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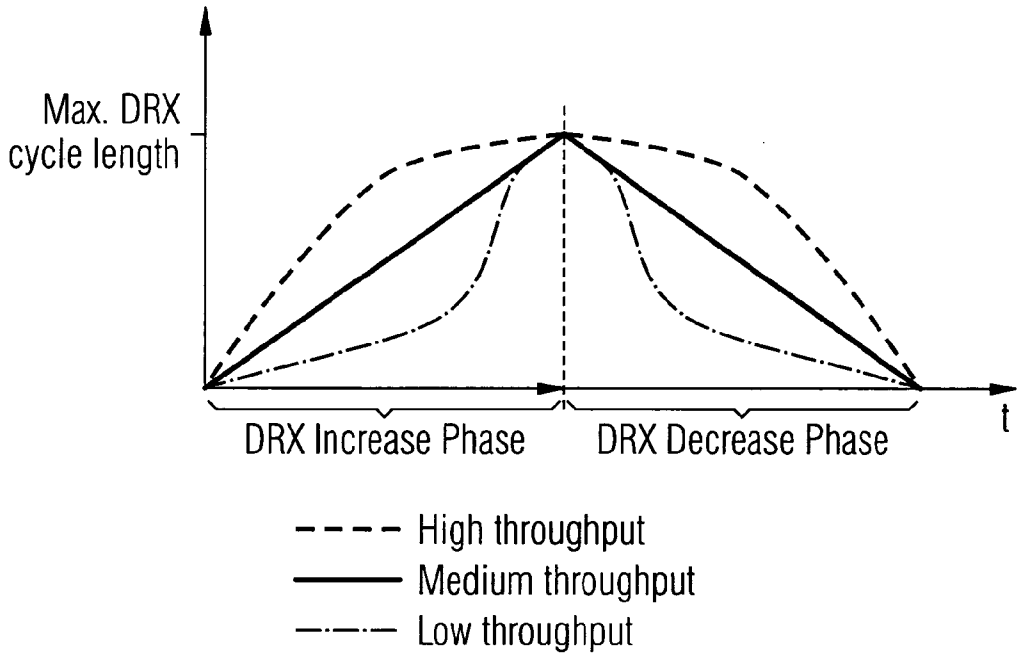
(54) Title: METHOD FOR DYNAMICALLY ADAPTING THE DRX CYCLE LENGTH IN A RADIO COMMUNICATIONS SYSTEM



(57) Abstract: According to the invention, a cycle length of a discontinuous reception (DRX) at a user terminal is dynamically adapted depending on connection and/or terminal related parameters.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Title of the invention

Method for dynamically adapting the DRX cycle length in a radio communications system

Field of the invention

The present invention relates to a method for dynamically adapting the DRX (Discontinuous Reception) cycle length in a radio communications system.

Summary of the invention

One of the most important requirements for the evolution of third generation (3G) radio communications systems, like e.g. UMTS, are efficient usage of battery power and short transition times (i.e. low C-plane latency) between inactive idle state and active state at the user terminal. A common way to save battery power and trigger state changes from inactive to active state is to use a paging mechanism wherein the user terminal periodically monitors a base station's paging channel in order to identify that it has to turn on its receiver in order to fetch transmitted data. If a DRX mechanism is applied together with paging, an optimised battery power utilisation can be achieved allowing a tradeoff between activation time and power consumption at the user terminal.

However, current systems only use a fixed value for the DRX cycles length (e.g. in 3G: one for CS (Circuit Switched), one for PS (Packet Switched) domain) which does not cope well with "real-world-usage-scenarios". Applying a fixed cycle length could lead to a situation where new data arrives at the radio access network just after the user terminal has finished reading the paging channel. This means, for

indicating this event to the user terminal the network has to wait almost an entire DRX cycle, which could last up to several seconds paging delay (e.g. up to 5 seconds in 3G). On the other hand, making the DRX cycle length shorter will result in a faster draining of the user terminal's battery. Especially, this would be highly inefficient in cases where a few short data packets are transmitted rather infrequently.

A need therefore exists for a technique that resolves the above mentioned issues and ensures that the power of a user terminal's battery is efficiently controlled and not wasted.

With the present invention the above mentioned issues are resolved. The proposed technique provides for an efficient and simple control of a user terminal's battery power.

The technique is achieved by the teaching contained in the independent claims. Further advantageous embodiments can be seen in the dependent claims.

Said independent method controls a discontinuous reception cycle length of a user terminal in a radio communications system, wherein the cycle length is dynamically adapted depending on connection and/or terminal related parameters.

Said independent user terminal of a radio communications system, comprises means for dynamically adapting a discontinuous reception cycle length depending on connection and/or terminal related parameters.

According to the present invention, the nowadays static DRX cycle length is dynamically adapted to the user terminal's behaviour, services and/or user characteristics in order to better match the time of inactivity from services perspective to the periodicity where the user terminal monitors the paging channel for detection of triggers for a state transition.

Furthermore, the DRX cycle length is dynamically adapted based on history/statistics and other information by

1. taking performance/service characteristics into account (data throughput [peak, average], data rate, data arrival rate [measured over a certain time period], known/estimated service scheduling times, etc.), and/or
2. taking user terminal/environment/user related aspects into account (terminal capability, operation environment [fixed installation], velocity, etc.).

Short description of the drawings

The present invention will become more fully apparent from the detailed description given herein below and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

Fig. 1 shows a DRX cycle length adaptation scheme based on data throughput.

Fig. 2 shows an exemplary variation of the DRX cycle length over time for a user terminal.

Fig. 3 shows a DRX cycle length adaptation scheme based on packet-arrival-rate.

Fig. 4 shows an exemplary embodiment depicting the different means used to implement the inventive technique.

Detailed description of the invention

Fig. 1 shows a DRX cycle length adaptation scheme based on data throughput. The exemplary scheme is based on data throughput wherein the DRX cycle length is continuously

adapted for a particular user. The process is characterised by two phases: a DRX Increase Phase and a DRX Decrease Phase.

According to this scheme, the cycle length will be increased in case the user has received a service where high throughput (e.g. good peak to average ratio) has been achieved in active state. Here it is assumed that the user terminal is in a good radio condition where a longer paging period may be compensated with high peak data rate for successive transmissions. The cycle length decreases in case the user terminal has received a service where low data throughput (e.g. bad peak to average ratio) has been achieved in active state. Here it is assumed that the user is in a bad radio condition where a short paging period is necessary because buffered data for successive transmissions (which triggered the paging) cannot be quickly transmitted over the air interface.

The gradient for increasing or decreasing the cycle length is defined by discrete curves, as shown in fig. 1 for three different situations, high, medium, low throughput. The new DRX cycle length can thus be calculated based on the current (stored) cycle length value which is used as an input parameter for the calculation of a new value according to the following DRX-formula.

New DRX cycle length = f (current DRX cycle length, data throughput)

In such a mode of operation, the DRX cycle length value would be continuously updated in case the user terminal changes from active to idle state, as shown for example in fig. 2.

Fig. 2 shows an exemplary variation of the DRX cycle length over time for a user terminal.

As mentioned above, in addition to "data throughput" parameter in the DRX-formula many other input parameters like e.g.

"packet-arrival-rate" may also be taking into account, which determines the period after the last transmitted packet and before a new data packet arrives.

The example of fig. 3 shows a DRX cycle length adaptation scheme based on packet-arrival-rate, continuously adapting the DRX cycle length for a particular user terminal.

According to this scheme, the DRX cycle length is increased if the last idle period was longer than the previous one, thus resulting in a lower packet arrival rate. In case the last idle period was shorter than the one before, i.e. a higher packet-arrival-rate, the DRX cycle length is decreased.

In fig. 3, the gradient for increasing or decreasing the cycle length is defined by discrete curves for the three different situations, high, medium and low arrival-rate. The new DRX cycle length will now be calculated based on the current (stored) cycle length value which is used as an input parameter in the calculation of the new value according to the DRX-formula below.

New DRX cycle length = f (current DRX cycle length, packet-arrival-rate)

However, in order to obtain better statistical results on the fluctuation of the period after the last transmitted packet and before a new data packet arrives (idle period), it would be beneficial to also take into account the history of packet-arrival-rates. For this purpose, a "DRX evaluation window" based on multiple individual "DRX evaluation periods" (arbitrary idle period) may be used to adapt the DRX cycle length to a cumulated packet-arrival-rate, as shown in fig. 2. As a consequence, the new DRX cycle length may be calculated according to the following DRX-formula.

New DRX cycle length = f (current DRX cycle length, packet-arrival-rate [DRX Evaluation Window])

It is of course also possible to combine different types of parameters in the DRX-formula, such as throughput and arrival-rate. Furthermore, it should even be possible to combine a continuous calculation of the cycle length with an a-priori knowledge about scheduling times of services (e.g. frequent scheduled news service). For this purpose, the a-priori knowledge would interrupt the continuous DRX process.

Additionally, by taking into account also information on the terminal, environment and/or user, it would be possible to configure short DRX cycle lengths for fixed installations, because battery power is not an issue.

Furthermore, the maximum DRX cycle may be a parameter signalled by the network or the base station to the user terminal, wherein the parameter is dimensioned depending on the operation environment the user is currently in. In different scenarios, the maximum value of the cycle length may also vary, for example depending on the cell environment (macro, micro, pico cells), terminal capacity and/or maximum expected user terminal speed, etc.

In fig. 4, a further exemplary embodiment is depicted showing the different means that can be used to implement the inventive technique. Fig. 4 depicts a radio communications system 1000 comprising of a plurality of base stations (BSs) 100 and a plurality of user terminals 10. For ease of understanding of the inventive technique only one base station 100 and one user terminal 10 are shown. In fig. 4, BS 100 and user terminal 10 communicate and exchange data over a connection C. Nevertheless, a person skilled in the art would be aware that in such a radio communications system 1000, there exist more of these devices.

User terminal 10 comprises of means 11 adapted for dynamically adapting a discontinuous reception cycle length depending on connection and/or user terminal 10 related parameters as already mentioned herein above. User terminal 10 also comprises of further means 12 adapted for receiving the at least one parameter transmitted from a base station 100 of the radio communications system 1000. Means 12 are also further adapted to transmit over a plurality of channels to base station 100. Means 11 are also further arranged to control the functioning of user terminal 10 and to execute any further operations required. User terminal 10 also comprises of means 13 arranged to store data, such as the different connection and/or user terminal 10 related parameters, cycle lengths, reception evaluation periods etc. The different means can be implemented in at least one of the following: a microcomputer, an integrated circuit, a microprocessor.

Base station 100 comprises of means 101 arranged to control the functioning of the base station 100, and, means 102 arranged to transmit and to receive transmissions from user terminal 10. The different means can also be implemented in at least one of the following: a microcomputer, an integrated circuit, a microprocessor.

Advantages of the present invention are the following:

- optimal adaptation of paging/DRX mechanism to service characteristics (e.g. packet-arrival-rate, pre-defined service scheduling),
- optimal adaptation of paging/DRX mechanism to radio characteristics/conditions (e.g. throughput),
- optimal adaptation/configuration of paging/DRX mechanism based on terminal/environment/user aspects (e.g. fixed installation, mobile),
- optimised utilisation of the terminal's battery power with fastest possible state switching (lowest C-plane latency for idle-active transition),

- increased system efficiency and user satisfaction, and
- maintained network and operator control due to maximum DRX cycle being a signalled parameter.

Although the invention has been described in terms of a preferred embodiment described herein, those skilled in the art will appreciate other embodiments and modifications which can be made without departing from the scope of the teachings of the invention. All such modifications are intended to be included within the scope of the claims appended hereto.

Patent claims

1. Method for controlling a discontinuous reception (DRX) cycle length of a user terminal in a radio communications system, wherein the cycle length is dynamically adapted depending on connection and/or user terminal related parameters.

2. Method according to claim 1, wherein
the connection parameters are at least one of performance characteristics, service characteristics, data throughput, data rate, data arrival rate, service scheduling times.

3. Method according to claim 1 or 2, wherein
the terminal related parameters are at least one of user terminal capacity, operation environment, cell size, user terminal speed.

4. Method according to one of the preceding claims, wherein
a gradient for increasing and/or decreasing the cycle length is described by discrete curves for different parameters.

5. Method according to one of the preceding claims, wherein
when adapting the cycle length, a previous cycle length is taken into account.

6. Method according to one of the preceding claims, wherein
when adapting the cycle length, an evaluation window containing a number of discontinuous reception evaluation periods is considered.

7. User terminal (10) of a radio communications system (1000), comprising means (11) for dynamically adapting a discontinuous reception cycle length depending on connection and/or user terminal (10) related parameters.

8. User terminal (10) according to claim 7, comprising means (12) for receiving the at least one parameter from a base station (100) of the radio communications system (1000).

FIG 1

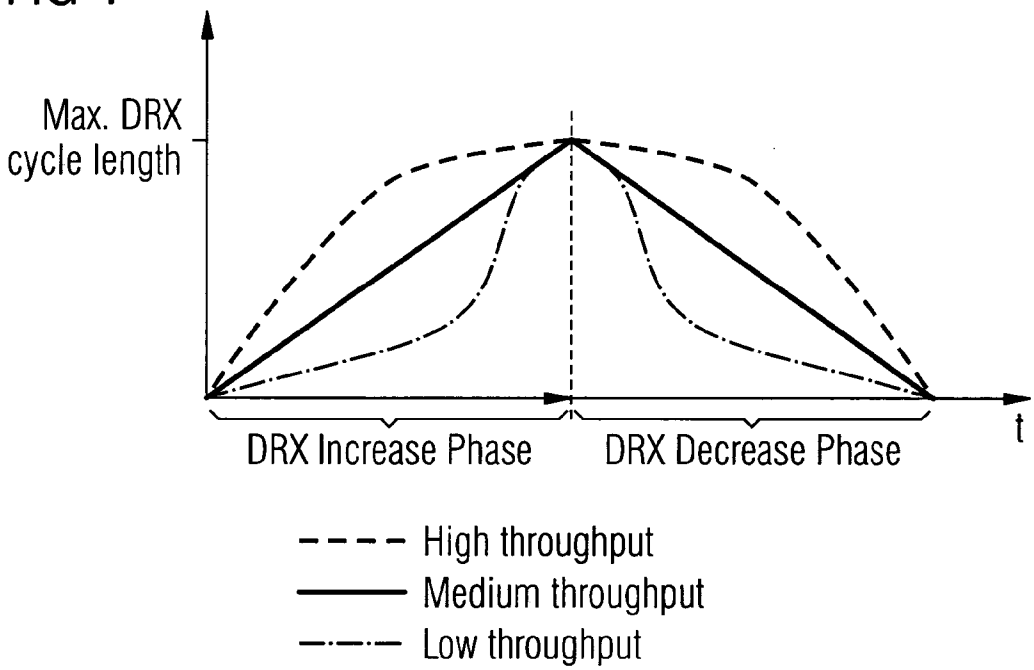

Max. DRX
cycle length
DRX Increase Phase
DRX Decrease Phase
t
High throughput
Medium throughput
Low throughput

FIG 2

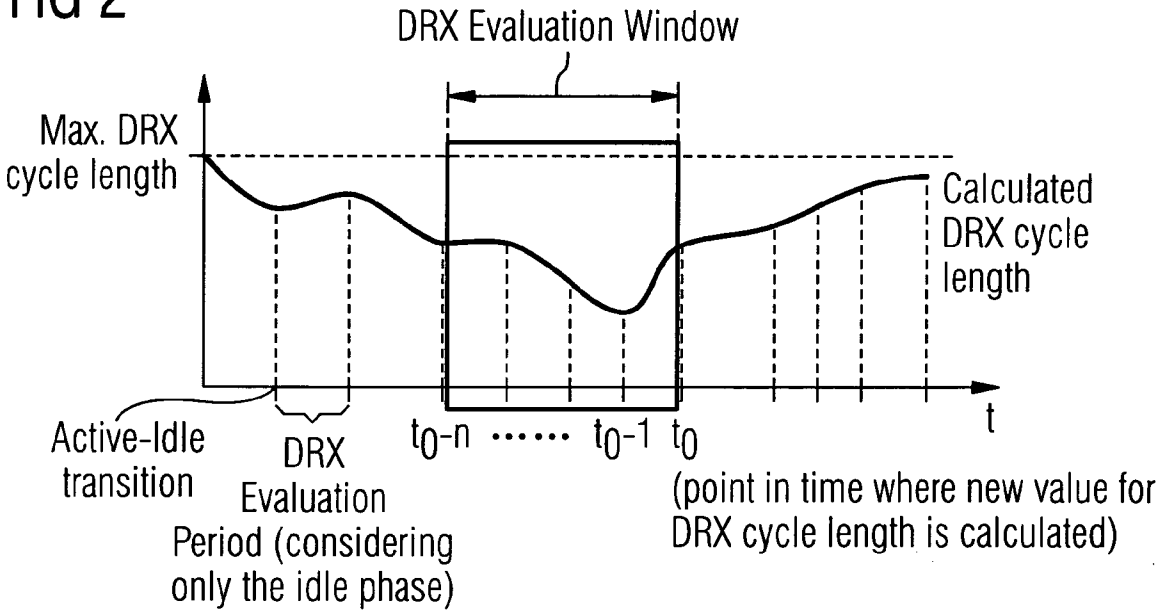

DRX Evaluation Window
Max. DRX
cycle length
Calculated
DRX cycle
length
t
Active-Idle
transition
DRX
Evaluation
Period (considering
only the idle phase)
t_{0-n} ..... t_{0-1} t_0
(point in time where new value for
DRX cycle length is calculated)

FIG 3

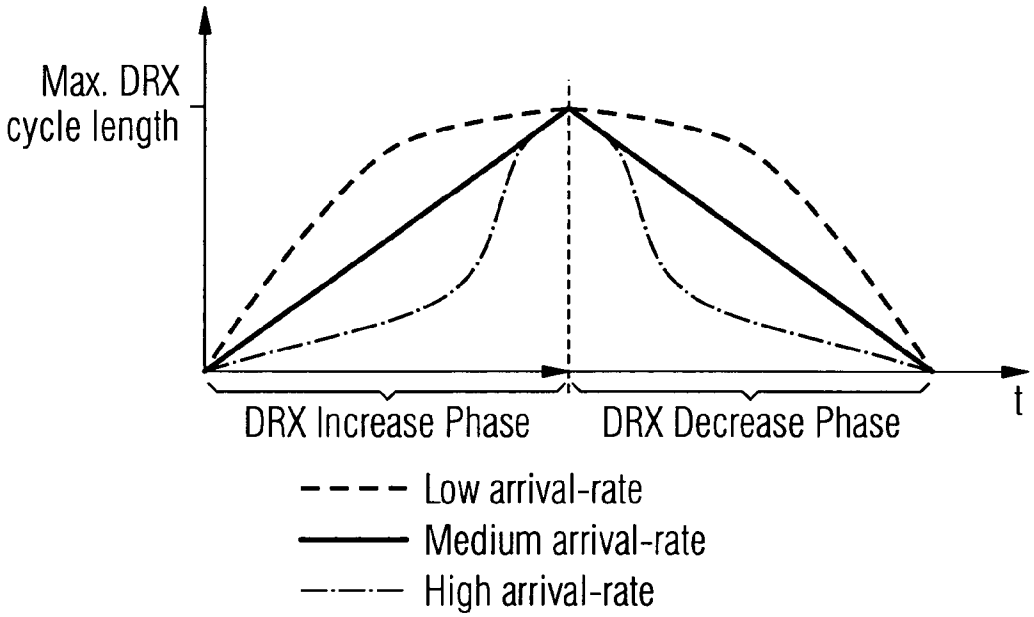
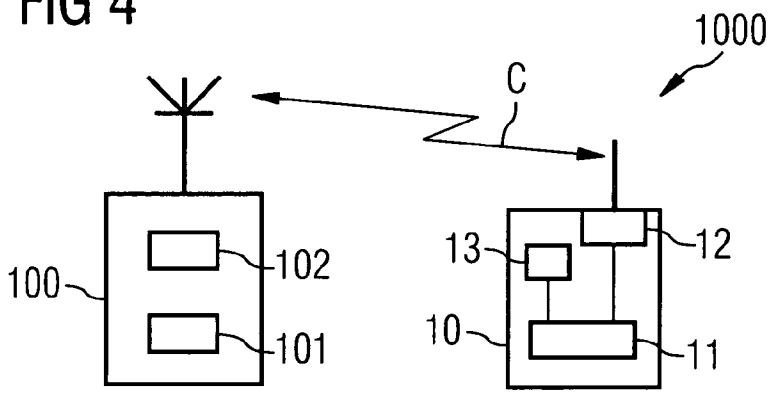

Max. DRX
cycle length
t
DRX Increase Phase
DRX Decrease Phase
Low arrival-rate
Medium arrival-rate
High arrival-rate

FIG 4


1000
C
100
102
101
13
12
10
11

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2007/050538

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B1/16 H04Q7/32

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 613 107 A (ERICSSON TELEFON AB L M [SE]) 4 January 2006 (2006-01-04) the whole document	1-8
X	TAO ZHENG ET AL: "PMAC: An Adaptive Energy-Efficient MAC Protocol for Wireless Sensor Networks" PARALLEL AND DISTRIBUTED PROCESSING SYMPOSIUM, 2005. PROCEEDINGS. 19TH IEEE INTERNATIONAL DENVER, CO, USA 04-08 APRIL 2005, PISCATAWAY, NJ, USA,IEEE, 4 April 2005 (2005-04-04), pages 237a-237a, XP010785829 ISBN: 0-7695-2312-9 the whole document	1-8

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 March 2007	28/03/2007

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2007/050538

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	EP 1 499 144 A (TOKYO SHIBAURA ELECTRIC CO [JP]) 19 January 2005 (2005-01-19) the whole document	1-8
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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