of subcarriers per interlace is modified, in the switching, by multiplying it by a power of two or dividing it by a power of two. The number of subcarriers per interlace is a multiple of a physical resource block size in subcarriers both before and after the switch.

FIGURE 6 is a flow graph of a method in accordance with at least some embodiments of the present invention. The phases of the illustrated method may be performed in mobile 110, in base station 120, or in a control device configured to control the functioning thereof, when installed therein.

Phase 610 comprises determining at least one interlace structure for interlace based resource allocation in a wireless communication, each interlace structure comprising a plurality of interlace substructures, each substructure indicating a resource allocation grid for a specific subcarrier spacing, and wherein a given interlace structure comprises a constant cluster bandwidth among the plurality of substructures, a constant number of interlaces among the plurality of substructures, and a varying number of subcarriers per interlace among the plurality of substructures, wherein the number of subcarriers per interlace depends on the subcarrier spacing and is, for each of the plurality of substructures, a multiple of a physical resource block size in subcarriers. Phase 620 comprises selecting a subcarrier spacing to be used in a communication of information, and phase 630 comprises performing the communication based on the substructure which corresponds to the selected subcarrier spacing for the communication.

In an embodiment, performing the communication may comprise the UE transmitting and/or receiving information. In an embodiment, performing the communication may comprise the gNB/eNB transmitting and/or receiving information. In an embodiment, the selection of the subcarrier spacing to be used in the communication of information may be performed by the gNB/eNB and/or by the UE, possibly due to an indication received by the UE from the network regarding the selection. In an embodiment, the determination of the interlace structure may be performed by the gNB/eNB, or another network element, and/or by the UE, possibly due to an indication received by the UE from the network regarding the determination. That is, the determination by the UE may be obtaining the interlace structure from the network or selecting the interlace structure based on an indication from the network, or otherwise determining the interlace structure.

In general there may be provided an apparatus comprising at least one processing core, at least one memory including computer program code, the at least one memory and the computer program code being configured to, with the at least one processing core, cause the apparatus at least to obtain first and second interlace substructures for wireless transmission, receive or transmit information over a wireless band using initially the first and then the second interlace substructure, and wherein when changing to the second interlace substructure, the following applies: a cluster bandwidth is kept constant, a number of interlaces is kept constant, and a number of subcarriers per interlace is modified by multiplying or dividing by a power of two, the number of subcarriers per interlace being a multiple of a physical resource block size in subcarriers before and after the change.

It is to be understood that the embodiments of the invention disclosed are not limited to the particular structures, process steps, or materials disclosed herein, but are extended to equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the purpose of describing particular embodiments only and is not intended to be limiting.

Reference throughout this specification to one embodiment or an embodiment means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases “in one embodiment” or “in an embodiment” in various places throughout this specification are not necessarily all referring to the same embodiment. Where reference is made to a numerical value using a term such as, for example, about or substantially, the exact numerical value is also disclosed.

As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary. In addition, various embodiments and example of the present invention may be referred to herein along with alternatives for the various components thereof. It is understood that such embodiments, examples, and alternatives are not to be construed as de facto equivalents of one another, but are to be considered as separate and autonomous representations of the present invention.

Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In the preceding description, numerous specific details are provided, such as examples of lengths, widths, shapes, etc., to provide a thorough understanding of embodiments of the invention. One skilled in the relevant art will recognize, however, that the invention can be practiced without one or more of the specific details, or with other methods, components, materials, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the invention.

While the forgoing examples are illustrative of the principles of the present invention in one or more particular applications, it will be apparent to those of ordinary skill in the art that numerous modifications in form, usage and details of implementation can be made without the exercise of inventive faculty, and without departing from the principles and concepts of the invention. Accordingly, it is not intended that the invention be limited, except as by the claims set forth below.

The verbs “to comprise” and “to include” are used in this document as open limitations that neither exclude nor require the existence of also un-recited features. The features recited in depending claims are mutually freely combinable unless otherwise explicitly stated. Furthermore, it is to be understood that the use of "a" or "an", that is, a singular form, throughout this document does not exclude a plurality.

INDUSTRIAL APPLICABILITY

At least some embodiments of the present invention find industrial application in managing transmissions in wireless communication systems.

ACRONYMS LIST

3GPP	3rd Generation Partnership Project
BW	bandwidth
DFT-S-OFDMA	discrete fourier transform spread OFDMA
DMRS	demodulation reference signal
ETSI	European telecommunications Standards Institute
FCC	Federal Communications Commission
FDM	frequency-division multiplexing
gNB	new radio, NR, base station
NFV	network functions virtualization
NR	new radio
LTE	long term evolution
OFDMA	orthogonal frequency division multiple access
PRB	physical resource block
PSD	power spectral density
PUSCH	physical uplink shared channel
RBG	resource block group
SC	sub-carrier
SCS	sub-carrier spacing
TDM	time-division multiplexing
UE	user equipment

UL	uplink
UL-SCH	uplink shared channel

REFERENCE SIGNS LIST

110	mobile
120, 130	base station
112, 113	radio link
123	inter-base station link
124, 134, 141	interface
140	network node
400 – 470	structure of the device of FIGURE 4
510 – 540	phases of signalling in FIGURE 5
610 – 620	phases of the method of FIGURE 6

CLAIMS:

1. An apparatus comprising at least one processing core, at least one memory including computer program code, the at least one memory and the computer program code being configured to, with the at least one processing core, cause the apparatus at least to:

- determine at least one interlace structure for interlace based resource allocation in a wireless communication, each interlace structure comprising a plurality of interlace substructures, each substructure indicating a resource allocation grid for a specific subcarrier spacing, and wherein a given interlace structure comprises:
    - a constant cluster bandwidth among the plurality of substructures,
    - a constant number of interlaces among the plurality of substructures, and
    - a varying number of subcarriers per interlace among the plurality of substructures, wherein the number of subcarriers per interlace depends on the subcarrier spacing and is, for each of the plurality of substructures, a multiple of a physical resource block size in subcarriers;
- select a subcarrier spacing to be used in a communication of information; and
- perform the communication based on the substructure which corresponds to the selected subcarrier spacing for the communication.

2. The apparatus according to claim 1, wherein in each interlace substructure, each physical resource block comprises 12 subcarriers.

3. The apparatus according to claim 1 or 2, wherein the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to apply spectrum sharing or the listen before talk principle in the transmitting of the information.

4. The apparatus according to any of claims 1 - 3, wherein the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to conditionally apply a requirement to occupy between 80% and 100% of a declared nominal channel bandwidth for the communication of the information.

5. The apparatus according to any of claims 1 - 4, wherein the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to perform the communication using a partial interlace comprised in the substructure corresponding to the selected subcarrier spacing.

6. The apparatus according to claim 5, wherein a number of clusters comprised in the partial interlace is reduced by a power of two compared to the number of clusters in a full interlace.

7. The apparatus according to any of claims 5 to 6, wherein the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to determine the number of clusters for the partial interlace such that a number of subcarriers comprised in the partial interlace form an integer number of at least one physical resource block.

8. The apparatus according to claim 5 to 7, wherein the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to process an allocation where clusters of a given interlace that are comprised in the partial interlace are allocated based on a given resource allocation scheme, and where the part of the given interlace that is not comprised in the partial interlace is allocated based on a different resource allocation scheme.

9. The apparatus according to any of claims 5 - 8, wherein the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to process an allocation wherein clusters of a given interlace comprised in the partial interlace are allocated for a first user equipment, and subcarriers on clusters of the given interlace that are not comprised in the partial interlace are allocated for a second user equipment.

10. The apparatus according to any of claims 5 to 9, wherein the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to determine that the apparatus need not occupy between 80% and 100% of the declared nominal channel bandwidth, and to responsively apply the partial interlace.

11. The apparatus according to any of claims 1- 10, wherein the apparatus is or is comprised in a user equipment and the transmission is an uplink transmission on an unlicensed band.

12. The apparatus according to any of claims 1 – 11, wherein the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to determine the at least one interlace structure by determining a first interlace structure having 240 kHz as the cluster bandwidth, six interlaces, and 12 clusters per interlace, wherein the first interlace structure comprises:

- a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1152 subcarriers in total and 16 physical resource blocks per interlace,
- a second substructure corresponding to a subcarrier spacing of 30 kHz and having 576 subcarriers in total and 8 physical resource blocks per interlace,

- a third substructure corresponding to a subcarrier spacing of 60 kHz and having 288 subcarriers in total and 4 physical resource blocks per interlace,
- a fourth substructure corresponding to a subcarrier spacing of 120 kHz and having 144 subcarriers in total and 2 physical resource blocks per interlace, and
- a fifth substructure corresponding to a subcarrier spacing of 240 kHz and having 72 subcarriers in total, and 1 physical resource block per interlace.

13. The apparatus according to any of claims 1 – 12, wherein the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to determine the at least one interlace structure by determining a second interlace structure having 120 kHz as the cluster bandwidth, 12 interlaces and 12 clusters per interlace, wherein the second interlace structure comprises:

- a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1152 subcarriers in total and 8 physical resource blocks per interlace,
- a second substructure corresponding to a subcarrier spacing of 30 kHz and having 576 subcarriers in total and 4 physical resource blocks per interlace,
- a third substructure corresponding to a subcarrier spacing of 60 kHz and having 288 subcarriers in total and 2 physical resource blocks per interlace, and
- a fourth substructure corresponding to a subcarrier spacing of 120 kHz and having 144 subcarriers in total and 1 physical resource block per interlace.

14. The apparatus according to any of claims 1 – 13, wherein the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to determine the at least one interlace structure by determining a third interlace structure having 240 kHz as the cluster bandwidth, 6 interlaces and 13 clusters per interlace, wherein the third interlace structure comprises:

- a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1248 subcarriers in total and 17,333 physical resource blocks per interlace,
- a second substructure corresponding to a subcarrier spacing of 30 kHz and having 624 subcarriers in total and 8.667 physical resource blocks per interlace,
- a third substructure corresponding to a subcarrier spacing of 60 kHz and having 312 subcarriers in total and 4.333 physical resource blocks per interlace,
- a fourth substructure corresponding to a subcarrier spacing of 120 kHz and having 156 subcarriers in total and 2.167 physical resource blocks per interlace, and
- a fifth substructure corresponding to a subcarrier spacing of 120 kHz and having 78 subcarriers in total and 1.083 physical resource blocks per interlace.

15. The apparatus according to any of claims 1 – 14, wherein the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to determine the at least one interlace structure by determining a fourth interlace structure having 180 kHz as the cluster bandwidth, 10 interlaces and 10 clusters per interlace, wherein the fourth interlace structure comprises:

- a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1200 subcarriers in total and 10 physical resource blocks per interlace,
- a second substructure corresponding to a subcarrier spacing of 30 kHz and having 600 subcarriers in total and 5 physical resource blocks per interlace, and
- a third substructure corresponding to a subcarrier spacing of 60 kHz and having 300 subcarriers in total and 2,5 physical resource blocks per interlace.

16. The apparatus according to any of claims 1 – 15, wherein the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to determine the at least one interlace structure by determining a fifth interlace structure having 360 kHz as the cluster bandwidth, five interlaces and 10 clusters per interlace, wherein the fifth interlace structure comprises:

- a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1200 subcarriers in total and 20 physical resource blocks per interlace,
- a second substructure corresponding to a subcarrier spacing of 30 kHz and having 600 subcarriers in total and 10 physical resource blocks per interlace, and
- a third substructure corresponding to a subcarrier spacing of 60 kHz and having 300 subcarriers in total and 5 physical resource blocks per interlace.

17. The apparatus according to any of claims 1 – 16, wherein the at least one memory and the computer program code are configured to, with the at least one processing core, cause the apparatus to determine the at least one interlace structure by determining a sixth interlace structure having 120 kHz as the cluster bandwidth, 13 interlaces and 12 clusters per interlace, wherein the sixth interlace structure comprises:

- a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1248 subcarriers in total and 8 physical resource blocks per interlace,
- a second substructure corresponding to a subcarrier spacing of 30 kHz and having 624 subcarriers in total and 4 physical resource blocks per interlace,
- a third substructure corresponding to a subcarrier spacing of 60 kHz and having 312 subcarriers in total and 2 physical resource blocks per interlace, and
- a fourth substructure corresponding to a subcarrier spacing of 120 kHz and having 156 subcarriers in total and 1 physical resource block per interlace.

18. A method comprising:
- determining at least one interlace structure for interlace based resource allocation in a wireless communication, each interlace structure comprising a plurality of interlace substructures, each substructure indicating a resource allocation grid for a specific subcarrier spacing, and wherein a given interlace structure comprises:
  - a constant cluster bandwidth among the plurality of substructures,
  - a constant number of interlaces among the plurality of substructures, and
  - a varying number of subcarriers per interlace among the plurality of substructures, wherein the number of subcarriers per interlace depends on the subcarrier spacing and is, for each of the plurality of substructures, a multiple of a physical resource block size in subcarriers;
- selecting a subcarrier spacing to be used in a communication of information; and
- performing the communication based on the substructure which corresponds to the selected subcarrier spacing for the communication.

19. The method according to claim 18, wherein in the first and second interlace structures each physical resource block comprises 12 subcarriers.

20. The method according to claim 18 or 19, further comprising applying spectrum sharing or the listen before talk principle in the transmitting of the information.

21. The method according to any of claims 18 - 20, further comprising conditionally applying a requirement to occupy between 80% and 100% of a declared nominal channel bandwidth for the communication of the information.

22. The method according to any of claims 18 - 21, comprising performing the communication using a partial interlace comprised in the substructure corresponding to the selected subcarrier spacing.

23. The method according to claim 22, wherein a number of clusters comprised in the partial interlace is reduced by a power of two compared to the number of clusters in a full interface.

24. The method according to any of claims 22 to 23, further comprising determining the number of clusters for the partial interlace such that the clusters comprised in the partial interlace form an integer number of at least one physical resource block.

25. The method according to claim 22 or 24, further comprising processing an allocation where clusters of a given interlace that are comprised in the partial interlace are allocated based on a

given resource allocation scheme, and where clusters of the given interlace that are not comprised in the partial interlace are allocated based on a different resource allocation scheme.

26. The method according to any of claims 22 - 25, further comprising processing an allocation wherein clusters of a given interlace comprised in the partial interlace are allocated for a first user equipment, and clusters of the given interlace that are not comprised in the partial interlace are allocated for a second user equipment.

27. The method according to any of claims 22 - 26, further comprising determining that the apparatus need not occupy between 80% and 100% of the declared nominal channel bandwidth, and responsively applying the partial interlace.

28. The method according to any of claims 18 - 27, wherein the method is performed in an apparatus that is or is comprised in a user equipment and the transmission is an uplink transmission on an unlicensed band.

29. The method according to any of claims 18 – 28, comprising determining the at least one interlace structure by determining a first interlace structure having 240 kHz as the cluster bandwidth, six interlaces, and 12 clusters per interlace, wherein the first interlace structure comprises:

- a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1152 subcarriers in total and 16 physical resource blocks per interlace,
- a second substructure corresponding to a subcarrier spacing of 30 kHz and having 576 subcarriers in total and 8 physical resource blocks per interlace,
- a third substructure corresponding to a subcarrier spacing of 60 kHz and having 288 subcarriers in total and 4 physical resource blocks per interlace,
- a fourth substructure corresponding to a subcarrier spacing of 120 kHz and having 144 subcarriers in total and 2 physical resource blocks per interlace, and
- a fifth substructure corresponding to a subcarrier spacing of 240 kHz and having 72 subcarriers in total, and 1 physical resource block per interlace.

30. The method according to any of claims 18 – 29, comprising determining the at least one interlace structure by determining a second interlace structure having 120 kHz as the cluster bandwidth, 12 interlaces and 12 clusters per interlace, wherein the second interlace structure comprises:

- a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1152 subcarriers in total and 8 physical resource blocks per interlace,

- a second substructure corresponding to a subcarrier spacing of 30 kHz and having 576 subcarriers in total and 4 physical resource blocks per interlace,
- a third substructure corresponding to a subcarrier spacing of 60 kHz and having 288 subcarriers in total and 2 physical resource blocks per interlace, and
- a fourth substructure corresponding to a subcarrier spacing of 120 kHz and having 144 subcarriers in total and 1 physical resource block per interlace.

31. The method according to any of claims 18 – 30, comprising determining the at least one interlace structure by determining a third interlace structure having 240 kHz as the cluster bandwidth, 6 interlaces and 13 clusters per interlace, wherein the third interlace structure comprises:

- a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1248 subcarriers in total and 17,333 physical resource blocks per interlace,
- a second substructure corresponding to a subcarrier spacing of 30 kHz and having 624 subcarriers in total and 8.667 physical resource blocks per interlace,
- a third substructure corresponding to a subcarrier spacing of 60 kHz and having 312 subcarriers in total and 4.333 physical resource blocks per interlace,
- a fourth substructure corresponding to a subcarrier spacing of 120 kHz and having 156 subcarriers in total and 2.167 physical resource blocks per interlace, and
- a fifth substructure corresponding to a subcarrier spacing of 120 kHz and having 78 subcarriers in total and 1.083 physical resource blocks per interlace.

32. The method according to any of claims 18 – 31, comprising determining the at least one interlace structure by determining a fourth interlace structure having 180 kHz as the cluster bandwidth, 10 interlaces and 10 clusters per interlace, wherein the fourth interlace structure comprises:

- a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1200 subcarriers in total and 10 physical resource blocks per interlace,
- a second substructure corresponding to a subcarrier spacing of 30 kHz and having 600 subcarriers in total and 5 physical resource blocks per interlace, and
- a third substructure corresponding to a subcarrier spacing of 60 kHz and having 300 subcarriers in total and 2,5 physical resource blocks per interlace.

33. The method according to any of claims 18 – 32, comprising determining the at least one interlace structure by determining a fifth interlace structure having 360 kHz as the cluster bandwidth, five interlaces and 10 clusters per interlace, wherein the fifth interlace structure comprises:

- a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1200 subcarriers in total and 20 physical resource blocks per interlace,
- a second substructure corresponding to a subcarrier spacing of 30 kHz and having 600 subcarriers in total and 10 physical resource blocks per interlace, and
- a third substructure corresponding to a subcarrier spacing of 60 kHz and having 300 subcarriers in total and 5 physical resource blocks per interlace.

34. The method according to any of claims 18 – 33, comprising determining the at least one interlace structure by determining a sixth interlace structure having 120 kHz as the cluster bandwidth, 13 interlaces and 12 clusters per interlace, wherein the sixth interlace structure comprises:

- a first substructure corresponding to a subcarrier spacing of 15 kHz and having 1248 subcarriers in total and 8 physical resource blocks per interlace,
- a second substructure corresponding to a subcarrier spacing of 30 kHz and having 624 subcarriers in total and 4 physical resource blocks per interlace,
- a third substructure corresponding to a subcarrier spacing of 60 kHz and having 312 subcarriers in total and 2 physical resource blocks per interlace, and
- a fourth substructure corresponding to a subcarrier spacing of 120 kHz and having 156 subcarriers in total and 1 physical resource block per interlace.

35. An apparatus comprising:

- means for determining at least one interlace structure for interlace based resource allocation in a wireless communication, each interlace structure comprising a plurality of interlace substructures, each substructure indicating a resource allocation grid for a specific subcarrier spacing, and wherein a given interlace structure comprises:
    - a constant cluster bandwidth among the plurality of substructures,
    - a constant number of interlaces among the plurality of substructures, and
    - a varying number of subcarriers per interlace among the plurality of substructures, wherein the number of subcarriers per interlace depends on the subcarrier spacing and is, for each of the plurality of substructures, a multiple of a physical resource block size in subcarriers;
- means for selecting a subcarrier spacing to be used in a communication of information; and
- means for performing the communication based on the substructure which corresponds to the selected subcarrier spacing for the communication.

36. A non-transitory computer readable medium having stored thereon a set of computer readable instructions that, when executed by at least one processor, cause an apparatus to at least:

- determine at least one interlace structure for interlace based resource allocation in a wireless communication, each interlace structure comprising a plurality of interlace substructures, each substructure indicating a resource allocation grid for a specific subcarrier spacing, and wherein a given interlace structure comprises:
    - a constant cluster bandwidth among the plurality of substructures,
    - a constant number of interlaces among the plurality of substructures, and
    - a varying number of subcarriers per interlace among the plurality of substructures, wherein the number of subcarriers per interlace depends on the subcarrier spacing and is, for each of the plurality of substructures, a multiple of a physical resource block size in subcarriers;
- select a subcarrier spacing to be used in a communication of information; and
- perform the communication based on the substructure which corresponds to the selected subcarrier spacing for the communication.

37. A computer program configured to cause a method in accordance with at least one of claims 18 - 34 to be performed.

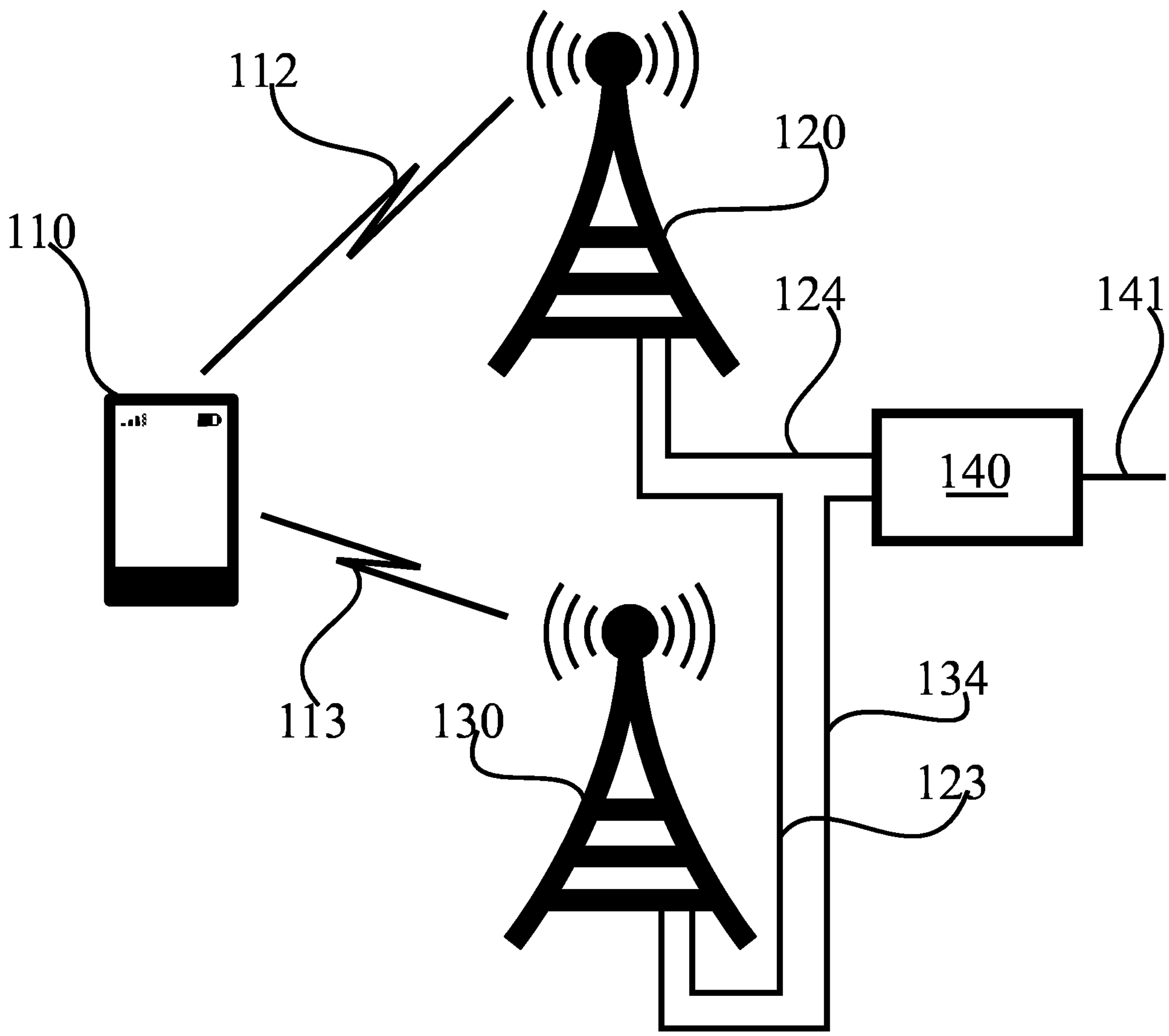

FIGURE 1

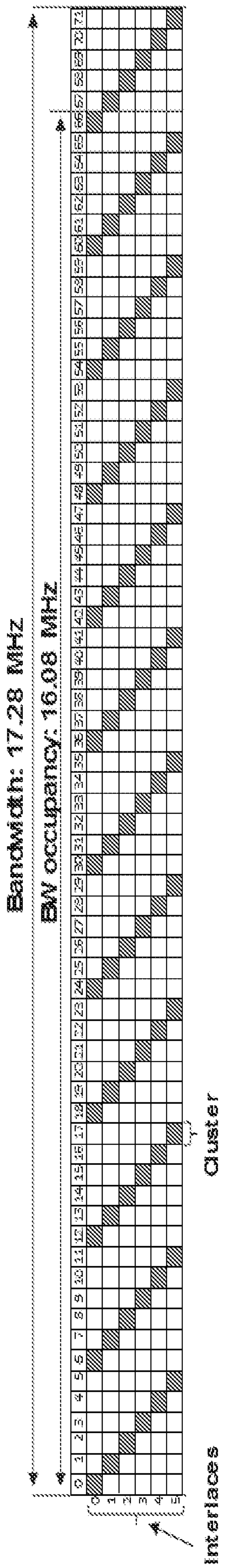

FIGURE 2A

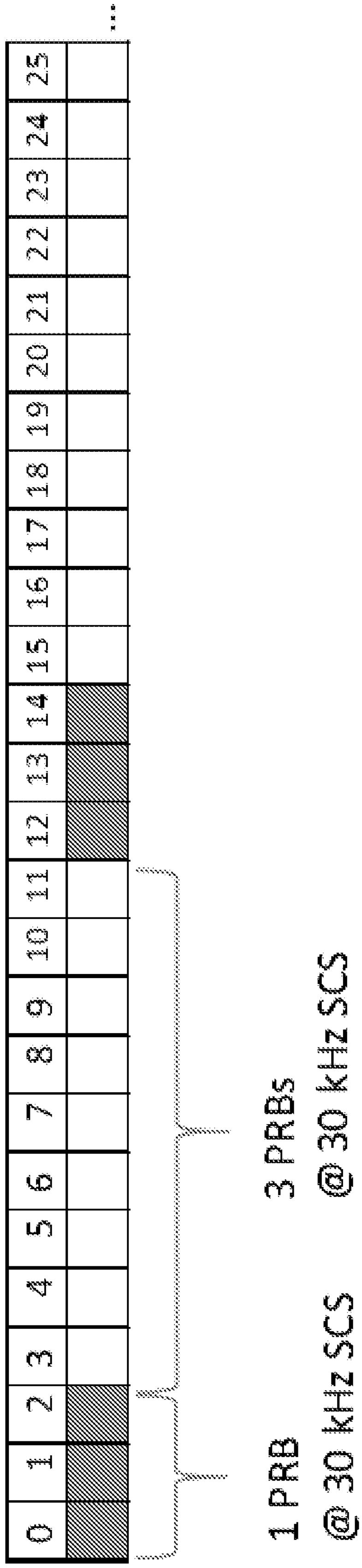

FIGURE 2B

3/6

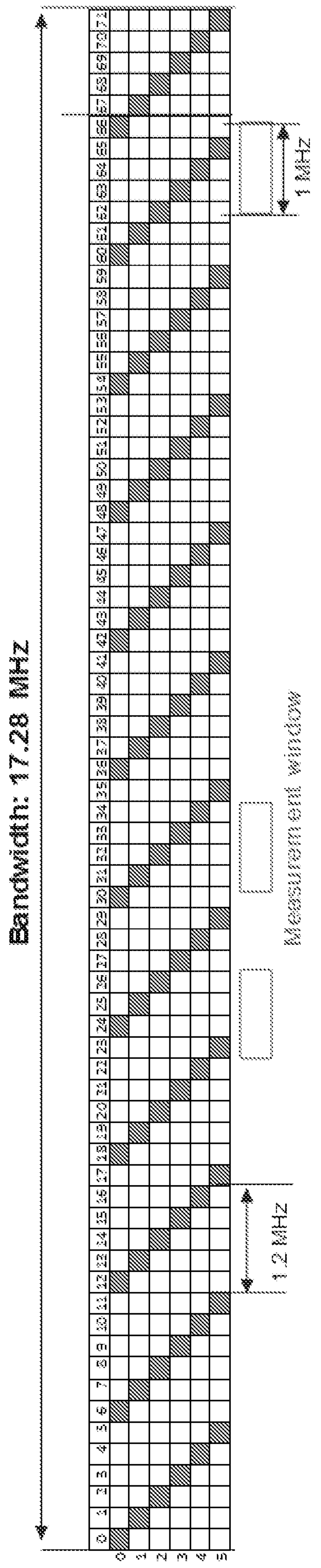

FIGURE 3A

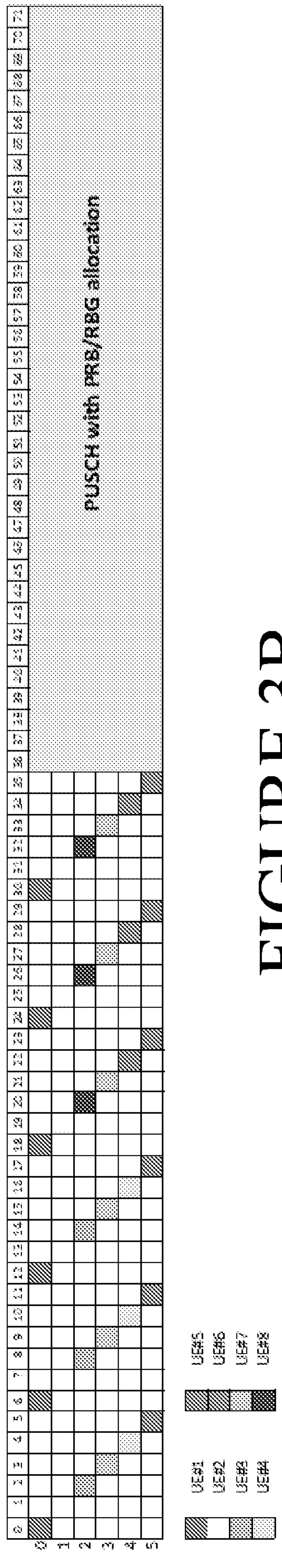

FIGURE 3B

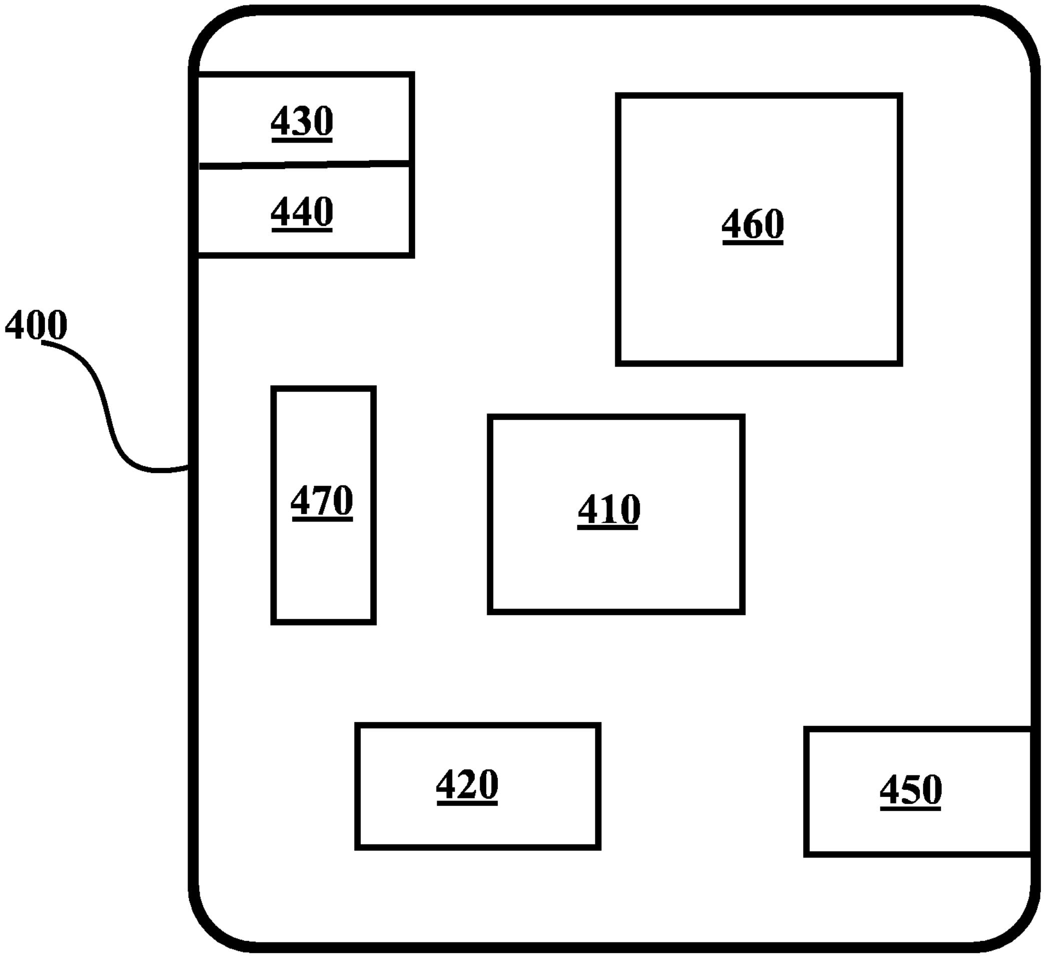

FIGURE 4

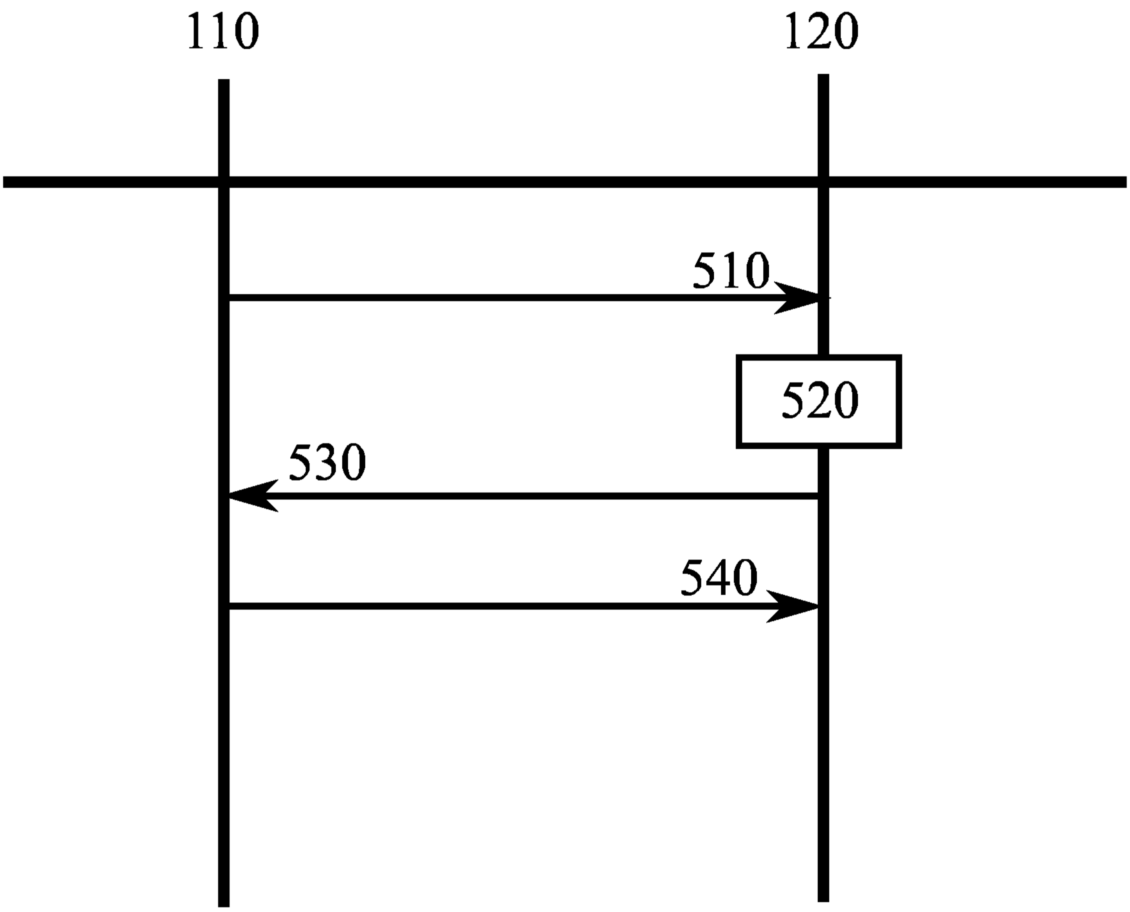

FIGURE 5

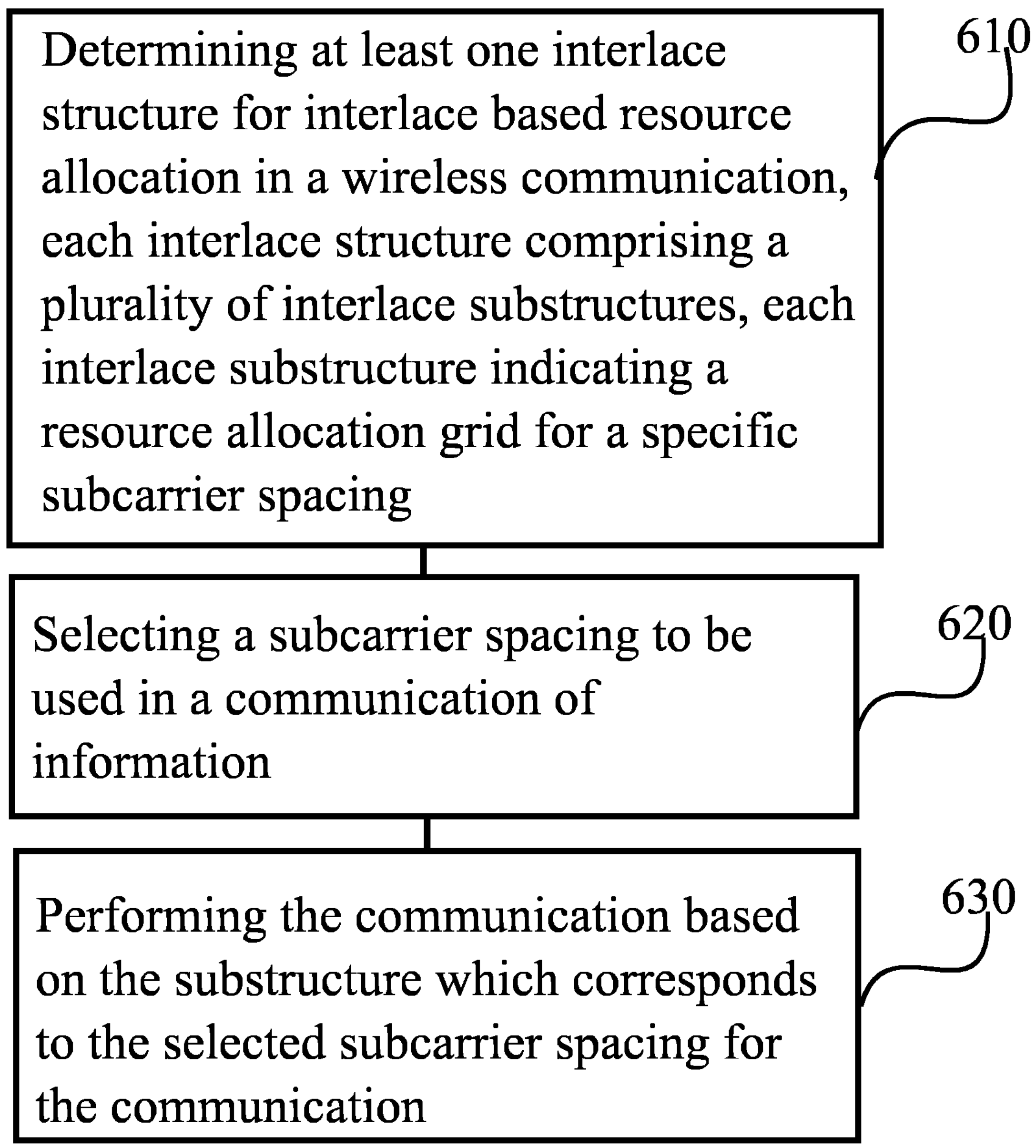
Determining at least one interlace structure for interlace based resource allocation in a wireless communication, each interlace structure comprising a plurality of interlace substructures, each interlace substructure indicating a resource allocation grid for a specific subcarrier spacing
610
Selecting a subcarrier spacing to be used in a communication of information
620
Performing the communication based on the substructure which corresponds to the selected subcarrier spacing for the communication
630

FIGURE 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2018/050820

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04L, H04W

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

FI, SE, NO, DK

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

EPODOC, WPIAP, EPO-Internal full-text databases, translation from Asian languages full-text databases

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2017099659 A1 (ERICSSON TELEFON AB L M (PUBL) [SE]) 15 June 2017 (15.06.2017) abstract, page 1 line 32 – page 2 line 34, page 4 lines 16-18, page 5 lines 29-31, page 7 lines 23-29, page 9 lines 4-13, page 10 lines 4-7, page 12 lines 1-14, page 20 line 4 – page 21 line 14, figs. 2, 4	1-4, 6-7, 10-21, 23-24, 27-37 5, 8-9, 22, 25-26
Y A	WO 2017166998 A1 (JRD COMMUNICATION INC [CN]) 05 October 2017 (05.10.2017) abstract, paras. [0010], [0083]	5, 8-9, 22, 25-26 1-4, 6-7, 10-21, 23-24, 27-37
A	WO 2017164626 A2 (SAMSUNG ELECTRONICS CO LTD [KR]) 28 September 2017 (28.09.2017) abstract, claim 1	1-37

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 February 2019 (04.02.2019)	07 February 2019 (07.02.2019)

Name and mailing address of the ISA/FI Finnish Patent and Registration Office FI-00091 PRH, FINLAND Facsimile No. +358 29 509 5328	Authorized officer Jorma Ristola Telephone No. +358 29 509 5000

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2015042396 A1 (QUALCOMM INC [US]) 26 March 2015 (26.03.2015) abstract	1-37
A	QUALCOMM INCORPORATED: "UPLINK WAVEFORM FOR LAA", 3GPP TSG RAN WG1 #81 R1 -152790, APRIL 25TH – 29TH 2015 FUKUOKA JAPAN. Introduction	1-37

Patent document cited in search report	Publication date	Patent family members(s)	Publication date
WO 2017099659 A1	15/06/2017	CN 108476114 A	31/08/2018
		EP 3387778 A1	17/10/2018
		US 2019013905 A1	10/01/2019
WO 2017166998 A1	05/10/2017	CN 109156001 A	04/01/2019
		GB 2548922 A	04/10/2017
		GB 2548922 B	12/09/2018
WO 2017164626 A2	28/09/2017	CN 109075914 A	21/12/2018
		EP 3417558 A2	26/12/2018
		KR 20180119563 A	02/11/2018
		US 2017273056 A1	21/09/2017
WO 2015042396 A1	26/03/2015	BR 112016008368 A2	04/12/2018
		CN 105557050 A	04/05/2016
		CN 105557050 B	30/11/2018
		EP 3047694 A1	27/07/2016
		EP 3047694 B1	24/10/2018
		JP 2016532331 A	13/10/2016
		KR 20160058125 A	24/05/2016
		US 2015085794 A1	26/03/2015

CLASSIFICATION OF SUBJECT MATTER

IPC
H04W 72/04 (2009.01)
H04L 5/00 (2006.01)
H04L 27/26 (2006.01)
H04W 16/14 (2009.01)
H04W 72/12 (2009.01)
H04W 72/08 (2009.01)
H04L 27/00 (2006.01)