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Ljung

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(54) **TERMINAL REQUESTED BASE STATION CONTROLLED TERMINAL TRANSMISSION THROTTLING**

(75) Inventor: **Rickard Ljung**, Helsingborg (SE)

(73) Assignees: **Sony Corporation**, Tokyo (JP); **Sony Mobile Communications AB**, Lund (SE)

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H04W 52/02	(2009.01)
H04W 76/04	(2009.01)

(52) **U.S. Cl.**

CPC ***H04W 52/0216*** (2013.01); *H04W 76/048* (2013.01)

(58) **Field of Classification Search**

CPC H04W 52/0216; H04W 76/048
USPC 455/422.1
See application file for complete search history.

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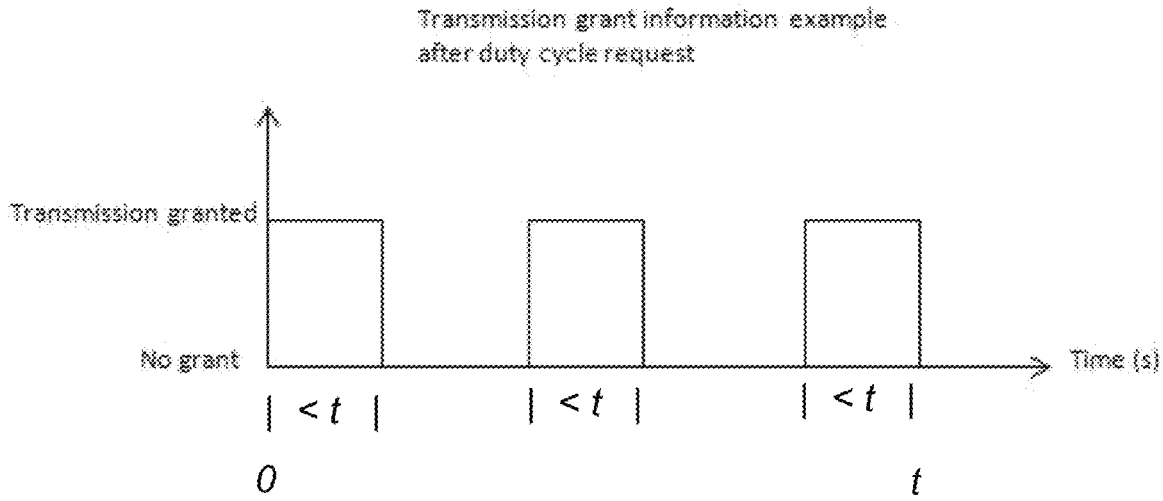
Primary Examiner — Shahriar Behnamian
(74) *Attorney, Agent, or Firm* — Renner, Otto, Boisselle & Sklar, LLP.

(57) **ABSTRACT**

A method for terminal requested base station controlled terminal transmission throttling includes determining whether terminal power consumption is to be reduced, if the terminal power consumption is to be reduced, transmitting a throttling request signal to the base station, the throttling request signal including data indicating to the base station to issue a discontinuous uplink transmission grant to the terminal, and receiving from the base station a discontinuous uplink transmission grant.

20 Claims, 6 Drawing Sheets



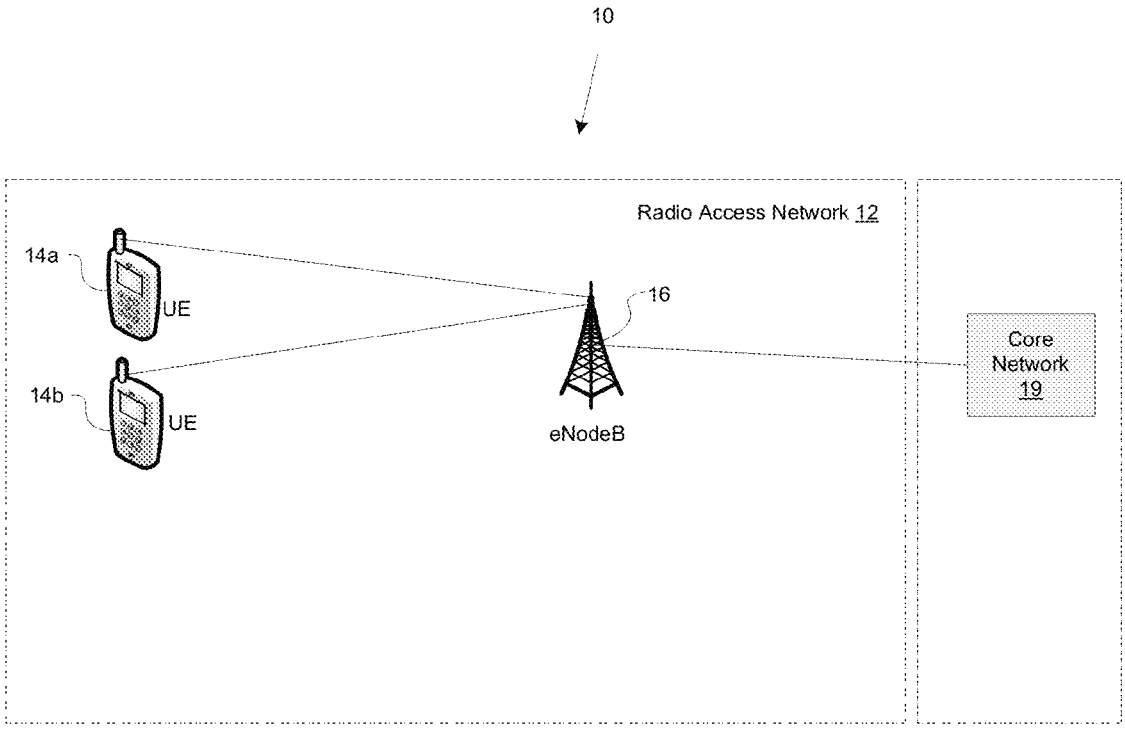

10
Radio Access Network 12
14a
UE
14b
UE
16
eNodeB
Core
Network
19

Figure 1

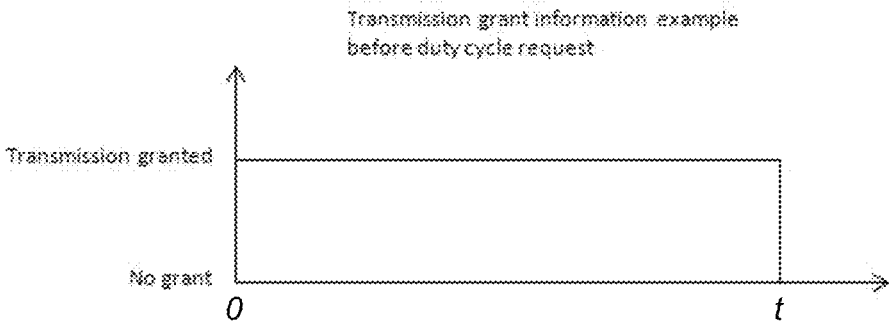


Figure 2A

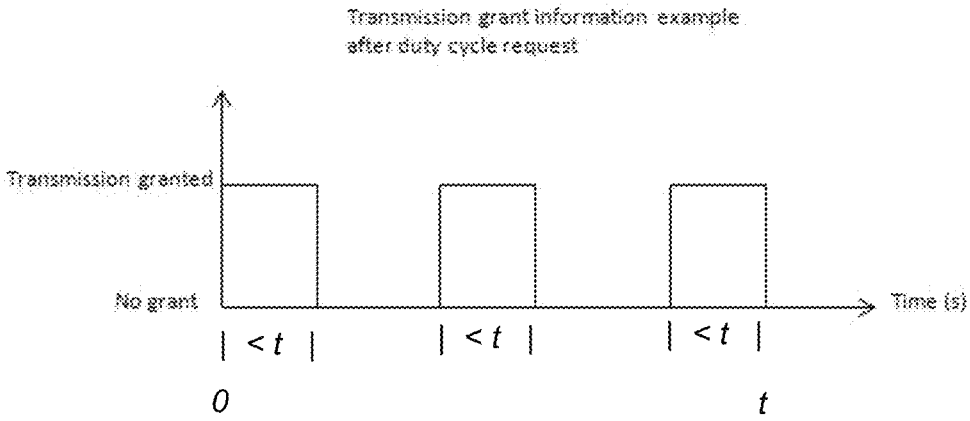


Figure 2B

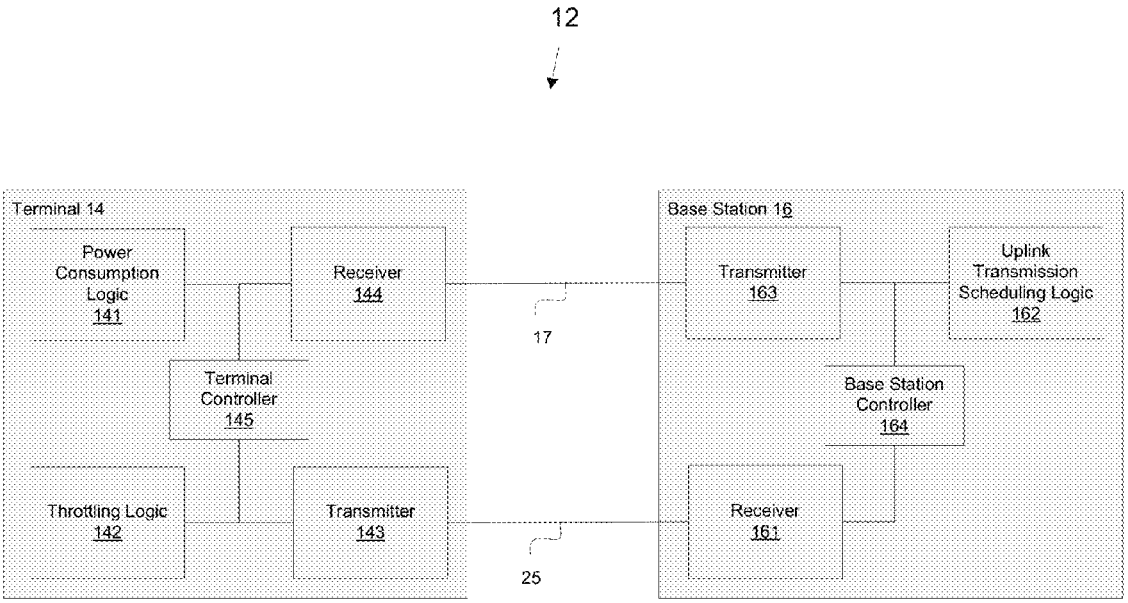

12
Terminal 14
Power Consumption Logic 141
Receiver 144
Terminal Controller 145
Throttling Logic 142
Transmitter 143
17
25
Base Station 16
Transmitter 163
Uplink Transmission Scheduling Logic 162
Base Station Controller 164
Receiver 161

Figure 3

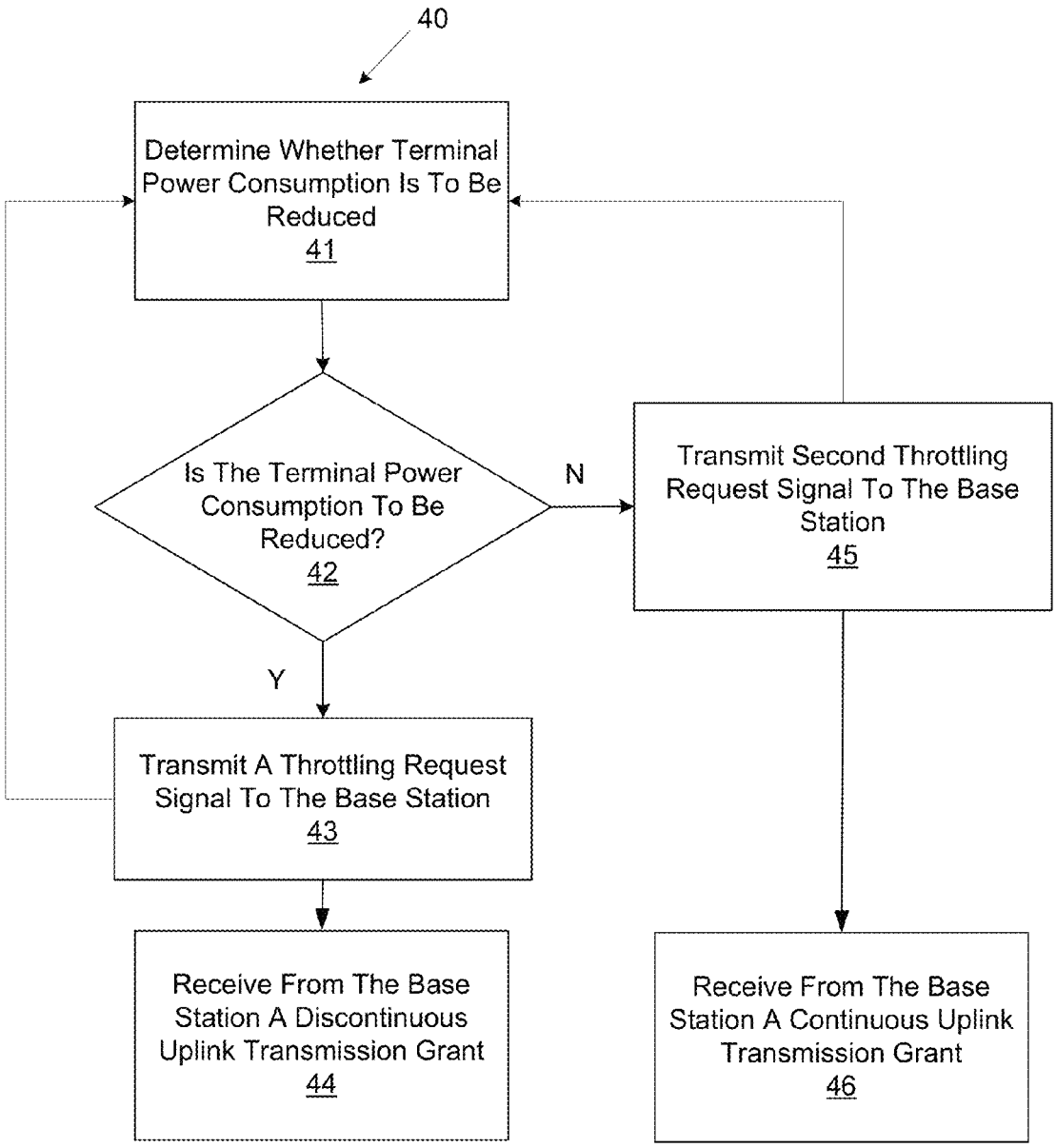

40
Determine Whether Terminal Power Consumption Is To Be Reduced
41
Is The Terminal Power Consumption To Be Reduced?
42
N
Y
Transmit Second Throttling Request Signal To The Base Station
45
Transmit A Throttling Request Signal To The Base Station
43
Receive From The Base Station A Discontinuous Uplink Transmission Grant
44
Receive From The Base Station A Continuous Uplink Transmission Grant
46

Figure 4

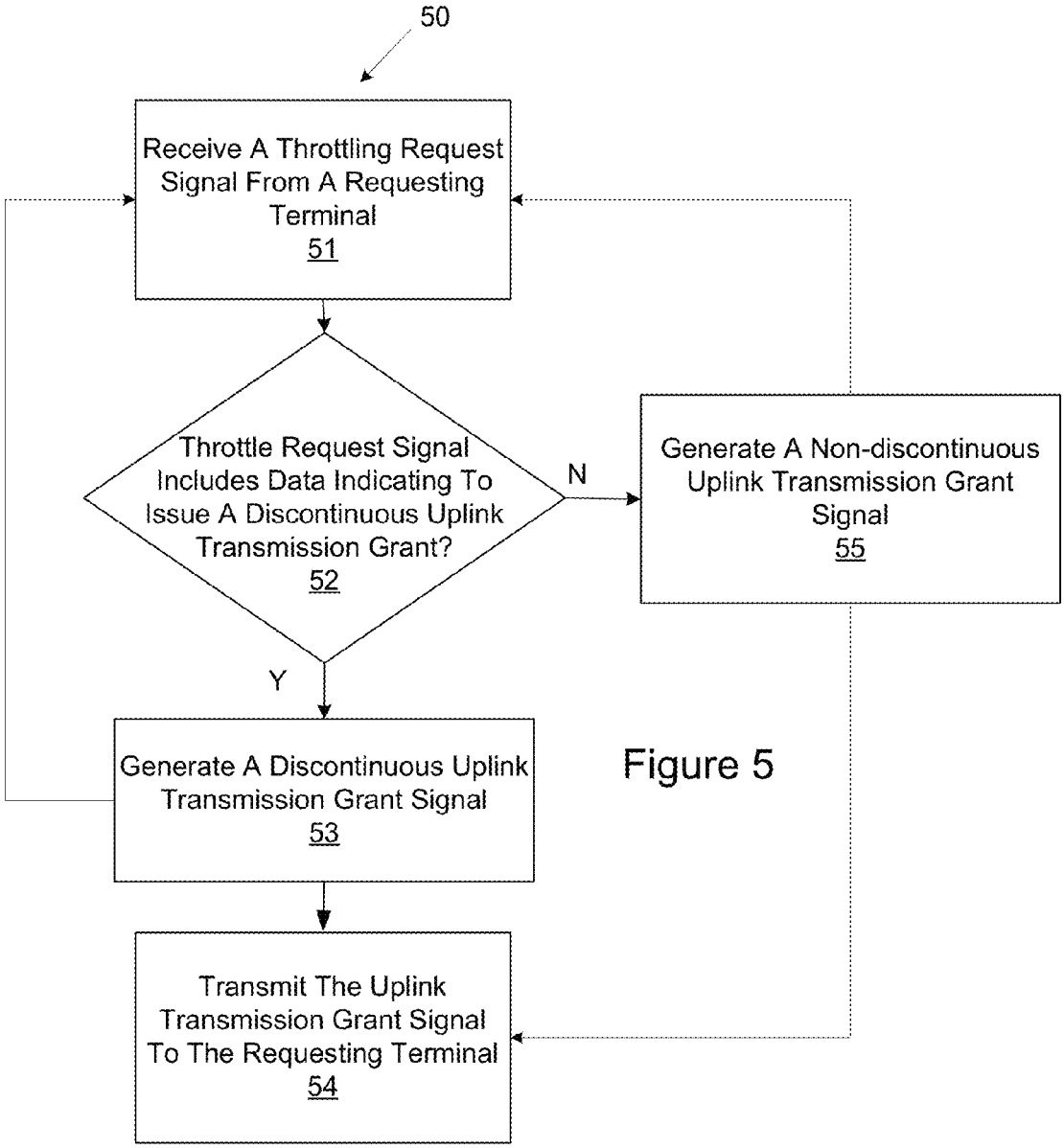

50
Receive A Throttling Request Signal From A Requesting Terminal
51
Throttle Request Signal Includes Data Indicating To Issue A Discontinuous Uplink Transmission Grant?
52
N
Generate A Non-discontinuous Uplink Transmission Grant Signal
55
Y
Generate A Discontinuous Uplink Transmission Grant Signal
53
Transmit The Uplink Transmission Grant Signal To The Requesting Terminal
54

Figure 5

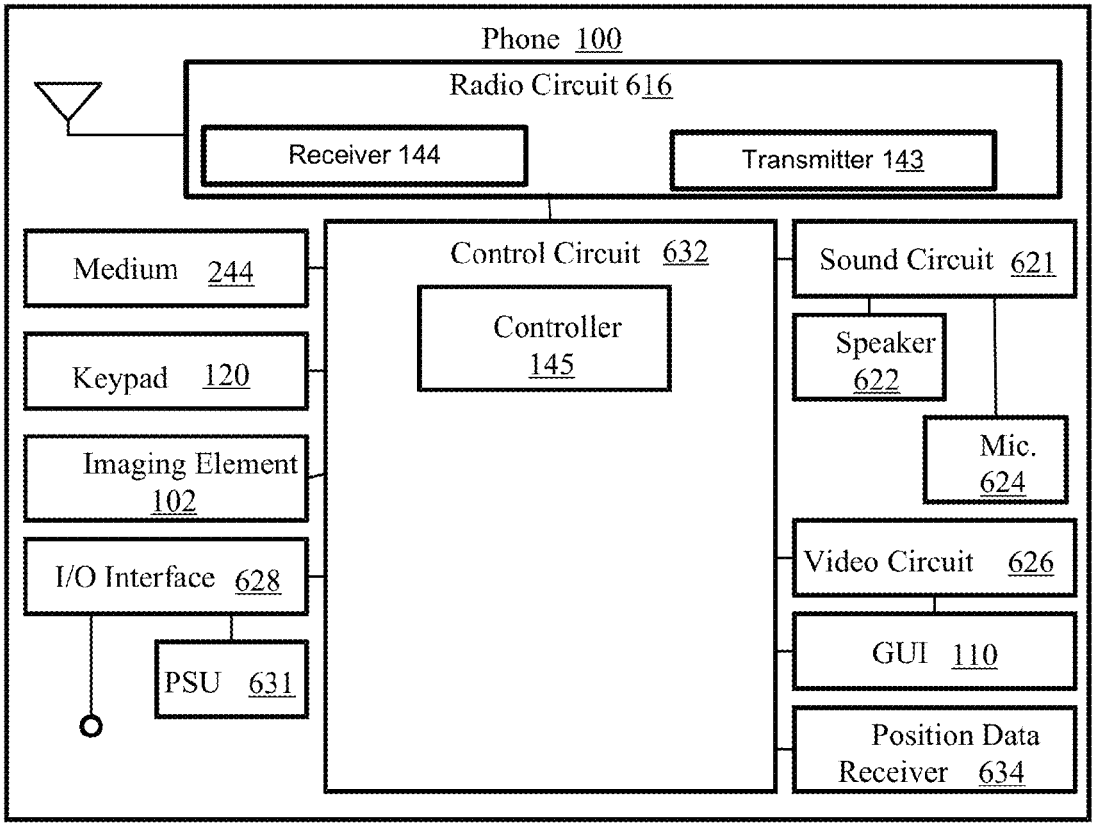

Phone 100
Radio Circuit 616
Receiver 144
Transmitter 143
Medium 244
Keypad 120
Imaging Element 102
I/O Interface 628
PSU 631
Control Circuit 632
Controller 145
Sound Circuit 621
Speaker 622
Mic. 624
Video Circuit 626
GUI 110
Position Data Receiver 634

Figure 6

TERMINAL REQUESTED BASE STATION CONTROLLED TERMINAL TRANSMISSION THROTTLING

TECHNICAL FIELD OF THE INVENTION

The technology of the present disclosure relates generally to portable electronic devices and transmission equipment operable in a wireless communication network and more particularly to systems and methods for terminal requested base station controlled terminal transmission throttling.

DESCRIPTION OF THE RELATED ART

Portable electronic devices that operate in a cellular network, such as mobile telephones and smartphones, tablet computers, cellular-connected laptop computers, and similar devices are ever increasing in popularity. In a typical wireless telecommunication network, terminals (also known as mobile stations and/or user equipment (UE)) communicate via a radio access network (RAN) to one or more core networks. The RAN covers a geographical area which is divided into cell areas, with each cell area being served by a base station, e.g., a radio base station (RBS), which in some networks may also be called, for example, NodeB in UMTS or eNodeB in LTE. A cell is a geographical area where radio coverage is provided by the radio base station equipment at a base station site. Each cell is identified by an identity within the local radio area, which is broadcast in the cell. The base stations communicate over the air interface operating on radio frequencies with the terminals within range of the base stations.

In one example of a RAN, the Universal Mobile Telecommunications System (UMTS) is a wireless telecommunication system that evolved from the Global System for Mobile Communications (GSM). In UMTS the RAN is referred to as a Universal Terrestrial Radio Access Network (UTRAN). UTRAN is a RAN that uses, among other radio access technologies (RAT), wideband code division multiple access (WCDMA) for communication between the mobile station and the terminal. Base stations in UMTS are known as NodeB, which connect to a radio network controller (RCN) which supervises and coordinates various activities of the NodeB connected thereto.

In another example of a RAN, Long Term Evolution (LTE) is a wireless telecommunication system that evolved from UMTS and utilizes a RAN known as evolved Universal Terrestrial Radio Access Network (E-UTRAN). E-UTRAN is a RAN that uses a RAT also known as LTE for communication between the mobile station and the terminal. In LTE, the base stations, known as eNodeB, are connected directly to the core network rather than to an RNC. In general, in LTE the functions of the RNC are distributed between the eNodeB in the network.

In a wireless communication system, such as UMTS and LTE, one of the largest power consuming elements in the terminal and the base station is typically the power amplifier to the radio transmitter. In these systems, the maximum available output power is usually lower in the uplink direction (i.e., transmissions from terminal to base station) than the downlink direction (i.e., transmissions from base station to terminal). The reason for such asymmetric power balance may be that the terminal is battery powered and thus its power amplifiers may be power limited, while the base station connects to power lines and thus has less constrains on the amount of power consumed by the power amplifier. This asymmetric power balance causes the total network coverage to generally be limited in the uplink direction as compared to the downlink direction.

Other reasons for the uplink transmissions to be limited in terms of maximum output power include heat generation. Unlike a base station that may reside in, for example, an uninhabited hut, the terminal is often intended to be used by human users. If the terminal were to continuously transmit at its maximum specified power, it may generate too much heat, which could make the terminal unsafe or at least uncomfortable for a user to handle. Another reason for the uplink transmissions to be limited in terms of maximum output power may be the maximum instantaneous power supply available to the terminal. For example, the terminal may be powered by a USB 2.0 connector, whose total maximum current drain is 500 mA @ 5V.

This asymmetric power balance limitation is particularly acute when the terminal involved is in a limited output power scenario that further limits terminal power.

SUMMARY

The concept of the systems and methods disclosed herein includes the capability for a terminal in a wireless communication system to signal the base station to effectively limit the duty cycle of the terminal's transmitter to limit its power amplifier's power consumption. Since the base station controls when the terminal transmits via uplink transmission grants, the terminal operating at low power levels may request the base station to throttle uplink transmissions to reduce its power amplifier's power consumption. The concept of the systems and methods disclosed herein may include adding a control signal possibility to the wireless communication system specification. For 3GPP standards relating to LTE and UTMS this concept may involve the addition of a message into the Radio Resource Control (RRC) signaling for indication of a terminal specific recommended maximum uplink transmission duty cycle. This additional signaling message would be intended for use by terminals that currently are in a limited output power scenario, enabling the terminal to request discontinuous uplink transmission grants.

Benefits of this concept include that the terminal can maintain a connection with the network even if instantaneous output power level is higher than what would be possible in a continuous uplink transmission. This can help solve transmission power related issues in the terminal including, but not limited to, providing larger network system coverage, enabling longer terminal battery lifetime, reducing risk for terminal overheating, and managing regulatory requirements on maximum terminal energy emission (SAR).

Accordingly, in one aspect of the invention a method for terminal requested base station controlled terminal transmission throttling includes determining whether terminal power consumption is to be reduced, if the terminal power consumption is to be reduced, transmitting a throttling request signal to the base station, the throttling request signal including data indicating to the base station to issue a discontinuous uplink transmission grant to the terminal, and receiving from the base station a discontinuous uplink transmission grant.

In one embodiment, the determining whether terminal power consumption is to be reduced includes at least one of determining that the terminal is at risk of overheating, determining a shortage power supply to the terminal, and determining that the terminal is at risk of exceeding Specific Absorption Rate (SAR) regulatory requirements.

In another embodiment, the transmitting the throttling request signal to the base station includes transmitting the throttling request signal via the radio resource control (RRC) layer.

In yet another embodiment, the throttling request signal includes data representing a maximum duty cycle for the discontinuous uplink transmission grant.

In one embodiment, the data representing the maximum duty cycle corresponds to 1 bit representing two potential maximum duty cycle levels, the maximum duty cycle levels selected from the group consisting of approximately ⅓ duty cycle and approximately ⅔ duty cycle; and approximately ½ duty cycle and approximately 100% duty cycle.

In another embodiment, the data representing the maximum duty cycle corresponds to 2 bits representing four potential maximum duty cycle levels, the maximum duty cycle levels selected from the group consisting of approximately ⅕ duty cycle, approximately ⅖ duty cycle, approximately ⅗ duty cycle, and approximately ⅘ duty cycle; and approximately ¼ duty cycle, approximately ½ duty cycle, approximately ¾ duty cycle, and approximately 100% duty cycle.

In yet another embodiment, the data representing the maximum duty cycle corresponds to 3 bits representing eight potential maximum duty cycle levels, the maximum duty cycle levels selected from the group consisting of approximately 1/9 duty cycle, approximately 2/9 duty cycle, approximately ⅓ duty cycle, approximately 4/9 duty cycle, approximately 5/9 duty cycle, approximately 6/9 duty cycle, approximately 7/9 duty cycle, and approximately 8/9 duty cycle; and approximately ⅛ duty cycle, approximately ¼ duty cycle, approximately ⅜ duty cycle, approximately ½ duty cycle, approximately ⅝ duty cycle, approximately ⅜ duty cycle, approximately ⅞ duty cycle, and approximately 100% duty cycle.

In one embodiment, the method includes, if the terminal power consumption is no longer to be reduced, transmitting a second throttling request signal to the base station, the second throttling request signal including data indicating to the base station to no longer issue the discontinuous uplink transmission grant to the terminal.

In another aspect of the invention, a terminal for operation in a wireless telecommunication system including terminal requested base station controlled terminal transmission throttling includes a power consumption logic configured to determine whether terminal power consumption is to be reduced, a throttling logic operatively connected to the power consumption logic and configured to receive from the power consumption logic an indication as to whether the terminal power consumption is to be reduced, wherein where the throttling logic receives from the power consumption logic the indication that the terminal power consumption is to be reduced, the throttling logic is configured to encode a throttling request signal including data indicating to the base station to issue a discontinuous uplink transmission grant to the terminal, a transmitter configured to transmit the throttling request signal, and a receiver configured to receive from the base station the discontinuous uplink transmission grant.

In one embodiment, the power consumption logic is configured to determine whether the terminal power consumption is to be reduced by at least one of determining that the terminal is at risk of overheating, determining a shortage power supply to the terminal, and determining that the terminal is at risk of exceeding Specific Absorption Rate (SAR) regulatory requirements.

In another embodiment, the transmitter is configured to transmit the throttling request signal via a radio resource control (RRC) layer.

In yet another embodiment, the throttling request signal includes data representing a maximum duty cycle for the discontinuous uplink transmission grant.

In one embodiment, the data representing the maximum duty cycle corresponds to 1 bit representing two potential maximum duty cycle levels, the maximum duty cycle levels selected from the group consisting of approximately ⅓ duty cycle and approximately ⅔ duty cycle; and approximately ½ duty cycle and approximately 100% duty cycle.

In another embodiment, the data representing the maximum duty cycle corresponds to 2 bits representing four potential maximum duty cycle levels, the maximum duty cycle levels selected from the group consisting of approximately ⅕ duty cycle, approximately ⅖ duty cycle, approximately ⅗ duty cycle, and approximately ⅘ duty cycle; and approximately ¼ duty cycle, approximately ½ duty cycle, approximately ¾ duty cycle, and approximately 100% duty cycle.

In yet another embodiment, the data representing the maximum duty cycle corresponds to 3 bits representing eight potential maximum duty cycle levels, the maximum duty cycle levels selected from the group consisting of approximately 1/9 duty cycle, approximately 2/9 duty cycle, approximately ⅓ duty cycle, approximately 4/9 duty cycle, approximately 5/9 duty cycle, approximately 6/9 duty cycle, approximately 7/9 duty cycle, and approximately 8/9 duty cycle; and approximately ⅛ duty cycle, approximately ¼ duty cycle, approximately ⅜ duty cycle, approximately ½ duty cycle, approximately ⅝ duty cycle, approximately ⅜ duty cycle, approximately ⅞ duty cycle, and approximately 100% duty cycle.

In one embodiment, the power consumption logic is further configured to determine whether the terminal power consumption is no longer to be reduced, the throttling logic is further configured to receive from the power consumption logic an indication as to whether the terminal power consumption is no longer to be reduced, wherein where the throttling logic receives from the power consumption logic the indication that the terminal power consumption is no longer to be reduced, the throttling logic is configured to encode a second throttling request signal including data indicating to the base station to no longer issue the discontinuous uplink transmission grant to the terminal, and the transmitter is further configured to transmit the second throttling request signal.

In yet another aspect of the invention, an electronic device for operation in a wireless telecommunication system including terminal requested base station controlled terminal transmission throttling includes a receiver configured to receive a throttling request signal from a requesting terminal, the throttling request signal including data indicating to issue a discontinuous uplink transmission grant to the terminal, an uplink transmission scheduling logic operatively connected to the receiver and configured to, upon the receiver receiving the throttling request signal including data indicating to issue a discontinuous uplink transmission grant to the terminal, generate a discontinuous uplink transmission grant signal, and a transmitter operatively connected to the uplink transmission scheduling logic and configured to transmit the discontinuous uplink transmission grant signal to the requesting terminal.

In one embodiment, the receiver is configured to receive the throttling request signal via a radio resource control (RRC) layer.

In another embodiment, the throttling request signal includes data representing a maximum duty cycle for the discontinuous uplink transmission grant and wherein the data representing the maximum duty cycle corresponds to at least

one of 1 bit representing two potential maximum duty cycle levels, the maximum duty cycle levels selected from the group consisting of approximately ⅓ duty cycle and approximately ⅔ duty cycle, and approximately ½ duty cycle and approximately 100% duty cycle; 2 bits representing four potential maximum duty cycle levels, the maximum duty cycle levels selected from the group consisting of approximately ⅕ duty cycle, approximately ⅖ duty cycle, approximately ⅗ duty cycle and approximately ⅘ duty cycle, and approximately ¼ duty cycle, approximately ½ duty cycle, approximately ¾ duty cycle, and approximately 100% duty cycle; and 3 bits representing eight potential maximum duty cycle levels, the maximum duty cycle levels selected from the group consisting of approximately ⅙ duty cycle, approximately ⅔ duty cycle, approximately ⅓ duty cycle, approximately ⅔ duty cycle, approximately ⅚ duty cycle, approximately ⅙ duty cycle, approximately ⅞ duty cycle, and approximately ⅞ duty cycle, and approximately ⅛ duty cycle, approximately ¼ duty cycle, approximately ⅜ duty cycle, approximately ½ duty cycle, approximately ⅝ duty cycle, approximately ⅜ duty cycle, approximately ⅞ duty cycle, and approximately 100% duty cycle.

In yet another embodiment, the receiver is further configured to receive a second throttling request signal from the requesting terminal, the second throttling request signal including data indicating to no longer issue the discontinuous uplink transmission grant to the terminal, the uplink transmission scheduling logic is further configured to, upon the receiver receiving the second throttling request signal, generate a non-discontinuous uplink transmission grant signal, and the transmitter is further configured to transmit the non-discontinuous uplink transmission grant signal to the requesting terminal.

These and further features of the present invention will be apparent with reference to the following description and attached drawings. In the description and drawings, particular embodiments of the invention have been disclosed in detail as being indicative of some of the ways in which the principles of the invention may be employed, but it is understood that the invention is not limited correspondingly in scope. Rather, the invention includes all changes, modifications and equivalents coming within the spirit and terms of the claims appended hereto.

Features that are described and/or illustrated with respect to one embodiment may be used in the same way or in a similar way in one or more other embodiments and/or in combination with or instead of the features of the other embodiments.

It should be emphasized that the terms "comprises" and "comprising," when used in this specification, are taken to specify the presence of stated features, integers, steps or components but do not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a portion of a wireless telecommunications network.

FIGS. **2**A and **2**B show diagrams illustrating an exemplary potential difference in terminal transmission grants before (FIG. **2**A) and after (FIG. **2**B) the terminal has signaled to the base station to issue discontinuous uplink transmission grants.

FIG. **3** illustrates a schematic diagram of a radio access network (RAN) including exemplary block diagrams of a terminal and a base station.

FIG. **4** illustrates a logical flow of a method for terminal requested base station controlled terminal transmission throttling.

FIG. **5** illustrates logical flow of a method for an electronic device for operation in a wireless telecommunication system including terminal requested base station controlled terminal transmission throttling is shown.

FIG. **6** illustrates a detailed block diagram of an exemplary terminal, which in the illustrated embodiment is represented by a mobile phone.

DETAILED DESCRIPTION OF EMBODIMENTS

Embodiments of the present invention will now be described with reference to the drawings, wherein like reference numerals are used to refer to like elements throughout. It will be understood that the figures are not necessarily to scale.

FIG. **1** illustrates a portion of a wireless telecommunications network **10**. The network **10** includes a radio access network (RAN) **12**. FIG. **1** illustrates the RAN **12** as an Evolved Universal Terrestrial Radio Access Network (EUTRAN), the RAN associated with LTE, as an example. However, the RAN **12** may also be any RAN other than EUTRAN including RAN that are currently deployed as well as RAN that are currently in development or that will be developed in the future. The network **10** includes a core network **19**, which includes the parts of the telecommunications network **10** that provide the various services to customers who are connected by the RAN **12**.

The RAN **12** includes terminals **14***a-b*. The terminals **14***a-b* are what in LTE is referred to as user equipment (UE). In wireless telecommunications networks other than LTE, including networks that are currently deployed as well as networks that are currently in development or that will be developed in the future, the terminals may be referred to by terms other than terminals, mobile stations, or user equipment. However, the term terminals as employed herein is intended to include those terminals in wireless telecommunications networks such as UMTS and LTE as well as networks other than UMTS and LTE, and terminals in yet to be developed or deployed networks where the terminals have similar functionality as the terminals described herein in the context of LTE.

The RAN **12** further includes a base station **16**. As discussed above, in LTE the base station **16** is known as eNodeB (evolved NodeB or eNB). In wireless telecommunications networks other than LTE, including networks that are currently deployed as well as networks that are currently in development or that will be developed in the future, the base stations may be referred to by terms other than base stations, NodeB, or eNodeB. However, the term base station as employed herein is intended to include those base stations in wireless telecommunications networks such as UMTS and LTE as well as networks other than UMTS and LTE, and base stations in yet to be developed or deployed networks where the base stations have similar functionality as the base stations described herein in the context of LTE. Moreover, a base station as the term is employed herein may include other entities in wireless telecommunications systems that control the uplink transmissions of the terminals in a similar manner as the base stations disclosed herein. For example, a relay node that may be made to control the uplink transmissions of the terminals behaves as a base station.

The base station **16** communicates with the terminals **14***a-b* using radio access technologies (RAT) via an air interface. In LTE the RAT is known as LTE and the air interface is known as LTE-Uu. Although RAN **12** has been described as

discreetly LTE, in practice, base stations may be multi radio units, capable of transmitting in several different RAT. Due to the reuse of infrastructure at the cellular sites, as well as backhaul capabilities, a single base station may be using more than one RAT and may be transmitting at more than one carrier frequency.

In many communication systems such as LTE the base station **16** has control over when the terminals **14***a-b* are allowed to transmit uplink transmissions, and for this purpose the base station **16** provides uplink transmission grants that control when the terminal is allowed to transmit. In this manner, the base station **16** can control system aspects such as data transmissions scheduling to optimize uplink transmission capacity, and to control the total uplink interference levels. The procedure to transmit data in the uplink direction after data has arrived to the terminal's buffer is typically as follows: 1) in the subframe where the base station **16** has a scheduling request (SR) resource available, the terminal transmits an SR, which is a one-bit flag to indicate that the terminal **14***a* or **14***b* has new data, 2) the base station **16** receives the SR and after a processing delay, an initial uplink transmission grant is transmitted to the terminal **14***a* or **14***b* allocating time/frequency resources for uplink transmission, 3) using the granted resources, the terminal **14***a* or **14***b* transmits data as well as a Buffer Status Report (BSR) to indicate to the base station **16** how much data it still has available in its buffer after the transmission, 4) when the base station **16** has received the BSR, it can continue allocating uplink resources to the terminal **14***a* or **14***b* and the terminal **14***a* or **14***b* can perform further uplink transmissions. Decisions regarding scheduling of uplink resources may be based on quality of service (QoS) parameters, buffer status, uplink channel quality measurements, terminal capabilities, etc.

In the RAN **12** the terminals **14***a-b* determine whether terminal power consumption needs to be reduced. The terminal's power consumption may need to be reduced because the terminal is at risk of overheating, because there is a shortage of power supply to the terminal, or because the terminal is at risk of exceeding Specific Absorption Rate (SAR) regulatory requirements, among other potential reasons. Whenever the terminal **14***a* or **14***b* determines that terminal power consumption needs to be reduced, the terminal **14***a* or **14***b* signals the base station **16** (e.g., via the radio resource control (RRC) layer) to issue a discontinuous uplink transmission grant to the terminal **14** or **14***b*. The base station **16**, in turn, issues the discontinuous uplink transmission grant effectively limiting the terminal's power consumption.

Similarly, whenever the terminal **14***a* or **14***b* determines that terminal power consumption no longer needs to be reduced, the terminal **14***a* or **14***b* signals the base station **16** to essentially inform the base station **16** that throttling is no longer necessary. The base station **16**, in turn, ceases to issue the discontinuous uplink transmission grant or issues a non-discontinuous uplink transmission grant.

RRC signaling is specified in 3GPP TS 25.331 for UTMS and TS 36.331 for LTE. A new message bit pattern could be included in the terminal capability update procedure. In one embodiment, the new message includes data representing a maximum duty cycle for the uplink transmission grant that may be signaled, for example, by one, two or three bits, giving the possibility for two, four, or eight duty cycle levels, respectively. Since several duty cycle levels are specified, in one embodiment, the same RRC signaling message can be reused by the terminal **14***a* or **14***b* currently being throttled to request the base station **16** to conclude throttling and/or to issue non-discontinuous uplink transmission grants.

FIGS. **2**A and **2**B show diagrams illustrating an exemplary potential difference in terminal transmission grants before (FIG. **2**A) and after (FIG. **2**B) the terminal has signaled to the base station to issue discontinuous uplink transmission grants. The illustrated uplink transmission grants are merely exemplary and the base station can provide many other different uplink transmission grants. In the example of FIG. **2**A continuous transmission is granted before the terminal signals the base station for discontinuous uplink transmission grants. Thus, before the terminal signals to the base station to issue discontinuous uplink transmission grants, the base station allows the terminal to transmit for a time t. Once the terminal signals the base station for discontinuous uplink transmission grants, as FIG. **2**B shows, discontinuous transmission is granted and thus uplink transmissions are limited to transmission bursts of less than time t after the discontinuous transmission uplink grants are received.

In one embodiment, the terminal transmits a requests signal that includes data representing a maximum duty cycle for the discontinuous uplink transmission grant. In one embodiment, the data representing the maximum duty cycle corresponds to 1 bit representing two potential maximum duty cycle levels. Possible maximum duty cycle levels with 1 bit signaling include approximately ⅓ duty cycle and approximately ⅔ duty cycle, and approximately ½ duty cycle and approximately 100% duty cycle. In another embodiment, the data representing the maximum duty cycle corresponds to 2 bit representing four potential maximum duty cycle levels. Possible maximum duty cycle levels with 2 bit signaling include approximately ⅕ duty cycle, approximately ⅖ duty cycle, approximately ⅗ duty cycle and approximately ⅘ duty cycle, and approximately ¼ duty cycle, approximately ½ duty cycle, approximately ¾ duty cycle and approximately 100% duty cycle. In yet another embodiment, the data representing the maximum duty cycle corresponds to 3 bit representing eight potential maximum duty cycle levels. Possible maximum duty cycle levels with 3 bits signaling include approximately 1/9 duty cycle, approximately 2/9 duty cycle, approximately ⅓ duty cycle, approximately 4/9 duty cycle, approximately 5/9 duty cycle, approximately 6/9 duty cycle, approximately 7/9 duty cycle, and approximately 8/9 duty cycle; and approximately ⅛ duty cycle, approximately ¼ duty cycle, approximately ⅜ duty cycle, approximately ½ duty cycle, approximately ⅝ duty cycle, approximately ⅜ duty cycle, approximately ⅞ duty cycle, and approximately 100% duty cycle.

FIG. **3** illustrates a schematic diagram of the RAN **12** including exemplary block diagrams of the terminal **14** and the base station **16**.

The terminal **14** includes a power consumption logic **141** that determines whether terminal power consumption is to be reduced. In one embodiment, the power consumption logic **141** determines that terminal power consumption is to be reduced because it determines that the terminal **14** is overheating or at risk of overheating. In another embodiment, the power consumption logic **141** determines that terminal power consumption is to be reduced because it determines that a shortage power supply to the terminal **14** exists. In yet another embodiment, the power consumption logic **141** determines that terminal power consumption is to be reduced because it determines that the terminal **14** has exceeded or is at risk of exceeding Specific Absorption Rate (SAR) regulatory requirements. When the power consumption logic **141** determines that terminal power consumption is to be reduced, it issues an indication.

The terminal **14** also includes a throttling logic **142** that receives from the power consumption logic **141** the indication

as to whether the terminal power consumption is to be reduced. When the throttling logic **142** receives from the power consumption logic **141** the indication that the terminal power consumption is to be reduced, the throttling logic **142** encodes a throttling request signal including data for transmission to the base station **16** and indicating to the base station **16** to issue a discontinuous uplink transmission grant to the terminal **14**.

The terminal **14** further includes a transmitter **143** that transmits the throttling request signal, and a receiver **144** configured to receive from the base station **16** the uplink transmission grants. In one embodiment, the transmitter **143** transmits the throttling request signal via a radio resource control (RRC) layer **25**.

The terminal **14** further includes a terminal controller **145** operatively connected to the power consumption logic **141**, the throttling logic **142**, the transmitter **143**, and the receiver **144** to thereby control the terminal **14**.

The base station **16** includes a receiver **161** that receives the throttling request signal from the terminal **14** and an uplink transmission scheduling logic **162** connected the receiver **161** and that generates a discontinuous uplink transmission grant signal upon receiving of the throttling request signal. The base station **16** further includes a transmitter **163** connected to the uplink transmission scheduling logic **162** that transmits the discontinuous uplink transmission grant signal to the terminal **14**. In one embodiment, the transmitter **163** transmits the discontinuous uplink transmission grant signal to the receiver **144** via the Physical Control Channel (PDCCH) **17** as specified for LTE, while in other embodiments other channels are used.

The base station **16** further includes a base station controller **164** operatively connected to the receiver **161**, the uplink transmission scheduling logic **162**, and the transmitter **163** to thereby control the base station **16**.

In one embodiment, the power consumption logic **141** also determines whether the terminal power consumption no longer needs to be reduced. In one embodiment, the power consumption logic **141** determines that terminal power consumption is no longer to be reduced because it determines that the terminal **14** is no longer at risk of overheating, that the shortage power supply to the terminal **14** no longer exists, or that the terminal **14** is no longer at risk of exceeding SAR regulatory requirements. When the power consumption logic **141** determines that terminal power consumption no longer is to be reduced, it issues another indication. The throttling logic **142** receives from the power consumption logic **141** the indication as to whether the terminal power consumption is no longer to be reduced and encodes a second throttling request signal including data indicating to the base station **16** to no longer issue the discontinuous uplink transmission grant to the terminal **14**. The transmitter **143** transmits the second throttling request signal. In this case, the receiver **161** receives the second throttling request signal from the requesting terminal **14** and the uplink transmission scheduling logic **162**, upon the receiving of the second throttling request signal, generates a non-discontinuous uplink transmission grant signal for the transmitter **163** to transmit to the requesting terminal **14**.

In accordance with the above features, FIGS. **4** and **5** show flowcharts that illustrate logical operations to implement exemplary methods for dynamic adaptation of one or more communication parameters for communication between a base station and a terminal in a wireless telecommunications network. The exemplary methods may be carried out by executing embodiments of the base stations, terminals, mobile telephones, flash devices or machine-readable storage media disclosed herein, for example. Thus, the flowcharts of FIGS. **4** and **5** may be thought of as depicting steps of a method carried out in the above-disclosed systems or devices by operation of hardware, software, or combinations thereof. Although FIGS. **4** and **5** show a specific order of executing functional logic blocks, the order of executing the blocks may be changed relative to the order shown. Also, two or more blocks shown in succession may be executed concurrently or with partial concurrence. Certain blocks also may be omitted.

In reference to FIG. **4**, logical flow of a method **40** for terminal requested base station controlled terminal transmission throttling includes, at **41**, determining whether terminal power consumption is to be reduced. At **42**, if the terminal power consumption is to be reduced, at **43**, transmit a throttling request signal to the base station for the base station to issue a discontinuous uplink transmission grant to the terminal and return to **41** to determining whether terminal power consumption is to be reduced. Also, at **44**, the method **40** includes receiving from the base station a discontinuous uplink transmission grant. Back to **42**, if the terminal power consumption is not to be reduced, at **45**, the method **40** includes, transmitting the second throttling request signal to the base station and return to **41** to determining whether terminal power consumption is to be reduced. In one embodiment, the transmitting the second throttling request signal to the base station occurs only if a discontinuous uplink transmission grant was previously received by the terminal. Also, at **46**, the method **40** includes receiving from the base station a non-discontinuous uplink transmission grant.

In reference to FIG. **5**, logical flow of a method **50** for an electronic device for operation in a wireless telecommunication system including terminal requested base station controlled terminal transmission throttling is shown. At **51**, the method **50** includes receiving a throttling request signal from a requesting terminal. At **52**, if the throttling request signal includes data indicating to issue a discontinuous uplink transmission grant to the terminal, at **53**, generate a discontinuous uplink transmission grant signal, and, at **54**, transmit the uplink transmission grant signal to the requesting terminal. Back to **52**, if the throttling request signal includes data indicating to not issue the discontinuous uplink transmission grant to the terminal, at **55**, generate a non-discontinuous uplink transmission grant signal and, at **54**, transmit the uplink transmission grant signal to the requesting terminal.

FIG. **6** illustrates a detailed block diagram of an exemplary terminal, which in the illustrated embodiment is represented by the mobile phone **100**. The phone **100** includes a control circuit **632** that is responsible for overall operation of the phone **100**. For this purpose, the control circuit **632** includes the terminal controller **145** that executes various applications, including applications related to or that form part of the phone **100** functioning as a terminal.

In one embodiment, functionality of the phone **100** acting as the terminal described above in reference to FIGS. **1-5** are embodied in the form of executable logic (e.g., lines of code, software, or a program) that is stored in the non-transitory computer readable medium **244** (e.g., a memory, a hard drive, etc.) of the phone **100** and is executed by the control circuit **632**. The described operations may be thought of as a method that is carried out by the phone **100**. Variations to the illustrated and described techniques are possible and, therefore, the disclosed embodiments should not be considered the only manner of carrying out phone **100** functions.

The phone **100** further includes the GUI **110**, which may be coupled to the control circuit **632** by a video circuit **626** that converts video data to a video signal used to drive the GUI

110. The video circuit **626** may include any appropriate buffers, decoders, video data processors and so forth.

The phone **100** further includes communications circuitry that enables the phone **100** to establish communication connections such as a telephone call. In the exemplary embodiment, the communications circuitry includes a radio circuit **616**. The radio circuit **616** includes one or more radio frequency transceivers including the receiver **144**, the transmitter **143** and an antenna assembly (or assemblies). Since the phone **100** is capable of communicating using more than one standard, the radio circuit **616** including the receiver **144** and the transmitter **143** represents each radio transceiver and antenna needed for the various supported connection types. The radio circuit **616** including the receiver **144** and the transmitter **143** further represents any radio transceivers and antennas used for local wireless communications directly with an electronic device, such as over a Bluetooth interface.

As indicated, the phone **100** includes the primary control circuit **632** that is configured to carry out overall control of the functions and operations of the phone **100**. The terminal controller **145** of the control circuit **632** may be a central processing unit (CPU), microcontroller or microprocessor. The terminal controller **145** executes code stored in a memory (not shown) within the control circuit **632** and/or in a separate memory, such as the machine-readable storage medium **244**, in order to carry out operation of the phone **100**. The machine-readable storage medium **244** may be, for example, one or more of a buffer, a flash memory, a hard drive, a removable media, a volatile memory, a non-volatile memory, a random access memory (RAM), or other suitable device. In a typical arrangement, the machine-readable storage medium **244** includes a non-volatile memory for long term data storage and a volatile memory that functions as system memory for the control circuit **632**. The machine-readable storage medium **244** may exchange data with the control circuit **632** over a data bus. Accompanying control lines and an address bus between the machine-readable storage medium **244** and the control circuit **632** also may be present. The machine-readable storage medium **244** is considered a non-transitory computer readable medium. In one embodiment, data regarding the indication is stored in the machine-readable storage medium **244**.

The phone **100** may further include a sound circuit **621** for processing audio signals. Coupled to the sound circuit **621** are a speaker **622** and a microphone **624** that enable a user to listen and speak via the phone **100**, and hear sounds generated in connection with other functions of the device **100**. The sound circuit **621** may include any appropriate buffers, encoders, decoders, amplifiers and so forth.

The phone **100** may further include a keypad **120** that provides for a variety of user input operations as described above in reference to FIG. **1**. The phone **100** may further include one or more input/output (I/O) interface(s) **628**. The I/O interface(s) **628** may be in the form of typical electronic device I/O interfaces and may include one or more electrical connectors for operatively connecting the phone **100** to another device (e.g., a computer) or an accessory (e.g., a personal handsfree (PHF) device) via a cable. Further, operating power may be received over the I/O interface(s) **628** and power to charge a battery of a power supply unit (PSU) **631** within the phone **100** may be received over the I/O interface (s) **628**. The PSU **631** may supply power to operate the phone **100** in the absence of an external power source.

The phone **100** also may include various other components. For instance, the imaging element **102** may be present for taking digital pictures and/or movies. Image and/or video files corresponding to the pictures and/or movies may be stored in the machine-readable storage medium **244**. As another example, a position data receiver **634**, such as a global positioning system (GPS) receiver, may be present to assist in determining the location of the phone **100**.

Although the invention has been shown and described with respect to certain preferred embodiments, it is understood that equivalents and modifications will occur to others skilled in the art upon the reading and understanding of the specification. The present invention includes all such equivalents and modifications, and is limited only by the scope of the following claims.

What is claimed is:

1. A method for terminal requested base station controlled terminal transmission throttling, the method comprising:

determining whether terminal power consumption is to be reduced;

when the terminal power consumption is to be reduced, transmitting a throttling request signal to the base station, the throttling request signal including data indicating to the base station to issue a discontinuous uplink transmission grant to the terminal, wherein the throttling request signal includes data representing a maximum duty cycle of forthcoming discontinuous uplink transmissions from the terminal to the base station;

receiving from the base station the discontinuous uplink transmission grant; and

transmitting discontinuous uplink transmissions from the terminal to the base station that do not exceed the maximum duty cycle, wherein the maximum duty cycle corresponds to discontinuous uplink transmission bursts of less than a time t corresponding to an uplink transmission frame prior to receiving from the base station the discontinuous uplink transmission grant.

2. The method of claim **1**, wherein the determining whether terminal power consumption is to be reduced includes at least one of:

determining that the terminal is at risk of overheating,

determining a shortage power supply to the terminal, and

determining that the terminal is at risk of exceeding Specific Absorption Rate (SAR) regulatory requirements.

3. The method of claim **1**, wherein the transmitting the throttling request signal to the base station includes transmitting the throttling request signal via the radio resource control (RRC) layer.

4. The method of claim **1**, wherein the terminal includes a buffer, the method further comprising:

transmitting only discontinuous uplink transmissions from the terminal to the base station that do not exceed the maximum duty cycle even when there is additional data in the terminal's buffer to be transmitted from the terminal to the base station.

5. The method of claim **1**, wherein the data representing the maximum duty cycle corresponds to 1 bit representing two potential maximum duty cycle levels of the forthcoming discontinuous uplink transmissions, the maximum duty cycle levels selected from the group consisting of:

⅓ duty cycle and ⅔ duty cycle; and

½ duty cycle and 100% duty cycle.

6. The method of claim **1**, wherein the data representing the maximum duty cycle corresponds to 2 bits representing four potential maximum duty cycle levels of the forthcoming discontinuous uplink transmissions, the maximum duty cycle levels selected from the group consisting of:

⅕ duty cycle, ⅖ duty cycle, ⅗ duty cycle, and ⅘ duty cycle; and

¼ duty cycle, ½ duty cycle, ¾ duty cycle, and 100% duty cycle.

7. The method of claim 1, wherein the data representing the maximum duty cycle corresponds to 3 bits representing eight potential maximum duty cycle levels of the forthcoming discontinuous uplink transmissions, the maximum duty cycle levels selected from the group consisting of:

1/9 duty cycle, 2/9 duty cycle, 1/3 duty cycle, 4/9 duty cycle, 5/9 duty cycle, 6/9 duty cycle, 7/9 duty cycle, and 8/9 duty cycle; and

1/8 duty cycle, 1/4 duty cycle, 3/8 duty cycle, 1/2 duty cycle, 5/8 duty cycle, 3/8 duty cycle, 7/8 duty cycle, and 100% duty cycle.

8. The method of claim 1, comprising:

if the terminal power consumption is no longer to be reduced, transmitting a second throttling request signal to the base station, the second throttling request signal including data indicating to the base station to no longer issue the discontinuous uplink transmission grant to the terminal.

9. A terminal for operation in a wireless telecommunication system including terminal requested base station controlled terminal transmission throttling, the terminal comprising:

a buffer having stored therein data to be transmitted from the terminal to the base station;

a power consumption logic configured to determine whether terminal power consumption is to be reduced;

a throttling logic operatively connected to the power consumption logic and configured to receive from the power consumption logic an indication as to whether the terminal power consumption is to be reduced, wherein where the throttling logic receives from the power consumption logic the indication that the terminal power consumption is to be reduced, the throttling logic is configured to encode a throttling request signal including data indicating to the base station to issue a discontinuous uplink transmission grant to the terminal, wherein the throttling request signal includes data representing a maximum duty cycle of forthcoming discontinuous uplink transmissions of the data stored in the buffer from the terminal to the base station;

a transmitter configured to transmit the throttling request signal; and

a receiver configured to receive from the base station the discontinuous uplink transmission grant,

wherein the transmitter is further configured to, upon the receiver receiving from the base station the discontinuous uplink transmission grant, transmit discontinuous uplink transmissions from the terminal to the base station that do not exceed the maximum duty cycle, wherein the maximum duty cycle corresponds to discontinuous uplink transmission bursts of less than a time t corresponding to an uplink transmission frame prior to receiving from the base station the discontinuous uplink transmission grant.

10. The terminal of claim 9, wherein the power consumption logic is configured to determine whether the terminal power consumption is to be reduced by at least one of:

determining that the terminal is at risk of overheating,

determining a shortage power supply to the terminal, and

determining that the terminal is at risk of exceeding Specific Absorption Rate (SAR) regulatory requirements.

11. The terminal of claim 9, wherein the transmitter is configured to transmit the throttling request signal via a radio resource control (RRC) layer.

12. The terminal of claim 9, wherein the transmitter is further configured to, upon the receiver receiving from the base station the discontinuous uplink transmission grant, transmit only discontinuous uplink transmissions from the terminal to the base station that do not exceed the maximum duty cycle regardless of whether there is additional data in the buffer to be transmitted from the terminal to the base station.

13. The terminal of claim 9, wherein the data representing the maximum duty cycle corresponds to 1 bit representing two potential maximum duty cycle levels of the forthcoming discontinuous uplink transmissions, the maximum duty cycle levels selected from the group consisting of:

1/3 duty cycle and 2/3 duty cycle; and

1/2 duty cycle and 100% duty cycle.

14. The terminal of claim 9, wherein the data representing the maximum duty cycle corresponds to 2 bits representing four potential maximum duty cycle levels of the forthcoming discontinuous uplink transmissions, the maximum duty cycle levels selected from the group consisting of:

1/5 duty cycle, 2/5 duty cycle, 3/5 duty cycle, and 4/5 duty cycle; and

1/4 duty cycle, 1/2 duty cycle, 3/4 duty cycle, and 100% duty cycle.

15. The terminal of claim 9, wherein the data representing the maximum duty cycle corresponds to 3 bits representing eight potential maximum duty cycle levels of the forthcoming discontinuous uplink transmissions, the maximum duty cycle levels selected from the group consisting of:

1/9 duty cycle, 2/9 duty cycle, 1/3 duty cycle, 4/9 duty cycle, 5/9 duty cycle, 6/9 duty cycle, 7/9 duty cycle, and 8/9 duty cycle; and

1/8 duty cycle, 1/4 duty cycle, 3/8 duty cycle, 1/2 duty cycle, 5/8 duty cycle, 3/8 duty cycle, 7/8 duty cycle, and 100% duty cycle.

16. The terminal of claim 9, wherein:

the power consumption logic is further configured to determine whether the terminal power consumption is no longer to be reduced,

the throttling logic is further configured to receive from the power consumption logic an indication as to whether the terminal power consumption is no longer to be reduced, wherein where the throttling logic receives from the power consumption logic the indication that the terminal power consumption is no longer to be reduced, the throttling logic is configured to encode a second throttling request signal including data indicating to the base station to no longer issue the discontinuous uplink transmission grant to the terminal, and

the transmitter is further configured to transmit the second throttling request signal.

17. An electronic device for operation in a wireless telecommunication system including terminal requested base station controlled terminal transmission throttling, the device comprising:

a receiver configured to receive a throttling request signal from a requesting terminal, the throttling request signal including data indicating to issue a discontinuous uplink transmission grant to the requesting terminal, wherein the throttling request signal includes data representing a maximum duty cycle of forthcoming discontinuous uplink transmissions from the terminal to the base station;

an uplink transmission scheduling logic operatively connected to the receiver and configured to, upon the receiver receiving the throttling request signal including data indicating to issue a discontinuous uplink transmission grant to the terminal, generate a discontinuous uplink transmission grant signal that instructs the requesting terminal to transmit only discontinuous uplink transmissions to the base station that do not

exceed the maximum duty cycle, wherein the maximum duty cycle corresponds to discontinuous uplink transmission bursts of less than a time t corresponding to a terminal transmission frame prior to receiving from the base station the discontinuous uplink transmission grant signal; and

a transmitter operatively connected to the uplink transmission scheduling logic and configured to transmit the discontinuous uplink transmission grant signal to the requesting terminal.

18. The device of claim **17**, wherein the receiver is configured to receive the throttling request signal via a radio resource control (RRC) layer.

19. The device of claim **17**, wherein the data representing the maximum duty cycle corresponds to at least one of:

1 bit representing two potential maximum duty cycle levels of the forthcoming discontinuous uplink transmissions, the maximum duty cycle levels selected from the group consisting of:

⅓ duty cycle and ⅔ duty cycle, and

½ duty cycle and 100% duty cycle;

2 bits representing four potential maximum duty cycle levels of the forthcoming discontinuous uplink transmissions, the maximum duty cycle levels selected from the group consisting of:

⅕ duty cycle, ⅖ duty cycle, ⅗ duty cycle and ⅘ duty cycle, and

¼ duty cycle, ½ duty cycle, ¾ duty cycle, and 100% duty cycle; and

3 bits representing eight potential maximum duty cycle levels of the forthcoming discontinuous uplink transmissions, the maximum duty cycle levels selected from the group consisting of:

⅑ duty cycle, ⅔ duty cycle, ⅓ duty cycle, ⅘ duty cycle, ⅚ duty cycle, ⅙ duty cycle, ⅞ duty cycle, and ⅛ duty cycle, and

⅛ duty cycle, ¼ duty cycle, ⅜ duty cycle, ½ duty cycle, ⅝ duty cycle, ⅜ duty cycle, ⅞ duty cycle, and 100% duty cycle.

20. The device of claim **17**, wherein:

the receiver is further configured to receive a second throttling request signal from the requesting terminal, the second throttling request signal including data indicating to no longer issue the discontinuous uplink transmission grant to the terminal;

the uplink transmission scheduling logic is further configured to, upon the receiver receiving the second throttling request signal, generate a non-discontinuous uplink transmission grant signal; and

the transmitter is further configured to transmit the non-discontinuous uplink transmission grant signal to the requesting terminal.

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