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(54) Title: A METHOD OF SCHEDULING DATA TRANSMISSION IN A RADIO NETWORK

(57) Abstract: In a method and apparatus for scheduling users in radio network system, the scheduling priority for each user of a group of users is made dependent on the unusable time for each user. Scheduling of the users is performed in accordance with the determined scheduling priority.

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A METHOD OF SCHEDULING DATA TRANSMISSION IN A RADIO NETWORK

TECHNICAL FIELD

The present invention relates to a method and a device for scheduling data transmission in a radio network.

BACKGROUND

Today a number of different technologies for cellular telecommunication exist. One such existing cellular telecommunication technology is Wideband Code Division Multiple Access (WCDMA).

In a WCDMA system, which is a powerful standard able to transmit data over a radio network at very high speed, a User Equipment (UE) such as a mobile telephone communicates over radio channels with base stations typically denoted Node B. The omni-area around a base station can be allocated into several sectors known as cells. The base station transmits and receives signals over selected radio channels in each cell. Typically, a base station is connected to one or more radio network controller nodes (RNC). One or more RNCs are, in turn, connected to the core network (CN). The CN is usually connected, e.g., via a gateway, to other telecommunication networks, such as the public switched telephone network or to a packet-data network such as the internet.

In a wideband code division multiple access (WCDMA) mobile telecommunications system, the information transmitted between a base station and a particular UE is modulated by mathematical codes (such as spreading codes) to differentiate the information for different services of this UE and the information for different UEs which are utilizing the same radio frequency. Thus, in WCDMA the data signal over each mobile radio employs its own unique code sequence to encode its signal. The receiver, knowing the code sequences of the mobile radio it services, decodes the received signal to recover data from each radio.

In the standard 3GPP Release. 5, High-Speed Downlink Packet Access (HSDPA) is introduced for WCDMA. HSDPA achieves the increase in the data transfer speeds by defining a new WCDMA channel: a high-speed downlink shared channel (HS-DSCH) that operates in a different way from existing DPCH channels and is used for downlink communications to the mobile.

Along with the HS-DSCH channel, three new physical channels are also introduced. One is the High Speed-Shared Control CHannel (HS-SCCH) which informs the user that data will be sent on the HS-DSCH 2 slots later. The second one is the uplink High Speed-Dedicated Physical Control CHannel (HS-DPCCH), which carries acknowledgement information and current channel quality indicator (CQI) of the user. This value is then used by the Node-B in scheduling, including scheduling user and calculating how much data to send to the scheduled UEs. The third downlink physical channel is the High Speed-Physical Dedicated Shared CHannel (HS-PDSCH), which carries the information transferred by HS-DSCH.

Furthermore, TTI, Transmission Time Interval, is a parameter in WCDMA and other digital telecommunication networks related to encapsulation of data from higher layers into frames for transmission on the radio link layer. TTI refers to the length of an independently decodable transmission on the radio link. The TTI is related to the size of the data blocks passed from the higher network layers to the radio link layer.

To combat errors due to fading and interference on the radio link the data in the transmitter buffer is divided into blocks and then the bits within a block are encoded and interleaved. The length of time required to transmit one such block determines the TTI. At the receiver side all bits of a given block must be received before they can be deinterleaved and decoded.

In order to be able to adapt quickly to the changing conditions in the radio link a communications system must have shorter TTIs. In order to benefit more from the effect of interleaving and to increase the efficiency of error-correction and compression techniques a system must, in general, have longer TTIs. These two contradicting requirements determine the choice of the TTI.

In 3GPP Release '99 the shortest TTI is 10 ms and can be 20 ms, 40 ms, or 80 ms. In 3GPP Release-5 the TTI for HSDPA is reduced to 2ms. This provides the advantage of faster response to link conditions and allows the system to quickly schedule transmissions to mobiles which temporarily enjoy better than usual link conditions

In Fig. 1, the timing of HSDPA transmission in the air interface is depicted. The control information for a UE is sent over the HS-SCCH 2 slots prior to the corresponding data transmission over the HS-DSCH in order to ensure that the UE has enough time to receive and decode the necessary information. Based on this information the UE determines if and how to receive the subsequent HS-DSCH data. If the UE determines that there is an HS-DSCH carrying data for that particular UE, the UE receives the HS-DSCH data and starts to process the received data as soon as the HS-DSCH receiving ends.

The UE takes about 7.5 slots to process the received HS-DSCH. Then the acknowledgement information for the HS-DSCH is sent over the first slot of HS-DPCCH. The duration from the HS-SCCH transmission start to the HS-DPCCH transmission end is about 15.5 slots and can not be interrupted, otherwise the data could be regarded as being lost.

In order to perform Inter Frequency Handover (IFHO) and Inter Radio Access Technology Handover (IRAT HO), Compressed Mode (CPM) for HSDPA is to be implemented.

Figure 2 shows the timing of the CPM timing in the air interface. The CPM is defined in "3GPP TS 25.215 V6.4.0, Technical Specification Group Radio Access Network; Physical layer - Measurements (FDD)". The following abbreviations will be used: TG: Transmission Gap. TGPL: Transmission Gap Pattern Length in number of frames. TGCFN: Transmission Gap Connection Frame Number, which is the Connection Frame Number (CFN) of the first radio frame of the first pattern within the TG-Pattern sequence. TGSN: Transmission Gap Starting Slot Number, which indicates the time offset from the TGPL start to the transmission gap start. TGL: Transmission Gap Length in number of slots. TGD: Transmission Gap start Distance in number slots, which is the duration between the starting slots of two consecutive transmission gaps within one transmission gap pattern.

Furthermore, there are different TG-Patterns for different measurement targets. Here are some examples:

The current default TG-Pattern for IFHO:

TGPL = 4, TGL = 7, TGSN = 4, TGD = 0, TGCFN = 0

The current default TG-Patterns for IRAT HO:

TGPL = 8, TGL = 7, TGSN = 4, TGD = 0, TGCFN = 0

TGPL = 8, TGL = 7, TGSN = 4, TGD = 0, TGCFN = 2

TGPL = 8, TGL = 7, TGSN = 4, TGD = 0, TGCFN = 6

There are also some proposed TG-Patterns namely:

TGPL = 4, TGL = 14, TGSN = 8, TGD = 0, TGCFN = 0

TGPL = 8, TGL = 14, TGSN = 8, TGD = 0, TGCFN = 0

TGPL = 24, TGL = 14, TGSN = 8, TGD = 0, TGCFN = 4

TGPL = 24, TGL = 14, TGSN = 8, TGD = 0, TGCFN = 12

TGPL = 24, TGL = 14, TGSN = 8, TGD = 0, TGCFN = 20

During the TG, the UE is performing measurements in another frequency in the original network or another network with different radio access technology (RAT). Hence, the UE can not transmit signal to or receive the signal from the original serving cell during this time.

The impact of the CPM on HSDPA users will now be described. As the process from the HS-SCCH transmission start to the corresponding HS-DPCCH transmission end can not be interrupted, scheduling a user in CPM should be avoided during a gap described above and the 15.5 slots before the gap. For a 7-slot or 14-slot gap, the number of the usable slots is

then about 22.5 or 29.5 slots.,The UE may work in multiple TG-Patterns. Also, depending on the TGD setting, there are possibly several gaps within one pattern.

Furthermore, the UE can be in CPM for several seconds or even longer, during which the UE suffers a longer packet delay than before the UE entered CPM.

Another factor that has to be considered is that the UE in CPM usually suffers very bad channel quality. For some schedulers such as proportional fair or maximum channel quality indicator (CQI), which considers the channel quality, the scheduling delay for the UEs in CPM is very large even if the impact of the gap is not taken into account.

Hence, the UEs in CPM experience a very large packet delay compared to those UEs not in the CPM due to both the bad channel quality and the transmission gap. The UEs in CPM also have a high risk of experiencing a high packet loss because of the retransmission failure resulted from T1 timer expires and the maximum scheduling delay reached if there is a maximum delay threshold setting in the scheduler such as the High Speed Medium Access protocol (MAC-hs) delay scheduler.

SUMMARY

It is an object of the present invention to improve the performance in a radio system having users operating in different modes within the same radio network.

It is another object of the present invention to overcome or at least reduce some of the problems associated with schedulers, in particular schedulers for use in radio networks supporting CPM.

These objects and others are obtained by providing a scheduler operative to take the unusable time for each user in group of users into account in the scheduler to increase the satisfaction rate of these users.

Thus, in the case when the radio system supports CPM, by increasing the scheduling priority of the UE in CPM according to $T_{unusable}$ during T_{pre} , the probability of the UE to be

scheduled before the start of $T_{unusable}$ is increased. This will turn result in that a UE in CPM will have an increased probability to send out the packets that is already queued for a long time and process the retransmissions before the start of $T_{unusable}$. Thus, the packet delay and the packet loss rate of the UEs in CPM is decreased.

Thus, by increasing the scheduling probability of the users in CPM before the unusable TTIs occurs, the impact from these unusable TTIs on the packet delay and the packet loss rate of these UEs can be reduced. For the UEs with delay sensitive services over HSDPA, such packet delay reduction can increase their probability to be satisfied.

The inclusion of the unusable time for each user as a parameter when determining the scheduling priority will hence increase performance for the overall system for CPM supporting systems as well as other systems with the same or similar properties.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described in more detail by way of non-limiting examples and with reference to the accompanying drawings, in which:

- Fig. 1 is a view of the timing of HSDPA transmission in the air interface
- Fig. 2 is a view of the timing of the CPM timing in the air interface
- Fig. 3 is a general view of a WCDMA system supporting HSPDA and CPM
- Fig. 4 is a view illustrating timing in a scheduler adapted to consider unusable TTIs
- Figs 5a – 5c are flowcharts illustrating different steps performed in a scheduler adapted to consider unusable TTIs

DETAILED DESCRIPTION

Fig. 3 is a general view of a WCDMA system 300 supporting HSPDA and CPM. The system 300 comprises a base station (Node B) 301. The base station 301 serves a number of mobile terminals, usually termed User Equipment (UE) 303, located within the area covered by the base station 301. The base station 101 is also connected to a radio network controller node (RNC) 305. The system 300 also comprises a scheduler 307 co-located with or an

integral part of the base station 301. Some aspects of the scheduler 307 will be described more in detail below.

In order to reduce the negative impact of CPM for the UEs the system 300 is configured to consider the impact of the unusable TTIs resulting from the gap in a certain period of time before the start of these unusable TTIs in the scheduling, for example the MAC-hs scheduling.

Fig. 4 illustrates an example when the scheduler considers the unusable TTIs in order to reduce the packet delay and packet loss rate for UEs in CPM. In Fig. 4 $T_{unusable}$ denotes is the number of the unusable slots resulted from one gap. Further, T_{pre} denotes the period of time that should consider $T_{unusable}$ before the start of $T_{unusable}$, and t_0 is the start of T_{pre} . By increasing the scheduling priority of the UE in CPM according to $T_{unusable}$ during T_{pre} , the probability of the UE to be scheduled before the start of $T_{unusable}$ is increased, which results in that a UE in CPM will have an increased probability to send out the packets that is already queued since long and process the retransmissions before the start of $T_{unusable}$. As a result, the packet delay and the packet loss rate of the UEs in CPM is decreased.

Below different examples on how to implement such an approach in different schedulers are described more closely:

Example 1: Implementation in a delay scheduler.

Prior to each gap, during T_{pre} , the coming unusable TTIs as is used as the delay:

$$f(\text{maximum_delay}) = \frac{1}{(T_{MAX} - (t_{queue} + T_{unusable}))}$$

where t_{queue} is the time corresponding to the time the packet has already been queued, T_{MAX} is the maximum allowable queuing delay and T_{pre} is determined by the scheduler and the delay requirements of different services.

Example 2: Implementation in a proportional fair scheduler:

Prior to each gap, during T_{pre} , take the coming unusable TTIs as the used time:

$$f(average_rate) = \left(\frac{N_b}{t_{used} + T_{unusable}} \right)^{-1}$$

where t_{used} is a certain period before the scheduling priority calculation, N_b is the number of transmitted bits during the time t_{used} and T_{pre} is determined by the scheduler and the delay requirements of different services.

Example 3: Adding a new priority coefficient in existing schedulers:

In addition to all the existing priority coefficients, during T_{pre} , a new priority coefficient, a pattern coefficient, is added for the users in CPM:

$$f(TG_Pattern) = \frac{TGPL_{max} * 5}{(TGPL_{max} * 5 - T_{unusable} / 3)}, \text{ TGPL in frame (10ms) unit, } T_{unusable} \text{ in slot unit.}$$

Where T_{pre} can be set as the number of HSDPA usable TTIs between the current gap and the last gap. If there is just one TG-Pattern for a UE in CPM, $T_{unusable}$ can be set the sum of the unusable TTIs within one pattern of the TG-Pattern sequence and $TGPL_{max}$ is the TGPL of this TG-Pattern. If there are multiple TG-Patterns time multiplexed for a UE in CPM, $TGPL_{max}$ is the largest TGPL of these TG-Patterns and $T_{unusable}$ can be set as the sum of the unusable TTIs from all of these TG-Patterns within one pattern of the TG-Pattern sequence with the largest TGPL.

Below some examples illustrating how the scheduling coefficients as described above can be used when determining the scheduling priority.

For a proportional scheduler,

$$\begin{aligned} \text{scheduling priority} = & f(average_rate) * f(CQI) \\ & * f(retrans) * f(TG_Pattern) \end{aligned}$$

where $f(average_rate)$ is the scheduling coefficient of average rate, $f(CQI)$ is the scheduling coefficient of CQI and $f(retrans)$ is the scheduling coefficient of retransmission.

For a delay scheduler,

$$\begin{aligned} \text{scheduling priority} = & f(max_inum_delay) * f(CQI) \\ & * f(retrans) * f(TG_Pattern) \end{aligned}$$

where $f(\text{maximum_delay})$ is the scheduling coefficient of maximum delay. Also, for all schedulers adapted to determine the scheduling priority based on many different scheduling coefficients different scheduling coefficients may be given different weights when determining the scheduling priority. Hence, in the case when the scheduler has access to many parameters representing a number of different scheduling coefficients, the scheduling priority can be determined as a function of all or some of those parameters depending on the environment in which the scheduler is deployed.

From a feasibility perspective, since the Node B and the UE are triggered usually 1~2 s before they enter the CPM simultaneously, there is enough time for the Node B to configure the scheduler in advance.

In Figs. 5a – 5c, different steps performed in a scheduler operating in accordance with the principles set out above are described in more detail.

In Fig. 5a, a flow chart illustrating steps performed in a scheduler, for example a MAC-hs, scheduler adapted to operate in accordance with the scheduling methods as described herein is shown. First the scheduling starts in a step 501. Next the scheduler obtains information about a first user in a user pool, step 503. Thereupon the scheduling priority for that particular user is calculated in a step 505. The calculations performed in step 505 can for example be any of the calculations described above for obtaining a scheduling priority. For all users in the pool the steps 503 and 505 are then repeated as indicated by step 507. When all users have been assigned a scheduling priority, the scheduler then schedules the users in accordance with their determined priorities, step 509.

In Fig. 5b, a flow chart illustrating some other steps performed in a scheduler, for example a MAC-hs scheduler, adapted to operate in accordance with the scheduling methods as described herein is shown. Thus, the scheduler 307 can at any time receive a signal from the RNC 305 that a particular UE 303 will enter CPM as indicated by step 511. Upon reception of such a signal for a particular UE the scheduler will check if that particular UE is associated with delay sensitive services provided by HSDPA, step 513. If the particular UE is associated with delay sensitive services provided by HSDPA, the scheduler will be

reconfigured, for example by updating the scheduler priority calculation algorithm for that particular UE, to reflect the changed mode of the UE, step 515. If the particular UE is not associated with delay sensitive services provided by HSDPA no action is taken in response to the signal received in step 511.

In Fig. 5c, a flow chart illustrating yet some other steps performed in a scheduler, for example a MAC-hs scheduler, adapted to operate in accordance with the scheduling methods as described herein is shown. Thus, the scheduler 307 can at any time receive a signal from the RNC 305 that a particular UE 303 will exit CPM as indicated by step 521. Upon reception of such an exit CPM signal for a particular UE the scheduler will check if that particular UE was reconfigured when entering CPM, step 523. If the particular UE was reconfigured the scheduler will restore, for example by updating the scheduler priority calculation algorithm for that particular UE, the UE to reflect the changed mode of the UE, step 525. If the particular UE was not reconfigured upon entry into CPM, no action is taken in response to the signal received in step 521. Of course other events may also trigger the scheduler to update the scheduler priority algorithm applied to a particular user, the above description serving as an example only.

Using the method and system as described herein will result in a significantly reduced packet delay and packet loss rate for users operating in a system environment having supporting different technologies, such as for example HSDPA users in a CPM supported radio network system. The method is easy to be implemented in products and has a low algorithm complexity. Furthermore there will be no impact on hardware and very small impact on software.

CLAIMS

1. A method of scheduling users in radio network system, **characterized by** the steps of:
 - for each user in a user group determining (505) a scheduling priority, the scheduling priority being dependent on a scheduling coefficient representing the unusable time for each user
 - scheduling (509) the users in accordance with the determined scheduling priority.
2. A method according to claim 1, **characterized by** the additional step of:
 - re-determining (515, 525) the scheduling priority for a user in response to a changed mode for said user.
3. A method according to claim 1 or 2, **characterized in that** the scheduling priority also is dependent on parameters representing other scheduling coefficients.
4. A method according to claim 3, **characterized in that** the other scheduling coefficients include coefficients corresponding to one or many of the following parameters: maximum delay, average rate, retransmission rate and channel quality indicator (CQI).
5. A method according to any of claims 3 or 4, when the radio network is a Wideband Code Division Multiple Access (WCDMA) network supporting High-Speed Downlink Packet Access (HSPDA) and Compressed Mode (CPM), **characterized in that** one other scheduling coefficient is a scheduling coefficient corresponding to a parameter representing the Transmission Gap (TG) pattern for a user in CPM.
6. A method according to claim 5, **characterized in that** the TG pattern scheduling coefficient is set to: $f(TG_Pattern) = \frac{TGPL_{max} * 5}{(TGPL_{max} * 5 - T_{unusable} / 3)}$

where, $T_{unusable}$ is the sum of the unusable Transmission Time Intervals (TTIs) within one pattern of the TG-Pattern sequence and $TGPL_{max}$ is the Transmission Gap Pattern Length in number of frames.

7. A method according to claim 6, when there are multiple TG-Patterns time multiplexed for a user in CPM **characterized in that** the, $TGPL_{max}$ is the largest TGPL of the TG-Patterns and $T_{unusable}$ is set as the sum of the unusable TTIs from all of these TG-Patterns within one pattern of the TG-Pattern sequence with the largest TGPL.

8. A method according to any of claims 1 - 7, when the users are scheduled in accordance with a maximum delay scheme, **characterized in that** prior to a transmission gap, during a pre-determined time period the unusable Transmission Time Intervals (TTIs) are set as the delay (maximum_Delay):

$$f(\text{maximum_delay}) = 1 / (T_{MAX} - (t_{queue} + T_{unusable}))$$

where t_{queue} is the time corresponding to the time a packet has already been queued and T_{MAX} is the maximum allowable queuing delay.

9. A method according to any of claims 1 - 7, when the users are scheduled in accordance with a proportional fair scheduling scheme, **characterized in that** prior to a transmission gap, during a pre-determined time period the unusable Transmission Time Intervals (TTIs) are set as the used time (t_{used}):

$$f(\text{average_rate}) = \left(\frac{N_b}{t_{used} + T_{unusable}} \right)^{-1}$$

where t_{used} is a certain period before the scheduling priority calculation and N_b is the number of transmitted bits during t_{used} .

10. A method according to any of claims 1 - 9, when more than one scheduling coefficient is used to determine the scheduling priority **characterized in that** the scheduling priority is determined as a function of all used scheduling coefficients.

11. A method according to claim 10, **characterized in that** the scheduling priority is determined as multiplication of all used scheduling coefficients.

12. A scheduler for scheduling users in radio network system, **characterized by:**

- means for determining a scheduling priority for each user in a user group where said determination means are adapted to determine the scheduling priority in response a scheduling coefficient representing the unusable time for each user, and
- means for scheduling the users in accordance with the determined scheduling priority.

13. A scheduler according to claim 12, **characterized by:**

- means for re-determining the scheduling priority for a user in response to a changed mode for said user.

14. A scheduler according to claim 12 or 13, **characterized in that** the means for determining a scheduling priority for each user in a user group are configured to determine the scheduling priority also in response to scheduling parameters representing additional scheduling coefficients.

15. A scheduler according to claim 14, **characterized in that** the other scheduling coefficients include coefficients corresponding to one or many of the following parameters: maximum delay, average rate, retransmission rate and channel quality indicator (CQI).

16. A scheduler according to any of claims 14 or 15, **characterized that** the means for determining a scheduling priority for each user in a user group are configured to determine the scheduling priority in response to a scheduling coefficient corresponding to a parameter representing the Transmission Gap (TG) pattern for a user in Compressed Mode (CPM).

17. A scheduler according to claim 16, **characterized in that** the TG pattern scheduling coefficient is set to: $f(TG_Pattern) = TGPL_{max} * 5 / (TGPL_{max} * 5 - T_{unusable} / 3)$

where, $T_{unusable}$ is the sum of the unusable Transmission Time Intervals (TTIs) within one pattern of the TG-Pattern sequence and $TGPL_{max}$ is the Transmission Gap Pattern Length in number of frames.

18. A scheduler according to claim 17, **characterized by** means for setting $TGPL_{max}$ to the largest TGPL of the TG-Patterns and $T_{unusable}$ to as the sum of the unusable TTIs from all of these TG-Patterns within one pattern of the TG-Pattern sequence with the largest TGPL and Compressed Mode when there are multiple TG-Patterns time multiplexed for a user in CPM.

19. A scheduler according to any of claims 12 – 18 for scheduling users in accordance with a maximum delay scheme, **characterized by** means for setting the unusable Transmission Time Intervals (TTIs) as the delay (maximum_Delay)

$$f(maximum_delay) = \frac{1}{(T_{MAX} - (t_{queue} + T_{unusable}))}$$

prior to a transmission gap and during a pre-determined time period where t_{queue} is the time corresponding to the time a packet has already been queued and T_{MAX} is the maximum allowable queuing delay.

20. A scheduler according to any of claims 12 - 18, for scheduling users in accordance with a proportional fair scheduling scheme, **characterized by** means for prior to a transmission gap, during a pre-determined time period setting the unusable Transmission Time Intervals (TTIs) are set as:

$$f(average_rate) = \left(\frac{N_b}{t_{used} + T_{unusable}} \right)^{-1}$$

where t_{used} is a certain period before the scheduling priority calculation and N_b is the number of transmitted bits during t_{used} .

21. A scheduler according to any of claims 12 - 20, **characterized by** means for determining the scheduling priority as a function of all used scheduling coefficients.

22. A scheduler according to claim 21, **characterized by** means for determining the scheduling priority as a multiplication of all used scheduling coefficients.

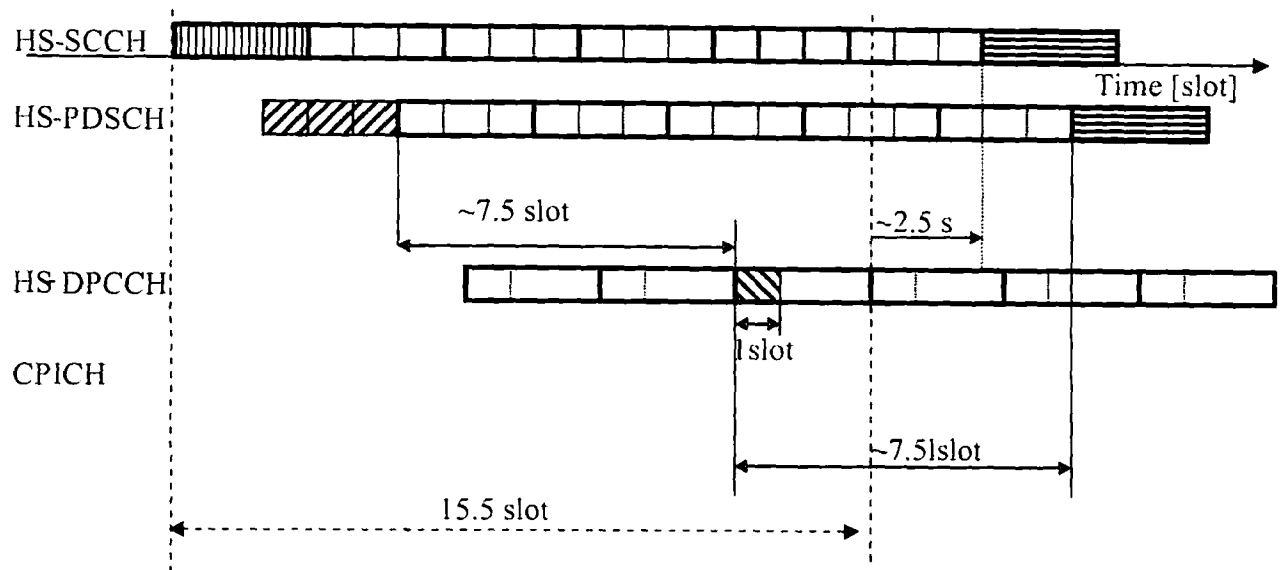


Fig. 1

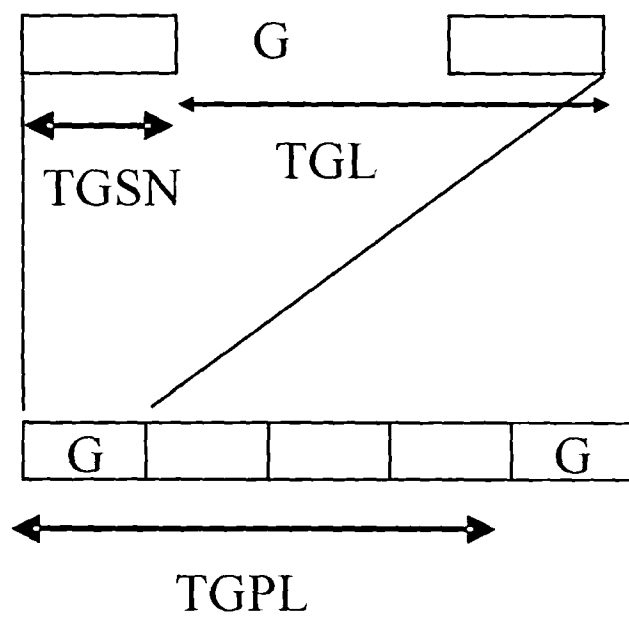


Fig. 2

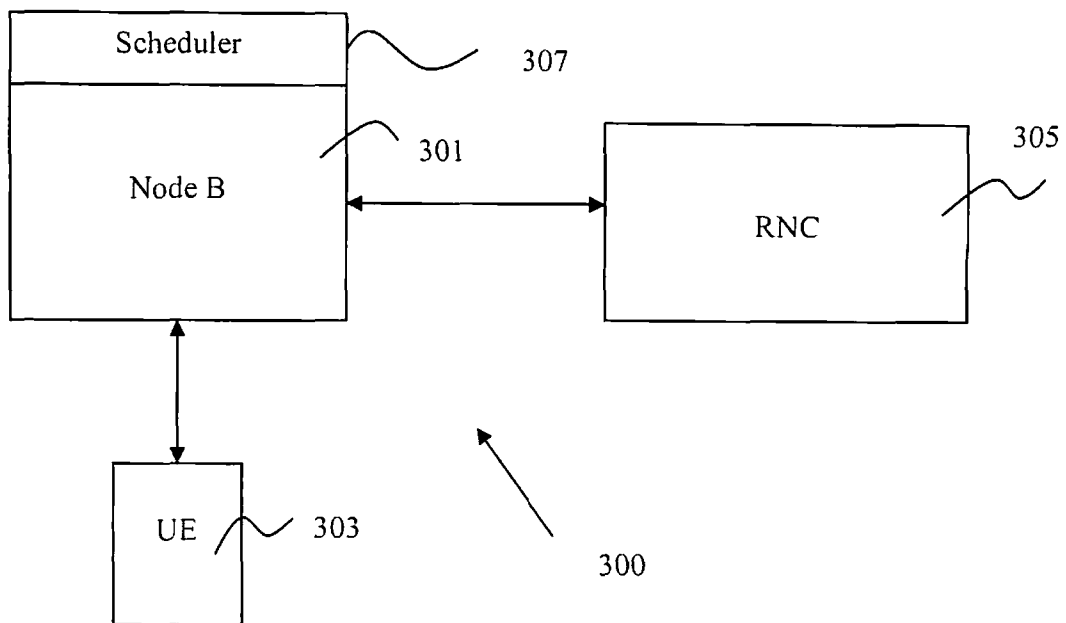


Fig. 3

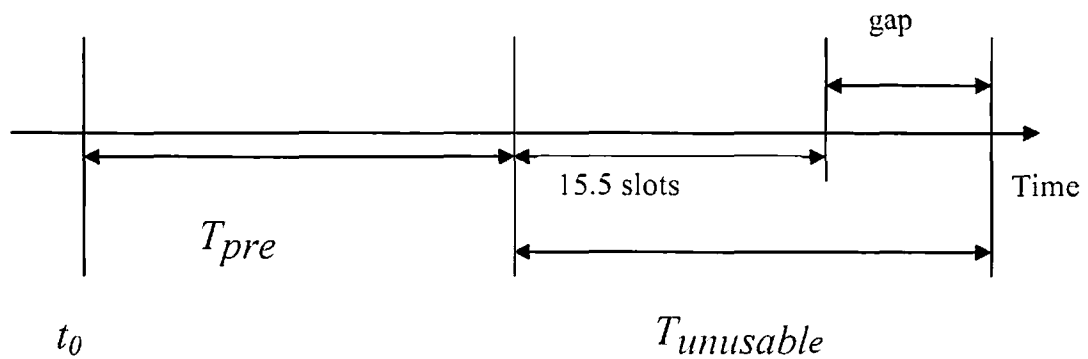


Fig 4

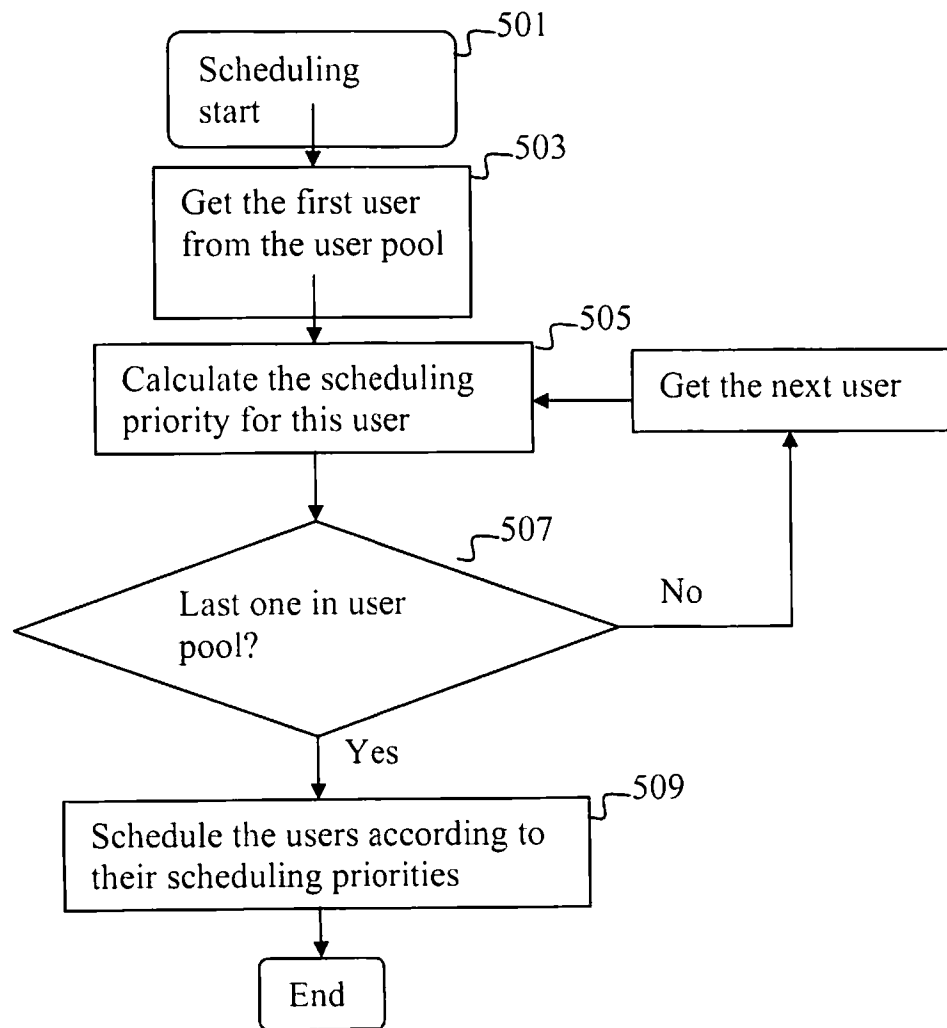


Fig. 5a

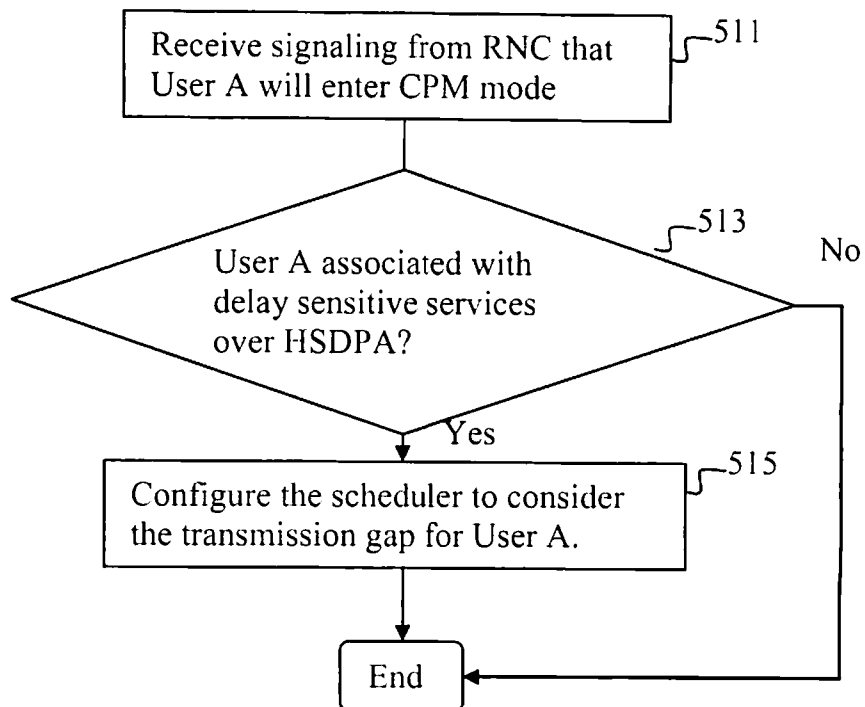


Fig. 5b

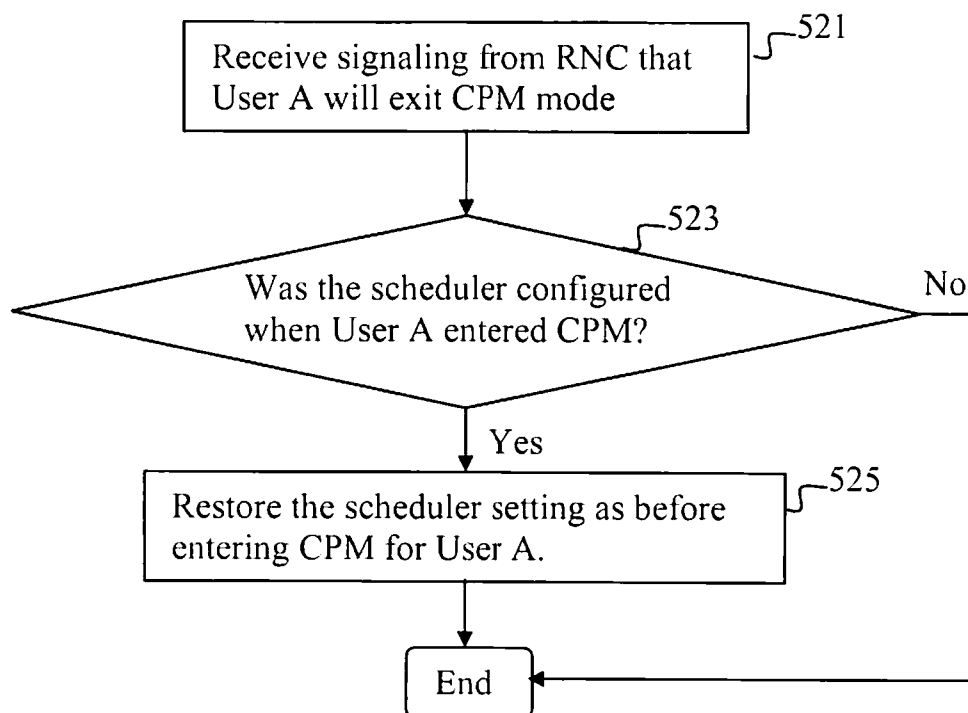


Fig. 5c

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE2006/050577

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04L, H04H, G06F

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

SE,DK,FI,NO classes as above

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

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 0245362 A2 (QUALCOMM INCORPORATED), 6 June 2002 (06.06.2002), page 2, line 1 - line 22; page 3, line 10 - line 23, claims 1-10, abstract --	1-22
A	US 20030012220 A1 (KIM, K.J. ET AL), 16 January 2003 (16.01.2003), paragraphs 0019-0029; claims 1-6 --	1-22
A	WO 03017572 A2 (QUALCOMM INCORPORATED), 27 February 2003 (27.02.2003), claims 1-4, abstract --	1-22

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1549004 A2 (NTT DOCOMO, INC.), 29 June 2005 (29.06.2005), paragraphs 0078-0178 --	1-22
A	US 20050043031 A1 (CHO, S-H. ET AL), 24 February 2005 (24.02.2005), paragraphs 0067-0077 --	1-22
A	US 6084855 A (SOIRINSUO, T. ET AL), 4 July 2000 (04.07.2000), figure 6, abstract -- -----	1-22

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International application No.

PCT/SE2006/050577

WO	0245362	A2	06/06/2002	AU	1779702	A	11/06/2002
				BR	PI0115760	A	02/05/2006
				EP	1410580	A	21/04/2004
				JP	2004537872	T	16/12/2004
				TW	535448	B	01/06/2003
				US	6847629	B	25/01/2005
				US	20020093976	A	18/07/2002
				US	20050129063	A	16/06/2005
US	20030012220	A1	16/01/2003	CN	1263320	C	05/07/2006
				CN	1396778	A	12/02/2003
				KR	2003005898	A	23/01/2003
				KR	20030005898	A	23/01/2003
				US	7245595	B	17/07/2007
WO	03017572	A2	27/02/2003	BR	PI0211950	A	04/04/2006
				CA	2459667	A	27/02/2003
				CN	1326374	C	11/07/2007
				CN	1565109	A	12/01/2005
				CN	1937847	A	28/03/2007
				EP	1417813	A	12/05/2004
				JP	2005500744	T	06/01/2005
				MX	PA04001474	A	08/07/2004
				NO	20041053	A	26/04/2004
				RU	2004107498	A	20/08/2005
				TW	238629	B	21/08/2005
				US	7027392	B	11/04/2006
				US	20030039213	A	27/02/2003
EP	1549004	A2	29/06/2005	CN	1638360	A	13/07/2005
				JP	2005191745	A	14/07/2005
				US	20050163111	A	28/07/2005
US	20050043031	A1	24/02/2005	EP	1508992	A	23/02/2005
				KR	20050020576	A	04/03/2005
US	6084855	A	04/07/2000	WO	0056114	A	21/09/2000
				AU	2838299	A	04/10/2000
				EP	1161851	A	12/12/2001