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FILING RECEIPT

31817
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MINNEAPOLIS, MN 55402



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Date Mailed: 04/20/2016

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Early Publication Request: No

Title

UL GRANT SKIPPING SOLUTIONS

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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Provisional Application for Patent Cover Sheet This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c)					
Inventor(s)					
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Given Name	Middle Name	Family Name	City	State	Country i
Jmesh		Phuyal	Beaverton	OR	US
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Youn Hyoung		Heo	San Jose	CA	US
All Inventors Must Be Listed – Additional Inventor Information blocks may be generated within this form by selecting the Add button.					Add
Title of Invention		UL GRANT SKIPPING SOLUTIONS			
Attorney Docket Number (if applicable)		111027-IDF134607			
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Applicant asserts small entity status under 37 CFR 1.27 or applicant certifies micro entity status under 37 CFR 1.29

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Signature	Michael S. Moore/			Date (YYYY-MM-DD)	2016-04-01
First Name	Michael S.	Last Name	Moore	Registration Number (If appropriate)	64003

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UNITED STATES PROVISIONAL APPLICATION

For

UL GRANT SKIPPING SOLUTIONS

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Prepared by:

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Reg. No. 64,003

UL GRANT SKIPPING SOLUTIONS

BACKGROUND

Various embodiments generally may relate to the field of wireless communications.

DETAILED DESCRIPTION

The following detailed description refers to the accompanying drawings. The same reference numbers may be used in different drawings to identify the same or similar elements. In the following description, for purposes of explanation and not limitation, specific details are set forth such as particular structures, architectures, interfaces, techniques, etc. in order to provide a thorough understanding of the various aspects of various embodiments. However, it will be apparent to those skilled in the art having the benefit of the present disclosure that the various aspects of the various embodiments may be practiced in other examples that depart from these specific details. In certain instances, descriptions of well-known devices, circuits, and methods are omitted so as not to obscure the description of the various embodiments with unnecessary detail. Embodiments herein may be related to Rel-14 latency reduction WI.

One technique for latency reduction may include:

- *Reduction of padding in case of dynamic and SPS based UL pre-scheduling to reduce interference and UE power consumption*

Embodiments herein may be enable the UE to ignore, i.e., skip the UL grant such that no UL transmission happens on PUSCH if UE has no data to transmit in the uplink. This is different from UE behavior captured in the legacy 3GPP specification where a padding PDU would be transmitted by the UE.

The objective may involve two parts – UL grant skipping for dynamic scheduling and UL grant skipping for SPS based pre-scheduling.

Impact on dynamic scheduling

When the network allocates a UL grant to a UE which the UE ultimately ignores, the network may not have any way to differentiate or identify whether it was skipped or UL transmission happens but PUSCH detection is failed. That means, at least one concern is that it is unclear to the network whether the resources corresponding to synchronous HARQ retransmission (non-adaptive) can be dynamically allocated to other UE or left alone for potential HARQ retransmission.

1. *Therefore, in absence of some sort of indication that dynamic UL grant is skipped, eNB may not allocate the resources to other UEs/purposes resulting in resource wastage.*

Impact on SPS based pre-scheduling

■ adaptive HARQ retransmissions

There are use cases where adaptive HARQ retransmissions need to be supported, e.g., SPS with short intervals. When UL grant skipping is allowed, eNB may not be aware whether the UL is absent or UL is failed. So, even if eNB wants to support HARQ retransmissions using explicit signaling, the decision may be erroneous. Specifically, eNB may not send explicit grant assuming that the UL was skipped when UE in fact performed UL transmission which got lost and eNB is unable to detect it, as depicted in Figure 1.

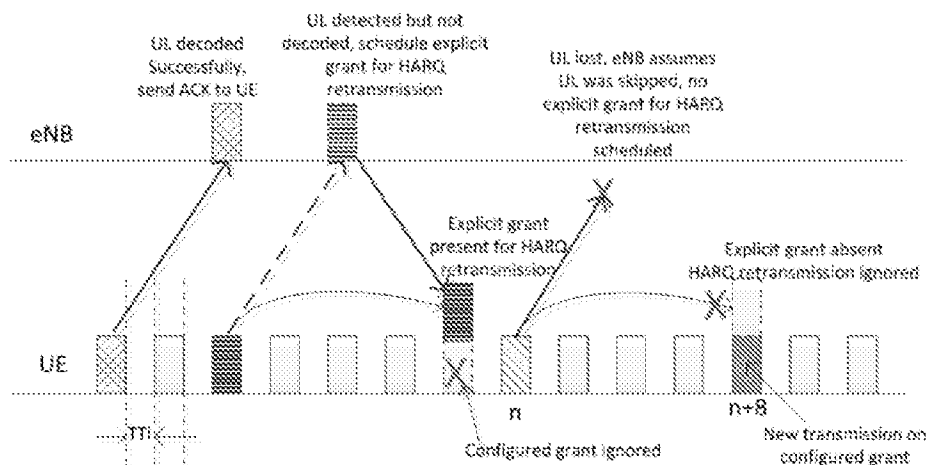


Figure 1 Example showing UL is lost but eNB assumes UL is skipped in case of SPS grant

2. *In absence of some sort of indication that UL grant is skipped, eNB can make wrong decisions related to supporting adaptive retransmissions when UL is lost but eNB assumes UL is skipped.*

■ **Impact on SPS activation/reactivation acknowledgment**

After SPS is configured and activated, the UE can skip the configured UL grant if there is no UL data. Therefore for the eNB, it is not clear whether the SPS activation/reactivation command is successful or that failed due to PDCCH loss. Even though PDCCH loss rate is low, but it is possible and can create ambiguity.

3. *Therefore eNB may not be aware about success or failure of SPS activation/reactivation command in absence of a UL grant skipping indication.*

Embodiments herein may relate to solving these issues. Note that the descriptions of various embodiments are not specific to latency reduction but are applicable in general for any communication where UL grant skipping is enabled.

Embodiments may include one or more of the following aspects:

- To increase PUSCH efficiency, allow the UE to skip the Uplink when its UL buffer is empty but to make sure there is no ambiguity, send the UL skipping indication by using low-overhead control channels
 - We provide some examples of such low overhead control channel
- Please note this is not exhaustive list and please see details below.

UL grant skipping is already agreed. However, detailed stage-3 work is not done yet. If no UL grant skipping indication is provided, there can be several issues as explained in section 1, in absence of some sort of indication that the UL grant is skipped by the UE:

1. For dynamic UL grant, eNB may hold on to the resources resulting in resource wastage.
2. For SPS based grant, eNB can make wrong decisions related to supporting adaptive retransmissions when UL is lost but eNB assumes UL is skipped.

3. eNB may not be aware of success or failure of SPS activation/reactivation command in absence of a UL grant skipping indication.

In Latency reduction SI phase, one potential technique may be eNB-implementation based. This technique relies on the eNB to identify whether UE skipped the UL grant or it was missed by NW by energy detection of DMRS resource (i.e., different DMRS Cyclic Shifts).

If the eNB does not detect any DMRS resource, it assumes UL grant was skipped. If the eNB finds that DMRS sequence corresponding to the scheduled UE is detected but the data is not decodable, then eNB knows that the UE indeed transmitted UL but UL transmission failed.

Even though the advantage of this approach is that it has low specification impact; the disadvantages include –

1. DMRS detection can be erroneous also, i.e., network cannot completely rely on DMRS detection.
2. In the current specification, the maximum number of cyclic shifts for a DMRS resource is 8 and in some scenarios, the eNB may only use part of them (e.g. 4 out of 8) to maximize the orthogonality. Therefore this technique is not scalable to support more than 8 UEs at a time, which seems impractical constraint.

Embodiments herein may solve these identified issues at a cost of low signaling overhead while being able to support large number of UEs simultaneously at a very low error probability. Note that the described embodiments are not specific to latency reduction but are applicable in general for any communication where UL grant skipping is enabled.

UL grant skipping indication (UGSI)

In this embodiment, UE sends the skipping indication signal by using one high capacity physical channel to inform NW whether UE skips the scheduled PUSCH or the scheduled PUSCH is transmitted.

According to certain aspects of the present disclosure, when the UE gets UL grant but there is no UL data to transmit, it skips the transmission on PUSCH. In more details, upon detection of PDCCH with UL grant (i.e. DCI format 0 or 4), UE shall

- transmit PUSCH in accordance with the received UL grant, if there is data available for transmission, as conventional LTE system; Or
- transmit a skipping indication signal on a pre-configured resource of one particular physical uplink channel.
 - In one embodiment, UE may transmit a UL Grant Skipping Indication (UGSI) on the PUCCH using PUCCH format 1 to indicate whether this particular UE is skipping this grant in the subframe n. The rationale of using PUCCH format 1 is to minimize the additional signaling overhead due to UGSI transmission. Detailed analysis with respect to control overhead is provided below.

Analysis on control overhead of UGSI transmission:

1 PRB can provide up to 36 orthogonal channels. Thus, one PRB can be used to multiplex up to 36 UEs for ULSI transmission while different UEs are separated using different orthogonal cover or different cyclic shift of a root CAZAC sequence. The value of 36 comes from 12 cyclic shift (CS) x 3 Orthogonal cover codes (OCC). The spectrum efficiency is significantly improved compared to legacy LTE system, as the signaling overhead of this technique is 1/36 compared to legacy LTE i.e., less than 3% compared to not skipping the UL in PUSCH in Rel-13 LTE system.

UGSI Channel Configuration

In the embodiments below, UGSI channel index is signaled to the UE. For such index to be signaled, the channel configuration needs to be known to the UE. There are multiple options.

Embodiment 1: The UGSI channel configuration can be broadcast by the network in a system information block (e.g., SIB2 or a new SIB can be defined).

Embodiment 2: The UGSI channel configuration is pre-defined in the standard and therefore known to the UEs.

UGSI Channel Assignment to UE

The channels used for UGSI transmission can be assigned to the UEs in semi-static approach by means of UE dedicated RRC message (Embodiments 3 & 4) or dynamic approach (Embodiments 5 & 6) by means of DCI format or a combination of these two schemes.

Embodiment 3: For dynamic UL grant skipping, the UGSI resource can be signalled in a RRC configuration message to enable UL skipping for a UE. This can be done, for example, by adding new IEs to MAC-MainConfig as shown by red text below.

```
MAC-MainConfig ::= SEQUENCE {
    ul-SCH-Config          SEQUENCE {
        maxHARQ-Tx          ENUMERATED {
            n1, n2, n3, n4, n5, n6, n7, n8,
            n10, n12, n16, n20, n24, n28,
            spare2, spare1}    OPTIONAL,    -- Need ON
        periodicBSR-Timer    PeriodicBSR-Timer-r12    OPTIONAL,    -- Need ON
        retxBSR-Timer        RetxBSR-Timer-r12,
        ttiBundling          BOOLEAN
    }
    drx-Config              DRX-Config              OPTIONAL,    -- Need ON
    timeAlignmentTimerDedicated TimeAlignmentTimer,
    phr-Config              CHOICE {
        release              NULL,
        setup                SEQUENCE {
            periodicPHR-Timer    ENUMERATED {sf10, sf20, sf50, sf100, sf200,
                sf500, sf1000, infinity},
            prohibitPHR-Timer    ENUMERATED {sf0, sf10, sf20, sf50, sf100,
                sf200, sf500, sf1000},
            dl-PathlossChange    ENUMERATED {dB1, dB3, dB6, infinity}
        }
    }
    ...
}
```

```

[[ sr-ProhibitTimer-r9          INTEGER (0..7)          OPTIONAL    -- Need ON
]],

[[ mac-MainConfig-v1020         SEQUENCE {
    sCellDeactivationTimer-r10   ENUMERATED {
        rf2, rf4, rf8, rf16, rf32, rf64, rf128,
        spare}                  OPTIONAL,    -- Need OP
    extendedBSR-Sizes-r10        ENUMERATED {setup}    OPTIONAL,    -- Need OR
    extendedPHR-r10              ENUMERATED {setup}    OPTIONAL    -- Need OR
    }                            OPTIONAL      -- Need ON
]],

[[ stag-ToReleaseList-r11       STAG-ToReleaseList-r11 OPTIONAL,    -- Need ON
    stag-ToAddModList-r11       STAG-ToAddModList-r11  OPTIONAL,    -- Need ON
    drx-Config-v1130            DRX-Config-v1130       OPTIONAL    -- Need ON
]],

[[ e-HARQ-Pattern-r12           BOOLEAN                OPTIONAL,    -- Need ON
    dualConnectivityPHR         CHOICE {
        release                  NULL,
        setup                    SEQUENCE {
            phr-ModeOtherCG-r12  ENUMERATED {real, virtual}
        }
    }                            OPTIONAL,    -- Need ON
    logicalChannelSR-Config-r12 CHOICE {
        release                  NULL,
        setup                    SEQUENCE {
            logicalChannelSR-ProhibitTimer-r12  ENUMERATED {sf20, sf40, sf64, sf128,
sf512, sf1024, sf2560, spare1}
        }
    }                            OPTIONAL      -- Need ON
]],

[[ skipUL-Config-r14            SkipUL-Config-r14      OPTIONAL    -- Need ON
]]
)

```

```

SkipUL-Config-r14 ::= CHOICE {
    release          NULL,
    setup            SEQUENCE {
        skipUL-r14    BOOLEAN,      OPTIONAL,    -- Need ON
        skipIndicationEnabled-r14    BOOLEAN,      OPTIONAL,    -- NEED ON
        skipIndicationChannelConfig-r14
        SkipIndicationChannelConfig-r14    OPTIONAL,    -- NEED ON
    }
}

```

<i>SkipUL-Config</i> field descriptions
SkipUL Indicates whether UL skipping is allowed for the UE as specified in TS 36.321.
skipIndicationEnabled Indicates whether the UE shall send indication to the eNB when UL is skipped. This field is applicable only when <i>SkipUL</i> is set to true.
skipIndicationChannelConfig Configuration of the skip indication channel to be used by the UE to indicate UL skipping. This field is applicable only when <i>skipIndicationEnabled</i> is set to true.

In another variation of this signaling, *skipIndicationEnabled* is not required. Presence of *skipIndicationChannelConfig* can indicate that UE shall send indication to the eNB when UL is skipped, and absence of *skipIndicationChannelConfig* can indicate that UE does not send any indication when UL in PUSCH is skipped.

The resource index used for UGSI transmission also needs to be signaled, which applies to both embodiments 1 & 2. The maximum Index of the UL channel depends on the amount of resources allocated for UGSI transmission. In the following, an example where 1 PRB is allocated for this purpose is shown, therefore the resource index is from 0 to 35.

```

-- ASN1START
SkipIndicationChannelConfig-r14 ::= CHOICE {
    release          NULL,
    setup            SEQUENCE {
        SkipIndicationChannelIndex-r14    INTEGER (0..35)    OPTIONAL    -- Need OR
    }
}
-- ASN1STOP

```

<i>SkipIndicationChannelConfig</i> field descriptions
SkipIndicationChannelIndex Indicates the index of skip indication channel as specified in 36.213 to be used when UL skipping is allowed and UE wants to indicate to the network that UL is skipped, as specified in 36.321.

Embodiment 4: For SPS grant skipping, resource for carrying UGSI may be signalled via RRC along with SPS configuration. For this purpose, for example new IEs can be added to *SPS-ConfigUL* IEs as indicated by red text below.

SPS-Config information element

```
-- ASN1START
SPS-ConfigUL ::= CHOICE {
    release          NULL,
    setup            SEQUENCE {
        semiPersistSchedIntervalUL    ENUMERATED {
            sf10, sf20, sf32, sf40, sf64, sf80,
            sf128, sf160, sf320, sf640, spare6,
            spare5, spare4, spare3, spare2,
            spare1},
        implicitReleaseAfter    ENUMERATED {e2, e3, e4, e8},
        p0-Persistent           SEQUENCE {
            p0-NominalPUSCH-Persistent    INTEGER (-126..24),
            p0-UE-PUSCH-Persistent        INTEGER (-8..7)
        } OPTIONAL,
        twoIntervalsConfig      ENUMERATED {true} OPTIONAL, -- Need OP -- Cond TDD
        ...,
        [[ p0-PersistentSubframeSet2-r12    CHOICE {
            release          NULL,
            setup            SEQUENCE {
                p0-NominalPUSCH-PersistentSubframeSet2-r12    INTEGER (-126..24),
                p0-UE-PUSCH-PersistentSubframeSet2-r12        INTEGER (-8..7)
            }
        } ]],
        [[ skipIndicationEnabled-r14    BOOLEAN, OPTIONAL, -- NEED ON
            skipIndicationChannelConfig-r14    SkipIndicationChannelConfig-r14
        ]],
        [[ skipIndicationChannelConfig-r14    OPTIONAL, -- NEED ON
        ]],
    }
}
-- ASN1STOP
```

SPS-Config field descriptions

skipIndicationEnabled

Indicates whether the UE shall send indication to the eNB when UL is skipped. This field is applicable only when UL SPS grant is allowed to be skipped by the UE if no UL data is present in the buffer as specified in TS 36.321.

skipIndicationChannelConfig

Configuration of the skip indication channel to be used by the UE to indicate UL skipping. This field is applicable only when *skipIndicationEnabled* is set to true.

In another variation of this signaling, *skipIndicationEnabled* is not required. Presence of *skipIndicationChannelConfig* can indicate that UE shall send indication to the eNB when UL is skipped, and absence of *skipIndicationChannelConfig* can indicate that UE does not send any indication when UL in PUSCH is skipped.

Embodiment 5: To make the skip indication channel allocation to a UE more dynamic in case of dynamic grants, this can be signalled along with UL grant using PDCCH. This requires modification in DCI format. In some examples of this disclosure, multiple resources for UGSI transmission may be configured by higher layers, e.g. by using RRC signaling. Then, one UGSI information element (IE) may be added to UL grant DCI format to dynamically select one from these available resources for UGSI transmission if needed in a flexible manner. This mechanism can benefit in overhead reduction by assigning N channels to M UEs, where $N < M$, under assumption that in most cases these M UEs is unlikely to have PUSCH scheduled simultaneously.

Embodiment 6: To make the skip indication channel allocation to a UE more dynamic in SPS case, this can be signalled along with SPS activation/reactivation command using PDCCH. Similar to Embodiment 3, this requires modification in UCI format. In some examples of this disclosure, multiple resources for UGSI transmission may be configured by higher layers, e.g. by using RRC signaling. Then, one UGSI information element (IE) may be added to SPS activation/reactivation DCI format to dynamically select one from these available resources for UGSI transmission if needed in a flexible manner.

UE capability for UGSI support

In order for the network to know if the UE is capable of signalling the UL grant skip indication, a UGSI capability indication can be added in UE capabilities which can be signaled by the UE to the network.

In one example, the UGSI capability can be added to E-UTRA UE Radio Access Capability Parameters, as shown below in red.

UE-EUTRA-Capability information element

```
-- ASN1START
UE-EUTRA-Capability-v13x0-IEs ::= SEQUENCE {
    dc-Parameters-v13x0          DC-Parameters-v13x0          OPTIONAL,
```

```

measParameters-v13xy          MeasParameters-v13xy          OPTIONAL,
mac-Parameters-v13x0          MAC-Parameters-v13x0          OPTIONAL,
pdcp-Parameters-v13x0          PDCP-Parameters-v13x0          OPTIONAL,
phyLayerParameters-v13x0       PhyLayerParameters-v13x0       OPTIONAL,
rf-Parameters-v13x0            RF-Parameters-v13x0            OPTIONAL,
rlc-Parameters-v13x0           RLC-Parameters-v13x0           OPTIONAL,
ue-CategoryDL-v13x0            INTEGER (17)              OPTIONAL,
ue-CategoryUL-v13x0            INTEGER (14)              OPTIONAL,
scptm-Parameters-v13x0         SCPTM-Parameters-v13x0         OPTIONAL,
sl-Parameters-r13              SL-Parameters-r13              OPTIONAL,
supportOfLAA-r13               ENUMERATED {supported}         OPTIONAL,
nonCriticalExtension            SEQUENCE UE-EUTRA-Capability-v14xy-IEs
                                OPTIONAL
)

UE-EUTRA-Capability-v14xy-IEs ::= SEQUENCE {
    ugsi-Supported-r14           BOOLEAN                      OPTIONAL,
    ...
}

-- ASN1STOP

```

UE-EUTRA-Capability field descriptions	FDD/ TDD diff
<i>ugsi-Supported</i> TRUE indicates UL Grant Skipping Indication is supported.	

Alternatively MAC capability parameter for r14 can be created and UGSI capability can be added there.

```

-- ASN1START
UE-EUTRA-Capability-v14xy-IEs ::= SEQUENCE {
    mac-Parameters-r14          MAC-Parameters-r14          OPTIONAL,
    ...
}

MAC-Parameters-r14 ::= SEQUENCE {
    ugsi-Supported-r14          BOOLEAN,
    ...
}

-- ASN1STOP

```

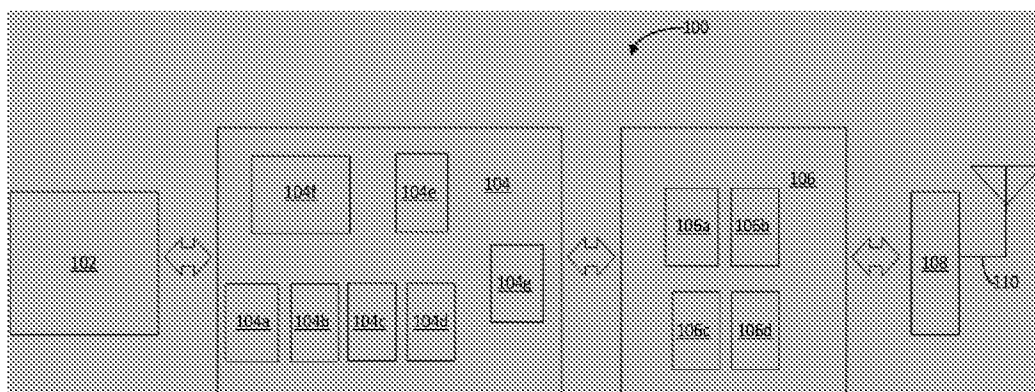


Figure X-1

As used herein, the term "circuitry" may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware.

Embodiments described herein may be implemented into a system using any suitably configured hardware and/or software. Figure X-1 illustrates, for one embodiment, example components of an electronic device 100. In embodiments, the electronic device 100 may be, implement, be incorporated into, or otherwise be a part of a user equipment (UE), an evolved NodeB (eNB), or some other electronic device. In some embodiments, the electronic device 100 may include application circuitry 102, baseband circuitry 104, Radio Frequency (RF) circuitry 106, front-end module (FEM) circuitry 108 and one or more antennas 110, coupled together at least as shown.

The application circuitry 102 may include one or more application processors. For example, the application circuitry 102 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with and/or may include memory/storage and

may be configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems to run on the system.

The baseband circuitry 104 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 104 may include one or more baseband processors and/or control logic to process baseband signals received from a receive signal path of the RF circuitry 106 and to generate baseband signals for a transmit signal path of the RF circuitry 106. Baseband processing circuitry 104 may interface with the application circuitry 102 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 106. For example, in some embodiments, the baseband circuitry 104 may include a second generation (2G) baseband processor 104a, third generation (3G) baseband processor 104b, fourth generation (4G) baseband processor 104c, and/or other baseband processor(s) 104d for other existing generations, generations in development or to be developed in the future (e.g., fifth generation (5G), 6G, etc.). The baseband circuitry 104 (e.g., one or more of baseband processors 104a-d) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 106. The radio control functions may include, but are not limited to, signal modulation/demodulation, encoding/decoding, radio frequency shifting, etc. In some embodiments, modulation/demodulation circuitry of the baseband circuitry 104 may include Fast-Fourier Transform (FFT), precoding, and/or constellation mapping/demapping functionality. In some embodiments, encoding/decoding circuitry of the baseband circuitry 104 may include convolution, tail-biting convolution, turbo, Viterbi, and/or Low Density Parity Check (LDPC) encoder/decoder functionality. Embodiments of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments.

In some embodiments, the baseband circuitry 104 may include elements of a protocol stack such as, for example, elements of an evolved universal terrestrial radio access network (EUTRAN) protocol including, for example, physical (PHY), media access control (MAC), radio link control (RLC), packet data convergence protocol (PDCP), and/or radio resource control (RRC) elements. A central processing unit (CPU) 104e of the baseband circuitry 104 may be configured to run elements of the protocol stack for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers. In some embodiments, the baseband circuitry may include one or more

audio digital signal processor(s) (DSP) 104f. The audio DSP(s) 104f may include elements for compression/decompression and echo cancellation and may include other suitable processing elements in other embodiments.

The baseband circuitry 104 may further include memory/storage 104g. The memory/storage 104g may be used to load and store data and/or instructions for operations performed by the processors of the baseband circuitry 104. Memory/storage for one embodiment may include any combination of suitable volatile memory and/or non-volatile memory. The memory/storage 104g may include any combination of various levels of memory/storage including, but not limited to, read-only memory (ROM) having embedded software instructions (e.g., firmware), random access memory (e.g., dynamic random access memory (DRAM)), cache, buffers, etc. The memory/storage 104g may be shared among the various processors or dedicated to particular processors.

Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 104 and the application circuitry 102 may be implemented together such as, for example, on a system on a chip (SOC).

In some embodiments, the baseband circuitry 104 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 104 may support communication with an evolved universal terrestrial radio access network (EUTRAN) and/or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN). Embodiments in which the baseband circuitry 104 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

RF circuitry 106 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 106 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 106 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 108 and provide baseband signals to the baseband circuitry 104. RF circuitry 106 may also include a transmit signal path which may include circuitry to up-convert baseband signals provided by the baseband circuitry 104 and provide RF output signals to the FEM circuitry 108 for transmission.

In some embodiments, the RF circuitry 106 may include a receive signal path and a transmit signal path. The receive signal path of the RF circuitry 106 may include mixer circuitry 106a, amplifier circuitry 106b and filter circuitry 106c. The transmit signal path of the RF circuitry 106 may include filter circuitry 106c and mixer circuitry 106a. RF circuitry 106 may also include synthesizer circuitry 106d for synthesizing a frequency for use by the mixer circuitry 106a of the receive signal path and the transmit signal path. In some embodiments, the mixer circuitry 106a of the receive signal path may be configured to down-convert RF signals received from the FEM circuitry 108 based on the synthesized frequency provided by synthesizer circuitry 106d. The amplifier circuitry 106b may be configured to amplify the down-converted signals and the filter circuitry 106c may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals. Output baseband signals may be provided to the baseband circuitry 104 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals, although this is not a requirement. In some embodiments, mixer circuitry 106a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 106a of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 106d to generate RF output signals for the FEM circuitry 108. The baseband signals may be provided by the baseband circuitry 104 and may be filtered by filter circuitry 106c. The filter circuitry 106c may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 106a of the receive signal path and the mixer circuitry 106a of the transmit signal path may include two or more mixers and may be arranged for quadrature downconversion and/or upconversion respectively. In some embodiments, the mixer circuitry 106a of the receive signal path and the mixer circuitry 106a of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 106a of the receive signal path and the mixer circuitry 106a may be arranged for direct downconversion and/or direct upconversion, respectively. In some embodiments, the mixer circuitry 106a of the receive signal path and the

mixer circuitry 106a of the transmit signal path may be configured for super-heterodyne operation.

In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input baseband signals may be digital baseband signals. In these alternate embodiments, the RF circuitry 106 may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry and the baseband circuitry 104 may include a digital baseband interface to communicate with the RF circuitry 106.

In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

In some embodiments, the synthesizer circuitry 106d may be a fractional-N synthesizer or a fractional $N/N+1$ synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 106d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

The synthesizer circuitry 106d may be configured to synthesize an output frequency for use by the mixer circuitry 106a of the RF circuitry 106 based on a frequency input and a divider control input. In some embodiments, the synthesizer circuitry 106d may be a fractional $N/N+1$ synthesizer.

In some embodiments, frequency input may be provided by a voltage controlled oscillator (VCO), although that is not a requirement. Divider control input may be provided by either the baseband circuitry 104 or the applications processor 102 depending on the desired output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 102.

Synthesizer circuitry 106d of the RF circuitry 106 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or $N+1$ (e.g., based on a carry out) to provide a fractional division ratio. In some example

embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be configured to break a VCO period up into N_d equal packets of phase, where N_d is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

In some embodiments, synthesizer circuitry 106d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times the carrier frequency) and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO frequency (fLO). In some embodiments, the RF circuitry 106 may include an IQ/polar converter.

FEM circuitry 108 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 110, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 106 for further processing. FEM circuitry 108 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 106 for transmission by one or more of the one or more antennas 110.

In some embodiments, the FEM circuitry 108 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include a low-noise amplifier (LNA) to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry 106). The transmit signal path of the FEM circuitry 108 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 106), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 110).

In some embodiments, the electronic device 100 may include additional elements such as, for example, memory/storage, display, camera, sensor, and/or input/output (I/O) interface.

In some embodiments, the electronic device of Figure X-1 may be configured to perform one or more processes, techniques, and/or methods as described herein, or portions thereof.

EXAMPLES

Example 1 may comprise a long term evolution (LTE) evolved NodeB (eNB) which can signal a UE to skip uplink (UL) grant when its uplink data buffer is empty.

Example 2 may comprise of the eNB of example 1 and/or some other example herein which can further signal an uplink grant skipping indication (UGSI) channel index to a UE.

Example 3 may comprise of the eNB of examples 1-2 and/or some other example herein, wherein the said signal is sent via radio resource control (RRC) configuration/reconfiguration signaling.

Example 4 may comprise of the eNB of example 1 and/or some other example herein, wherein the said UL grant is dynamic UL grant.

Example 5 may comprise of the eNB of example 1 and/or some other example herein wherein the said UL grant is a semi-persistent scheduling (SPS) UL grant.

Example 6 may comprise of an LTE UE which can receive the said signal of examples 1-5 and/or some other example to configure UL grant skipping when its uplink data buffer is empty.

Example 7 may comprise of the UE of example 6 and/or some other example herein which can indicate whether or not it is capable of supporting UGSI channel for UGSI transmission.

Example 8 may comprise of the UE of example 7 and/or some other example herein, wherein said capability indication is signaled by the UE to network using UE capability RRC signaling.

Example 9 may comprise of the UE of example 6-8 and/or some other example herein which can skip the UL grant when its uplink buffer is empty if configured and send the skipping indication to the network using UGSI channel index signaled to it.

Example 10 may comprise of the UE of example 6-8 and/or some other example herein which can skip the UL grant when its uplink buffer is empty if configured and send the skipping indication to the network using UGSI channel index preconfigured for it.

Example 11 may comprise of the said UGSI channel of examples 2, 7-10 and/or some other example herein, wherein the channel is a low overhead uplink channel to carry an uplink grant skip indication when the UE skips the UL grant instead of performing physical uplink shared channel (PUSCH) transmission.

Example 12 may comprise of the said uplink grant skip indication of example 11 and/or some other example herein, wherein the indication is sent on the physical uplink control channel (PUCCH) using PUCCH format 1 to indicate whether this particular UE is skipping this UL grant.

Example 13 may comprise of the said UGSI channel of examples 2, 7-11 and/or some other example herein, wherein the UGSI channel is predefined in the standard.

Example 14 may comprise of the said UGSI channel of examples 2, 7-11 and/or some other example herein, wherein the UGSI channel configuration is signalled to the UE using a network broadcast using a system information broadcast (e.g., system information block type 2 (SIB2) or a new system information block (SIB) can be defined).

Example 15 may include an apparatus comprising means to perform one or more elements of a method described in or related to any of examples 1-14, or any other method or process described herein.

Example 16 may include one or more non-transitory computer-readable media comprising instructions to cause an electronic device, upon execution of the instructions by one or more processors of the electronic device, to perform one or more elements of a method described in or related to any of examples 1-14, or any other method or process described herein.

Example 17 may include an apparatus comprising logic, modules, and/or circuitry to perform one or more elements of a method described in or related to any of examples 1-14, or any other method or process described herein.

Example 18 may include a method, technique, or process as described in or related to any of examples 1-14, or portions or parts thereof.

Example 19 may include an apparatus comprising: one or more processors and one or more computer readable media comprising instructions that, when executed by the one or more processors, cause the one or more processors to perform the method, techniques, or process as described in or related to any of examples 1-14, or portions thereof.

Example 20 may include a method of communicating in a wireless network as shown and described herein.

Example 21 may include a system for providing wireless communication as shown and described herein.

Example 22 may include a device for providing wireless communication as shown and described herein.

The foregoing description of one or more implementations provides illustration and description, but is not intended to be exhaustive or to limit the scope of embodiments to the precise form disclosed. Modifications and variations are possible in light of the above teachings or may be acquired from practice of various embodiments.

Electronic Patent Application Fee Transmittal				
Application Number:				
Filing Date:				
Title of Invention:		UL GRANT SKIPPING SOLUTIONS		
First Named Inventor/Applicant Name:		Umesh Phuyal		
Filer:		Michael Sean Moore/Brandi Henley		
Attorney Docket Number:		111027-IDF134607		
Filed as Large Entity				
Filing Fees for Provisional				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
Provisional Application Filing	1005	1	260	260
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				260

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Application Number:	62317207
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Title of Invention:	UL GRANT SKIPPING SOLUTIONS
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Customer Number:	31817
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Application Type:	Provisional

Payment information:	
Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	\$ 260
RAM confirmation Number	4504
Deposit Account	504238
Authorized User	MOORE, MICHAEL S.
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	
Charge any Additional Fees required under 37 CFR 1.17 (Patent application and reexamination processing fees)	

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Provisional Cover Sheet (SB16)	134607_Provisional_Cover_Sheet.pdf	1477413	no	4
			3af77916c3ebae90d45503fd6d271fcb7edbcde		
Warnings:					
Information:					
2	Specification	134607_Provisional_Application.pdf	401350	no	21
			c6d359005d609cf8dde618db80b1978a27a955e1		
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	29887	no	2
			8669f999bf848198ff4ef622446a72a41b9e6b1		
Warnings:					
Information:					
Total Files Size (in bytes):			1908650		
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