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Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document specifies and establishes the characteristics of the physical layer procedures for shared spectrum channel.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 36.104: "Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception".

[3] 3GPP TS 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception".

[4] 3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

3.2 Symbols

For the purposes of the present document, the following symbols apply:

CW_p Contention window for a given priority class

$CW_{\max,p}$ Maximum contention window for a given priority class

$CW_{\min,p}$ Minimum contention window for a given priority class

$T_{m\cot,p}$ Maximum channel occupancy time for a given priority class

$T_{ulm\cot,p}$ Maximum Uplink channel occupancy time for a given priority class

X_{Thresh} Energy detection threshold

$X_{\mathrm{Thresh\_max}}$ Maximum energy detection threshold

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

AUL-DFI	Autonomous UL Downlink feedback indication
COT	Channel Occupancy Time
LAA	Licensed Assisted Access
MCOT	Maximum Channel Occupancy Time

4 Channel access procedure

4.1 Downlink channel access procedures

An eNB operating LAA Scell(s) shall perform the channel access procedures described in this sub clause for accessing the channel(s) on which the LAA Scell(s) transmission(s) are performed.

4.1.1 Channel access procedure for transmission(s) including PDSCH/PDCCH/EPDCCH

The eNB may transmit a transmission including PDSCH/PDCCH/EPDCCH on a carrier on which LAA Scell(s) transmission(s) are performed , after first sensing the channel to be idle during the slot durations of a defer duration T_d ; and after the counter N is zero in step 4. The counter N is adjusted by sensing the channel for additional slot duration(s) according to the steps below:

1) set $N = N_{init}$, where N_{init} is a random number uniformly distributed between 0 and CW_p , and go to step 4;

2) if $N > 0$ and the eNB chooses to decrement the counter, set $N = N - 1$;

3) sense the channel for an additional slot duration, and if the additional slot duration is idle, go to step 4; else, go to step 5;

4) if $N = 0$, stop; else, go to step 2.

5) sense the channel until either a busy slot is detected within an additional defer duration T_d or all the slots of the additional defer duration T_d are detected to be idle;

6) if the channel is sensed to be idle during all the slot durations of the additional defer duration T_d , go to step 4; else, go to step 5;

If an eNB has not transmitted a transmission including PDSCH/PDCCH/EPDCCH on a carrier on which LAA Scell(s) transmission(s) are performed after step 4 in the procedure above, the eNB may transmit a transmission including PDSCH/PDCCH/EPDCCH on the carrier, if the channel is sensed to be idle at least in a slot duration T_{sl} when the eNB is ready to transmit PDSCH/PDCCH/EPDCCH and if the channel has been sensed to be idle during all the slot durations of a defer duration T_d immediately before this transmission. If the channel has not been sensed to be idle in a slot duration T_{sl} when the eNB first senses the channel after it is ready to transmit or if the channel has been sensed to be not idle during any of the slot durations of a defer duration T_d immediately before this intended transmission, the eNB proceeds to step 1 after sensing the channel to be idle during the slot durations of a defer duration T_d .

The defer duration T_d consists of duration $T_f = 16us$ immediately followed by m_p consecutive slot durations where each slot duration is $T_{sl} = 9us$, and T_f includes an idle slot duration T_{sl} at start of T_f;

A slot duration T_{sl} is considered to be idle if the eNB senses the channel during the slot duration, and the power detected by the eNB for at least $4us$ within the slot duration is less than energy detection threshold X_{Thresh}. Otherwise, the slot duration T_{sl} is considered to be busy.

$CW_{\min,p} \le CW_p \le CW_{\max,p}$ is the contention window. CW_p adjustment is described in sub clause 4.1.4.

$CW_{\min,p}$ and $CW_{\max,p}$ are chosen before step 1 of the procedure above.

m_p, $CW_{\min,p}$, and $CW_{\max,p}$ are based on channel access priority class associated with the eNB transmission, as shown in Table 4.1.1-1.

X_{Thresh} adjustment is described in sub clause 4.1.4

If the eNB transmits discovery signal transmission(s) not including PDSCH/PDCCH/EPDCCH when $N > 0$ in the procedure above, the eNB shall not decrement N during the slot duration(s) overlapping with discovery signal transmission.

The eNB shall not continuously transmit on a carrier on which the LAA Scell(s) transmission(s) are performed, for a period exceeding $T_{m\cot,p}$ as given in Table 4.1.1-1.

For $p = 3$ and $p = 4$, if the absence of any other technology sharing the carrier can be guaranteed on a long term basis (e.g. by level of regulation), $T_{m\cot,p} = 10ms$, otherwise, $T_{m\cot,p} = 8ms$.

Table 4.1.1-1: Channel Access Priority Class

Channel Access Priority Class (p)	m_p	$CW_{\min,p}$	$CW_{\max,p}$	$T_{m\cot,p}$	allowed CW_p sizes
1	1	3	7	2 ms	{3,7}
2	1	7	15	3 ms	{7,15}
3	3	15	63	8 or 10 ms	{15,31,63}
4	7	15	1023	8 or 10 ms	{15,31,63,127,255,511,1023}

For LAA operation in Japan, if the eNB has transmitted a transmission after $N = 0$ in step 4 of the procedure above, the eNB may transmit the next continuous transmission, for duration of maximum T_j =4 ms, immediately after sensing the channel to be idle for at least a sensing interval of T_{js} =34us and if the total sensing and transmission time is not more than $1000 \cdot T_{mcot} + \lceil T_{mcot} / T_j - 1 \rceil \cdot T_{js}$ µsec. T_{js} consists of duration $T_f = 16us$ immediately followed by two slot durations $T_{sl} = 9us$ each and T_f includes an idle slot duration T_{sl} at start of T_f. The channel is considered to be idle for T_{js} if it is sensed to be idle during the during the slot durations of T_{js}.

4.1.2 Channel access procedure for transmissions including discovery signal transmission(s) and not including PDSCH

An eNB may transmit a transmission including discovery signal but not including PDSCH on a carrier on which LAA Scell(s) transmission(s) are performed immediately after sensing the channel to be idle for at least a sensing interval $T_{\text{drs}} = 25us$ and if the duration of the transmission is less than 1 ms. T_{drs} consists of a duration $T_f = 16us$ immediately followed by one slot duration $T_{sl} = 9us$ and T_f includes an idle slot duration T_{sl} at start of T_f. The channel is considered to be idle for T_{drs} if it is sensed to be idle during the slot durations of T_{drs}.

4.1.3 Channel access procedure for transmissions including PDCCH and not including PDSCH

If a PUSCH transmission indicates COT sharing, an eNB may transmit a transmission including PDCCH but not including PDSCH on the same carrier immediately after sensing the channel to be idle for at least a sensing interval $T_{\text{pdcch}} = 25us$, if the duration of the PDCCH is less than or equal to two OFDM symbols length and it shall contain at least AUL-DFI or UL grant to the UE from which the PUSCH transmission indicating COT sharing was received. T_{pdcch} consists of a duration $T_f = 16us$ immediately followed by one slot duration $T_{sl} = 9us$ and T_f includes an idle slot duration T_{sl} at start of T_f. The channel is considered to be idle for T_{pdcch} if it is sensed to be idle during the slot durations of T_{pdcch}.

4.1.4 Contention window adjustment procedure

If the eNB transmits transmissions including PDSCH that are associated with channel access priority class p on a carrier, the eNB maintains the contention window value CW_p and adjusts CW_p before step 1 of the procedure described in sub clause 4.1.1 for those transmissions using the following steps:

1) for every priority class $p \in \{1,2,3,4\}$ set $CW_p = CW_{\min,p}$
2) if at least $Z = 80\%$ of HARQ-ACK values corresponding to PDSCH transmission(s) in reference subframe k are determined as NACK, increase CW_p for every priority class $p \in \{1,2,3,4\}$ to the next higher allowed value and remain in step 2; otherwise, go to step 1.

Reference subframe k is the starting subframe of the most recent transmission on the carrier made by the eNB, for which at least some HARQ-ACK feedback is expected to be available.

The eNB shall adjust the value of CW_p for every priority class $p \in \{1,2,3,4\}$ based on a given reference subframe k only once.

If $CW_p = CW_{\max,p}$, the next higher allowed value for adjusting CW_p is $CW_{\max,p}$.

For determining Z,

- if the eNB transmission(s) for which HARQ-ACK feedback is available start in the second slot of subframe k, HARQ-ACK values corresponding to PDSCH transmission(s) in subframe $k+1$ are also used in addition to the HARQ-ACK values corresponding to PDSCH transmission(s) in subframe k.
- if the HARQ-ACK values correspond to PDSCH transmission(s) on an LAA SCell that are assigned by (E)PDCCH transmitted on the same LAA SCell,
  - if no HARQ-ACK feedback is detected for a PDSCH transmission by the eNB, or if the eNB detects 'DTX', 'NACK/DTX' or 'any' state, it is counted as NACK.

- if the HARQ-ACK values correspond to PDSCH transmission(s) on an LAA SCell that are assigned by (E)PDCCH transmitted on another serving cell,
  - if the HARQ-ACK feedback for a PDSCH transmission is detected by the eNB, 'NACK/DTX' or 'any' state is counted as NACK, and 'DTX' state is ignored.
  - if no HARQ-ACK feedback is detected for a PDSCH transmission by the eNB
    - if PUCCH format 1b with channel selection is expected to be used by the UE, 'NACK/DTX' state corresponding to 'no transmission' as described in Subclauses 10.1.2.2.1, 10.1.3.1 and 10.1.3.2.1 is counted as NACK, and 'DTX' state corresponding to 'no transmission' is ignored in [4].
    - Otherwise, the HARQ-ACK for the PDSCH transmission is ignored.
- if a PDSCH transmission has two codewords, the HARQ-ACK value of each codeword is considered separately
- bundled HARQ-ACK across M subframes is considered as M HARQ-ACK responses.

If the eNB transmits transmissions including PDCCH/EPDCCH with DCI format 0A/0B/4A/4B and not including PDSCH that are associated with channel access priority class p on a channel starting from time t_0, the eNB maintains the contention window value CW_p and adjusts CW_p before step 1 of the procedure described in sub clause 4.1.1 for those transmissions using the following steps:

1) for every priority class $p \in \{1,2,3,4\}$ set $CW_p = CW_{\min,p}$
2) if less than 10% of the UL transport blocks scheduled by the eNB using Type 2 channel access procedure (described in sub clause 4.2.1.2) in the time interval between t_0 and $t_0 + T_{CO}$ have been received successfully, increase CW_p for every priority class $p \in \{1,2,3,4\}$ to the next higher allowed value and remain in step 2; otherwise, go to step 1.

where T_{CO} is computed as described in Subclause 4.2.1.

If the $CW_p = CW_{\max,p}$ is consecutively used K times for generation of N_{init}, CW_p is reset to $CW_{\min,p}$ only for that priority class p for which $CW_p = CW_{\max,p}$ is consecutively used K times for generation of N_{init}. K is selected by eNB from the set of values {1, 2, …,8} for each priority class $p \in \{1,2,3,4\}$.

4.1.5 Energy detection threshold adaptation procedure

An eNB accessing a carrier on which LAA Scell(s) transmission(s) are performed, shall set the energy detection threshold (X_{Thresh}) to be less than or equal to the maximum energy detection threshold $X_{\text{Thresh\_max}}$.

$X_{\text{Thresh\_max}}$ is determined as follows:

- If the absence of any other technology sharing the carrier can be guaranteed on a long term basis (e.g. by level of regulation) then:
  - $X_{\text{Thresh\_max}} = \min \left\{ \begin{matrix} T_{\max} + 10\,dB, \\ X_r \end{matrix} \right\}$
    - X_r is Maximum energy detection threshold defined by regulatory requirements in dBm when such requirements are defined, otherwise $X_r = T_{\max} + 10\,dB$
- Otherwise,

- $$X_{\text{Thres\_max}} = \max\left\{\begin{array}{l} -72 + 10\cdot\log 10(BWMHz/20MHz)\ dBm, \\ \min\left\{\begin{array}{l} T_{\max}, \\ T_{\max} - T_A + \left(P_H + 10\cdot\log 10(BWMHz/20MHz) - P_{TX}\right) \end{array}\right\} \end{array}\right\}$$

- Where:
  - T_A = 10dB for transmission(s) including PDSCH;
  - T_A = 5dB for transmissions including discovery signal transmission(s) and not including PDSCH;
  - P_H = 23 dBm;
  - P_{TX} is the set maximum eNB output power in dBm for the carrier;
    - eNB uses the set maximum transmission power over a single carrier irrespective of whether single carrier or multi-carrier transmission is employed
  - $T_{\max}(\text{dBm}) = 10\cdot\log 10\left(3.16228\cdot 10^{-8}(mW/MHz)\cdot BWMHz\ (MHz)\right)$;
  - BWMHz is the single carrier bandwidth in MHz.

4.1.6 Channel access procedure for transmission(s) on multiple carriers

An eNB can access multiple carriers on which LAA Scell(s) transmission(s) are performed, according to one of the Type A or Type B procedures described in this Subclause.

4.1.6.1 Type A multi-carrier access procedures

The eNB shall perform channel access on each carrier $c_i \in C$, according to the procedures described in Subclause 4.1.1, where C is a set of carriers on which the eNB intends to transmit, and $i = 0,1,\ldots q-1$, and q is the number of carriers on which the eNB intends to transmit.

The counter N described in Subclause 4.1.1 is determined for each carrier c_i and is denoted as N_{c_i}. N_{c_i} is maintained according to Subclause 4.1.5.1.1or 4.1.5.1.2.

4.1.6.1.1 Type A1

Counter N as described in Subclause 4.1.1 is independently determined for each carrier c_i and is denoted as N_{c_i}.

If the absence of any other technology sharing the carrier cannot be guaranteed on a long term basis (e.g. by level of regulation), when the eNB ceases transmission on any one carrier $c_j \in C$, for each carrier $c_i \neq c_j$, the eNB can resume decrementing N_{c_i} when idle slots are detected either after waiting for a duration of $4\cdot T_{sl}$, or after reinitialising N_{c_i}.

4.1.6.1.2 Type A2

Counter N is determined as described in Subclause 4.1.1 for carrier $c_j \in C$, and is denoted as N_{c_j}, where c_j is the carrier that has the largest CW_p value. For each carrier c_i, $N_{c_i} = N_{c_j}$.

When the eNB ceases transmission on any one carrier for which N_{c_i} is determined, the eNB shall reinitialise N_{c_i} for all carriers.

4.1.6.2 Type B multi-carrier access procedure

A carrier $c_j \in C$ is selected by the eNB as follows

- the eNB selects c_j by uniformly randomly choosing c_j from C before each transmission on multiple carriers $c_i \in C$, or
- the eNB selects c_j no more frequently than once every 1 second,

where C is a set of carriers on which the eNB intends to transmit, $i = 0,1,\ldots q-1$, and q is the number of carriers on which the eNB intends to transmit.

To transmit on carrier c_j

- the eNB shall perform channel access on carrier c_j according to the procedures described in Subclause 4.1.1 with the modifications described in 4.1.5.2.1 or 4.1.5.2.2.

To transmit on carrier $c_i \neq c_j$, $c_i \in C$

- for each carrier c_i, the eNB shall sense the carrier c_i for at least a sensing interval $T_{\mathrm{mc}} = 25us$ immediately before the transmitting on carrier c_j, and the eNB may transmit on carrier c_i immediately after sensing the carrier c_i to be idle for at least the sensing interval T_{mc}. The carrier c_i is considered to be idle for T_{mc} if the channel is sensed to be idle during all the time durations in which such idle sensing is performed on the carrier c_j in given interval T_{mc}.

The eNB shall not continuously transmit on a carrier $c_i \neq c_j$, $c_i \in C$, for a period exceeding $T_{m\cot,p}$ as given in Table 4.1.1-1, where the value of $T_{m\cot,p}$ is determined using the channel access parameters used for carrier c_j.

4.1.6.2.1 Type B1

A single CW_p value is maintained for the set of carriers C.

For determining CW_p for channel access on carrier c_j, step 2 of the procedure described in sub clause 4.1.3 is modified as follows

- if at least $Z = 80\%$ of HARQ-ACK values corresponding to PDSCH transmission(s) in reference subframe k of all carriers $c_i \in C$ are determined as NACK, increase CW_p for each priority class $p \in \{1,2,3,4\}$ to the next higher allowed value; otherwise, go to step 1.

4.1.6.2.2 Type B2

A CW_p value is maintained independently for each carrier $c_i \in C$ using the procedure described in Subclause 4.1.3.

For determining N_{init} for carrier c_j, CW_p value of carrier $c_{j1} \in C$ is used, where c_{j1} is the carrier with largest CW_p among all carriers in set C.

4.2 Uplink channel access procedures

A UE and a eNB scheduling UL transmission(s) for the UE shall perform the procedures described in this sub clause for the UE to access the channel(s) on which the LAA Scell(s) transmission(s) are performed.

4.2.1 Channel access procedure for uplink transmission(s)

The UE can access a carrier on which LAA Scell(s) UL transmission(s) are performed according to one of Type 1 or Type 2 UL channel access procedures. Type 1 channel access procedure is described in sub clause 4.2.1.1. Type 2 channel access procedure is described in sub clause 4.2.1.2.

If an UL grant scheduling a PUSCH transmission indicates Type 1 channel access procedure, the UE shall use Type 1 channel access procedure for transmitting transmissions including the PUSCH transmission unless stated otherwise in this sub clause.

A UE shall use Type 1 channel access procedure for transmitting transmissions including the PUSCH transmission on autonomous UL resources unless stated otherwise in this sub clause.

If an UL grant scheduling a PUSCH transmission indicates Type 2 channel access procedure, the UE shall use Type 2 channel access procedure for transmitting transmissions including the PUSCH transmission unless stated otherwise in this sub clause.

The UE shall use Type 1 channel access procedure for transmitting SRS transmissions not including a PUSCH transmission. UL channel access priority class $p=1$ is used for SRS transmissions not including a PUSCH.

If the UE is scheduled to transmit PUSCH and SRS in subframe n , and if the UE cannot access the channel for PUSCH transmission in subframe n , the UE shall attempt to make SRS transmission in subframe n according to uplink channel access procedures specified for SRS transmission.

Table 4.2.1-1: Channel Access Priority Class for UL

Channel Access Priority Class (p)	m_p	$CW_{\min,p}$	$CW_{\max,p}$	$T_{ulm\cot,p}$	allowed CW_p sizes
1	2	3	7	2 ms	{3,7}
2	2	7	15	4 ms	{7,15}
3	3	15	1023	6ms or 10 ms	{15,31,63,127,255,511,1023}
4	7	15	1023	6ms or 10 ms	{15,31,63,127,255,511,1023}
NOTE1: For $p=3,4$, $T_{ulm\cot,p}$ =10ms if the higher layer parameter '*absenceOfAnyOtherTechnology-r14'* indicates TRUE, otherwise, $T_{ulm\cot,p}$ =6ms. NOTE 2: When $T_{ulm\cot,p}$ =6ms it may be increased to 8 ms by inserting one or more gaps. The minimum duration of a gap shall be 100 μs. The maximum duration before including any such gap shall be 6 ms.					

If the UL duration and offset' field configures an 'UL offset' l and an 'UL duration' d for subframe n , then

the scheduled UE may use channel access Type 2 for transmissions in subframes $n+l+i$ where $i=0,1,\ldots d-1$, irrespective of the channel access Type signalled in the UL grant for those subframes, if the end of UE transmission occurs in or before subframe $n+l+d-1$.

If the 'UL duration and offset' field configures an 'UL offset' l and an 'UL duration' d for subframe n and the 'COT sharing indication for AUL' field is set to true, then a UE configured with autonomous UL may use channel access Type 2 for autonomous UL transmissions corresponding to any priority class in subframes $n+l+i$ where $i=0,1,\ldots d-1$, if the end of UE autonomous UL transmission occurs in or before subframe $n+l+d-1$ and the autonomous UL transmission between $n+l$ and $n+l+d-1$ shall be contiguous.

If the 'UL duration and offset' field configures an 'UL offset' l and an 'UL duration' d for subframe n and the 'COT sharing indication for AUL' field is set to false, then a UE configured with autonomous UL shall not transmit autonomous UL in subframes $n+l+i$ where $i=0,1,\ldots d-1$.

If the UE scheduled to transmit transmissions including PUSCH in a set subframes $n_0, n_1, \cdots, n_{w-1}$ using PDCCH DCI Format 0B/4B, and if the UE cannot access the channel for a transmission in subframe n_k, the UE shall attempt to make a transmission in subframe n_{k+1} according to the channel access type indicated in the DCI, where $k \in \{0,1,\cdots w-2\}$, and w is the number of scheduled subframes indicated in the DCI.

If the UE is scheduled to transmit transmissions without gaps including PUSCH in a set of subframes $n_0, n_1, \cdots, n_{w-1}$ using one or more PDCCH DCI Format 0A/0B/4A/4B and the UE performs a transmission in subframe n_k after accessing the carrier according to one of Type 1 or Type 2 UL channel access procedures, the UE may continue transmission in subframes after n_k where $k \in \{0,1,\cdots w-1\}$.

If the beginning of UE transmission in subframe $n+1$ immediately follows the end of UE transmission in subframe n, the UE is not expected to be indicated with different channel access types for the transmissions in those subframes.

If the UE is scheduled to transmit transmissions including PUSCH Mode 1 in a set subframes $n_0, n_1, \cdots, n_{w-1}$ using PDCCH DCI Format 0A/4A/0B/4B and Type 1 channel access procedure, and if the UE cannot access the channel for a transmission in subframe n_k according to the PUSCH starting position indicated in the DCI, the UE shall attempt to make a transmission in subframe n_k with an offset of o_i OFDM symbol and according to the channel access type indicated in the DCI, where $k \in \{0,1,\cdots w-1\}$ and $i \in \{0,7\}$, for i =0 the attempt is made at the PUSCH starting position indicated in the DCI, and w is the number of scheduled subframes indicated in the DCI. There is no limit on the number of attempts the UE should make for the transmission.

If the UE is scheduled to transmit transmissions including PUSCH Mode 1 in a set subframes $n_0, n_1, \cdots, n_{w-1}$ using PDCCH DCI Format 0A/4A/0B/4B and Type 2 channel access procedure, and if the UE cannot access the channel for a transmission in subframe n_k according to the PUSCH starting position indicated in the DCI, the UE may attempt to make a transmission in subframe n_k with an offset of o_i OFDM symbol and according to the channel access type indicated in the DCI, where $k \in \{0,1,\cdots w-1\}$ and $i \in \{0,7\}$, for i =0 the attempt is made at the PUSCH starting position indicated in the DCI, and w is the number of scheduled subframes indicated in the DCI . The number of attempts the UE should make for the transmission is limited to $w+1$, where w is the number of scheduled subframes indicated in the DCI.

If the UE is scheduled to transmit without gaps in subframes $n_0, n_1, \cdots, n_{w-1}$ using one or more PDCCH DCI Format 0A/0B/4A/4B, and if the UE has stopped transmitting during or before subframe n_{k1}, $k1 \in \{0,1,\cdots w-2\}$, and if the channel is sensed by the UE to be continuously idle after the UE has stopped transmitting, the UE may transmit in a later subframe n_{k2}, $k2 \in \{1,\cdots w-1\}$ using Type 2 channel access procedure. If the channel sensed by the UE is not continuously idle after the UE has stopped transmitting, the UE may transmit in a later subframe n_{k2}, $k2 \in \{1,\cdots w-1\}$ using Type 1 channel access procedure with the UL channel access priority class indicated in the DCI corresponding to subframe n_{k2}.

If the UE receives an UL grant and the DCI indicates a PUSCH transmission starting in subframe n using Type 1 channel access procedure, and if the UE has an ongoing Type 1 channel access procedure before subframe n.

- if the UL channel access priority class value p_1 used for the ongoing Type 1 channel access procedure is same or larger than the UL channel access priority class value p_2 indicated in the DCI, the UE may transmit the PUSCH transmission in response to the UL grant by accessing the carrier by using the ongoing Type 1 channel access procedure.
- if the UL channel access priority class value p_1 used for the ongoing Type 1 channel access procedure is smaller than the UL channel access priority class value p_2 indicated in the DCI, the UE shall terminate the ongoing channel access procedure.

If the UE

- is scheduled to transmit on a set of carriers C in subframe n , and if the UL grants scheduling PUSCH transmissions on the set of carriers C indicate Type 1 channel access procedure, and if the same '*PUSCH starting position*' is indicated for all carriers in the set of carriers C , or
- intends to perform an autonomous uplink transmission on the set of carriers C in subframe n with Type 1 channel access procedure, and if the same $N_{\text{Start}}^{\text{FS3}}$ is used for all carriers in the set of carriers C , and

if the carrier frequencies of set of carriers C is a subset of one of the sets of carrier frequencies defined in Subclause 5.7.4 in [2]

- the UE may transmit on carrier $c_i \in C$ using Type 2 channel access procedure,
  - if Type 2 channel access procedure is performed on carrier c_i immediately before the UE transmission on carrier $c_j \in C$, $i \neq j$, and
  - if the UE has accessed carrier c_j using Type 1 channel access procedure,
    - where carrier c_j is selected by the UE uniformly randomly from the set of carriers C before performing Type 1 channel access procedure on any carrier in the set of carriers C .

If the UE is scheduled to transmit on carrier c_i by a UL grant received on carrier c_j , $i \neq j$, and if the UE is transmitting using autonomous UL on carrier c_i , the UE shall terminate the ongoing PUSCH transmissions using the autonomous UL at least one subframe before the UL transmission according to the received UL grant.

If the UE is scheduled by a UL grant received on a carrier to transmit a PUSCH transmission(s) starting from subframe n on the same carrier using Type 1 channel access procedure and if at least for the first scheduled subframe occupies $N_{\text{RB}}^{\text{UL}}$ resource blocks and the indicated 'PUSCH starting position is OFDM symbol zero, and if the UE starts autonomous UL transmissions before subframe n using Type 1 channel access procedure on the same carrier, the UE may transmit UL transmission(s) according to the received UL grant from subframe n without a gap, if the priority class value of the performed channel access procedure is larger than or equal to priority class value indicated in the UL grant, and the autonomous UL transmission in the subframe preceding subframe n shall end at the last OFDM symbol of the subframe regardless of the higher layer parameter *AulEndingPosition*. The sum of the lengths of the autonomous UL transmission(s) and the scheduled UL transmission(s) shall not exceed the maximum channel occupancy time corresponding to the priority class value used to perform the autonomous uplink channel access procedure. Otherwise, the UE shall terminate the ongoing autonomous UL transmission at least one subframe before the start of the UL transmission according to the received UL grant on the same carrier.

A eNB may indicate Type 2 channel access procedure in the DCI of an UL grant scheduling transmission(s) including PUSCH on a carrier in subframe n when

- the eNB has transmitted on the carrier according to the channel access procedure described in sub clause 4.1.1,
- or an eNB may indicate using the 'UL duration and offset' field that the UE may perform a Type 2 channel access procedure for transmissions(s) including PUSCH on a carrier in subframe n when the eNB has transmitted on the carrier according to the channel access procedure described in sub clause 4.1.1,
- or an eNB may indicate using the 'UL duration and offset' field and 'COT sharing indication for AUL' field that a UE configured with autonomous UL may perform a Type 2 channel access procedure for autonomous UL transmissions(s) including PUSCH on a carrier in subframe n when the eNB has transmitted on the carrier according to the channel access procedure described in sub clause 4.1.1 and acquired the channel using the largest priority class value and the eNB transmission includes PDSCH,
- or an eNB may schedule transmissions including PUSCH on a carrier in subframe n , that follows a transmission by the eNB on that carrier with a duration of $T_{\text{short\_ul}} = 25us$, if subframe n occurs within the time interval starting at t_0 and ending at $t_0 + T_{CO}$, where $T_{CO} = T_{m\text{cot},p} + T_g$, where

- t_0 is the time instant when the eNB has started transmission,
- $T_{m\cot,p}$ value is determined by the eNB as described in sub clause 4.1,
- T_g is the total duration of all gaps of duration greater than 25us that occur between the DL transmission of the eNB and UL transmissions scheduled by the eNB, and between any two UL transmissions scheduled by the eNB starting from t_0.

The eNB shall schedule UL transmissions between t_0 and $t_0 + T_{CO}$ in contiguous subframes if they can be scheduled contiguously.

For an UL transmission on a carrier that follows a transmission by the eNB on that carrier within a duration of $T_{\text{short\_ul}} = 25us$, the UE may use Type 2 channel access procedure for the UL transmission.

If the eNB indicates Type 2 channel access procedure for the UE in the DCI, the eNB indicates the channel access priority class used to obtain access to the channel in the DCI.

4.2.1.1 Type 1 UL channel access procedure

The UE may transmit the transmission using Type 1 channel access procedure after first sensing the channel to be idle during the slot durations of a defer duration T_d ; and after the counter N is zero in step 4. The counter N is adjusted by sensing the channel for additional slot duration(s) according to the steps described below.

1) set $N = N_{init}$, where N_{init} is a random number uniformly distributed between 0 and CW_p, and go to step 4;
2) if $N > 0$ and the UE chooses to decrement the counter, set $N = N - 1$;
3) sense the channel for an additional slot duration, and if the additional slot duration is idle, go to step 4; else, go to step 5;
4) if $N = 0$, stop; else, go to step 2.
5) sense the channel until either a busy slot is detected within an additional defer duration T_d or all the slots of the additional defer duration T_d are detected to be idle;
6) if the channel is sensed to be idle during all the slot durations of the additional defer duration T_d, go to step 4; else, go to step 5;

If the UE has not transmitted a transmission including PUSCH or SRS on a carrier on which LAA Scell(s) transmission(s) are performed after step 4 in the procedure above, the UE may transmit a transmission including PUSCH or SRS on the carrier, if the channel is sensed to be idle at least in a slot duration T_{sl} when the UE is ready to transmit the transmission including PUSCH or SRS, and if the channel has been sensed to be idle during all the slot durations of a defer duration T_d immediately before the transmission including PUSCH or SRS. If the channel has not been sensed to be idle in a slot duration T_{sl} when the UE first senses the channel after it is ready to transmit, or if the channel has not been sensed to be idle during any of the slot durations of a defer duration T_d immediately before the intended transmission including PUSCH or SRS, the UE proceeds to step 1 after sensing the channel to be idle during the slot durations of a defer duration T_d.

The defer duration T_d consists of duration $T_f = 16us$ immediately followed by m_p consecutive slot durations where each slot duration is $T_{sl} = 9us$, and T_f includes an idle slot duration T_{sl} at start of T_f;

A slot duration T_{sl} is considered to be idle if the UE senses the channel during the slot duration, and the power detected by the UE for at least $4us$ within the slot duration is less than energy detection threshold X_{Thresh}. Otherwise, the slot duration T_{sl} is considered to be busy.

$CW_{\min,p} \le CW_p \le CW_{\max,p}$ is the contention window. CW_p adjustment is described in sub clause 4.2.2.

$CW_{\min,p}$ and $CW_{\max,p}$ are chosen before step 1 of the procedure above.

m_p, $CW_{\min,p}$, and $CW_{\max,p}$ are based on channel access priority class signalled to the UE, as shown in Table 4.2.1-1.

X_{Thresh} adjustment is described in sub clause 4.2.3.

4.2.1.2 Type 2 UL channel access procedure

If the UL UE uses Type 2 channel access procedure for a transmission including PUSCH, the UE may transmit the transmission including PUSCH immediately after sensing the channel to be idle for at least a sensing interval $T_{\text{short\_ul}} = 25us$. $T_{\text{short\_ul}}$ consists of a duration $T_f = 16us$ immediately followed by one slot duration $T_{sl} = 9us$ and T_f includes an idle slot duration T_{sl} at start of T_f. The channel is considered to be idle for $T_{\text{short\_ul}}$ if it is sensed to be idle during the slot durations of $T_{\text{short\_ul}}$.

4.2.2 Contention window adjustment procedure

If the UE transmits transmissions using Type 1 channel access procedure that are associated with channel access priority class p on a carrier, the UE maintains the contention window value CW_p and adjusts CW_p for those transmissions before step 1 of the procedure described in sub clause 4.2.1.1, using the following procedure

- If the UE receives an UL grant or an AUL-DFI, the contention window size for all the priority classes is adjusted as following:
  - If the NDI value for at least one HARQ process associated with HARQ_ID_ref is toggled, or if the HARQ-ACK value(s) for at least one of the HARQ processes associated with HARQ_ID_ref received in the earliest AUL-DFI after n_{ref} +3 indicates ACK.
    - For every priority class $p \in \{1,2,3,4\}$ set $CW_p = CW_{\min,p}$
  - Otherwise, increase CW_p for every priority class $p \in \{1,2,3,4\}$ to the next higher allowed value;
- If there exist one or more previous transmissions $\{T_0, \ldots, T_n\}$ using Type 1 channel access procedure, from the start subframe(s) of the previous transmission(s) of which, N or more subframes have elapsed and neither UL grant nor AUL-DFI was received, where N = max (Contention Window Size adjustment timer X, T_i burst length+1) if X > 0 and N = 0 otherwise, for each transmission T_i, CW_p is adjusted as following:
  - increase CW_p for every priority class $p \in \{1,2,3,4\}$ to the next higher allowed value;
  - The CW_p is adjusted once
- Else if the UE transmits transmissions using Type 1 channel access procedure before N subframes have elapsed from the start of previous UL transmission burst using Type 1 channel access procedure and neither UL grant nor AUL-DFI is received,
  - the CW_p is unchanged.

- If the UE receives an UL grant or an AUL-DFI indicates feedback for one or more previous transmissions { T_0 , … , T_n } using Type 1 channel access procedure, from the start subframe(s) of the previous transmission(s) of which, N or more subframes have elapsed and neither UL grant nor AUL-DFI was received, where N = max (Contention Window Size adjustment timer X, T_i burst length+1) if X > 0 and N = 0 otherwise, the UE may recompute CW_p as follows:
  - The UE reverts CW_p to the value used to transmit at n_{T0} using Type 1 channel access procedure.
  - The UE updates CW_p sequentially in the order of the transmission { T_0 , … , T_n }
    - If the NDI value for at least one HARQ process associated with HARQ_ID_ref' is toggled, or if the HARQ-ACK value(s) for at least one of the HARQ processes associated with HARQ_ID_ref' received in the earliest AUL-DFI after n_{Ti} +3 indicates ACK.
      - For every priority class $p \in \{1,2,3,4\}$ set $CW_p = CW_{\min,p}$
    - Otherwise, increase CW_p for every priority class $p \in \{1,2,3,4\}$ to the next higher allowed value
- If the UE transmits transmissions using Type 1 channel access procedure before N subframes have elapsed from the start of previous UL transmission burst using Type 1 channel access procedure and neither UL grant nor AUL-DFI is received,
  - CW_p is unchanged.

HARQ_ID_ref is the HARQ process ID of UL-SCH in reference subframe n_{ref} . The reference subframe n_{ref} is determined as follows

- If the UE receives an UL grant or an AUL-DFI in subframe n_g , subframe n_w is the most recent subframe before subframe $n_g - 3$ in which the UE has transmitted UL-SCH using Type 1 channel access procedure.
  - If the UE transmits transmissions including UL-SCH without gaps starting with subframe n_0 and in subframes $n_0, n_1, \cdots, n_w$ and the UL-SCH in subframe n_0 is not PUSCH Mode 1 that starts in the second slot of the subframe, reference subframe n_{ref} is subframe n_0 ,
  - If the UE transmits transmissions including PUSCH Mode 1 without gaps starting with second slot of subframe n_0 and in subframes $n_0, n_1, \cdots, n_w$ and the, reference subframe n_{ref} is subframe n_0 and n_1 ,
  - otherwise, reference subframe n_{ref} is subframe n_w ,

HARQ_ID_ref' is the HARQ process ID of UL-SCH in reference subframe n_{Ti} . The reference subframe n_{Ti} is determined as the start subframe of a transmission T_i using Type 1 channel access procedure and of which, N subframes have elapsed and neither UL grant nor AUL-DFI was received.

If the AUL-DFI with DCI format 0A is indicated to a UE that is activated with AUL transmission and transmission mode 2 is configured for the UE for grant-based uplink transmissions, the spatial HARQ-ACK bundling shall be performed by logical OR operation across multiple codewords for the HARQ process not configured for autonomous UL transmission.

If CW_p changes during an ongoing channel access procedure, the UE shall draw a counter N_{init} and applies it to the ongoing channel access procedure.

The UE may keep the value of CW_p unchanged for every priority class $p \in \{1,2,3,4\}$, if the UE scheduled to transmit transmissions without gaps including PUSCH in a set subframes $n_0, n_1, \cdots, n_{w-1}$ using Type 1 channel access procedure, and if the UE is not able to transmit any transmission including PUSCH in the set of subframes.

The UE may keep the value of CW_p for every priority class $p \in \{1,2,3,4\}$ the same as that for the last scheduled transmission including PUSCH using Type 1 channel access procedure, if the reference subframe for the last scheduled transmission is also n_{ref}.

If $CW_p = CW_{\max,p}$, the next higher allowed value for adjusting CW_p is $CW_{\max,p}$.

If the $CW_p = CW_{\max,p}$ is consecutively used K times for generation of N_{init}, CW_p is reset to $CW_{\min,p}$ only for that priority class p for which $CW_p = CW_{\max,p}$ is consecutively used K times for generation of N_{init}. K is selected by UE from the set of values {1, 2, …,8} for each priority class $p \in \{1,2,3,4\}$.

4.2.3 Energy detection threshold adaptation procedure

A UE accessing a carrier on which LAA Scell(s) transmission(s) are performed, shall set the energy detection threshold (X_{Thresh}) to be less than or equal to the maximum energy detection threshold $X_{\text{Thresh\_max}}$.

$X_{\text{Thresh\_max}}$ is determined as follows:

- If the UE is configured with higher layer parameter '*maxEnergyDetectionThreshold-r14*',
    - $X_{\text{Thresh\_max}}$ is set equal to the value signalled by the higher layer parameter.
- otherwise
    - the UE shall determine $X'_{\text{Thresh\_max}}$ according to the procedure described in sub clause 4.2.3.1
    - if the UE is configured with higher layer parameter '*energyDetectionThresholdOffset-r14*'
        - $X_{\text{Thresh\_max}}$ is set by adjusting $X'_{\text{Thresh\_max}}$ according to the offset value signalled by the higher layer parameter
    - otherwise
        - The UE shall set $X_{\text{Thresh\_max}} = X'_{\text{Thresh\_max}}$

4.2.3.1 Default maximum energy detection threshold computation procedure

If the higher layer parameter '*absenceOfAnyOtherTechnology-r14*' indicates TRUE:

- $X'_{\text{Thresh\_max}} = \min\left\{ \begin{matrix} T_{\max} + 10dB, \\ X_r \end{matrix} \right\}$ where
    - X_r is Maximum energy detection threshold defined by regulatory requirements in dBm when such requirements are defined, otherwise $X_r = T_{\max} + 10\,dB$

otherwise

- $$X'_{\text{Thres\_max}} = \max \left\{ \begin{array}{l} -72 + 10 \cdot \log 10(BWMHz / 20MHz)\ dBm, \\ \min \left\{ \begin{array}{l} T_{\max}, \\ T_{\max} - T_A + \left(P_H + 10 \cdot \log 10(BWMHz / 20MHz) - P_{TX}\right) \end{array} \right\} \end{array} \right\}$$

Where

- $T_A = 10\text{dB}$
- $P_H = 23$ dBm;
- P_{TX} is the set to the value of $P_{\text{CMAX\_H},c}$ as defined in [3].
- $T_{\max}(\text{dBm}) = 10 \cdot \log 10\left(3.16228 \cdot 10^{-8} (mW / MHz) \cdot BWMHz\ (MHz)\right)$;
  - BWMHz is the single carrier bandwidth in MHz.

Annex X (informative): Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2018-04	RAN1#92 bis	R1-1804453				First version	0.0.1
2018-04	RAN1#92 bis	R1-1805351				Removal of FeLAA agreements	0.0.2
2018-04	RAN1#92 bis	R1-1805352				Addition of FeLAA agreements	0.0.3
2018-04	RAN1#92 bis	R1-1805416				First endorsed version	0.1.0
2018-05	RAN1#92 bis	R1-1805788				Correction to FeLAA agreements and alignment with other specifications	0.1.1
2018-05	RAN1#92 bis	R1-1805790				Second endorsed version	0.2.0
2018-05	RAN1#93	R1-1807911				Update based on agreements at RAN1 #93	0.2.1
2018-06	RAN1#93	R1-1807932				Endorsed version	1.0.0
2018-06	RAN#80					Spec under change control further to RAN approval decision	15.0.0