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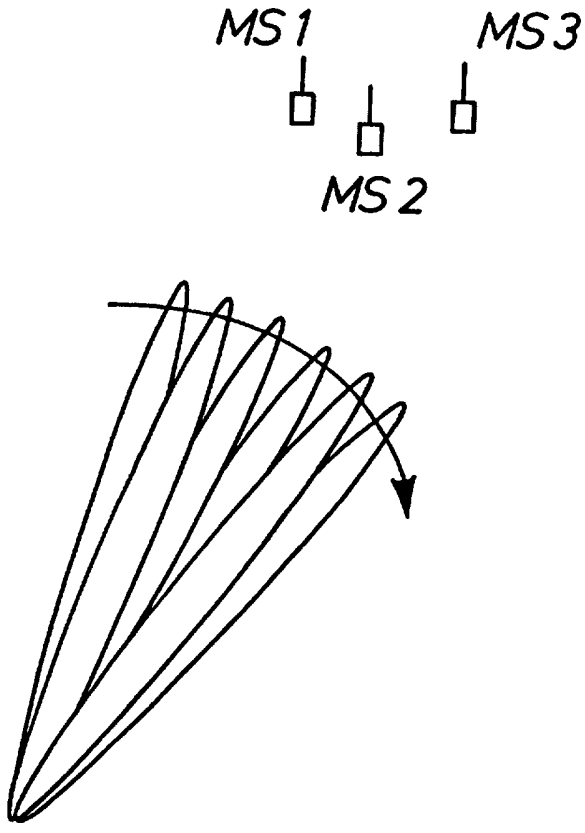
(54) Title: ROTATING LOBE ACCESS METHOD

(57) Abstract

The invention relates to a rotating lobe access method. The invention simplifies making fast and simple initial acquisition, paging, or call set up, both in downlink and uplink in mobile radio (telephone) systems. Thus, the present invention provides a rotating lobe access method in a telecommunication system including at least one base station and a number of mobile stations and having antenna means supporting a number of horizontal lobes for communication between the base station and the mobile stations. Signals to and from the antenna means are modulated by a lobe shaping unit to bring the lobe to rotate in a horizontal plane. Also, rotations or sweeps in different vertical angles are possible. Preferably, the method uses separate transmission and reception lobes and the reception lobe is a delayed replica of the transmission lobe. After achieving synchronisation with the base station transmission lobe, the mobile stations goes into a sleep mode.



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TITLE OF INVENTION: ROTATING LOBE ACCESS METHOD

Field of the invention

The present invention relates to a rotating lobe access method. The main ideas of the invention are in the field of access, paging and call set-up procedures for conventional FDMA and TDMA mobile radio systems such as mobile telephone and PMR (Private Mobile Radio) systems. Another application of the invention is location systems.

The invention simplifies making fast and simple initial acquisition, paging, or call set up, both in downlink and uplink in mobile radio systems. The invention can be used in FDMA and TDMA systems and their hybrids working either in FDD (Frequency Division Duplex) or TDD (Time Division Duplex).

The invention is related to the following patent applications with the same filing date as the present application or to be filed in the near future, having the same owner as the present application and entitled:

METHOD AND ARRANGEMENT OF CONVERTING A CELLULAR TELECOMMUNICATION SYSTEM;
ANTENNA SYSTEM;
ADAPTIVE AIR INTERFACE.

State of the art

Omnidirectional or 120° sector antennas for access and communication are most common today in mobile communication systems. Problem areas are difficulties achieving high sensitivity and/or range. One solution today is using very high power in the base station (BS). However, this may create increased interference levels and low power consumption is generally desired.

The present invention, on the other hand, proposes using a narrow rotating lobe and achieving reply from the mobile station in the same, or somewhat delayed receiving

lobe, resulting in the following advantages:

The suggested method increases sensitivity and/or range and capacity using the narrow lobe system.

The method is power efficient, avoiding high output power from the base station.

The mobile station gives fixed delay + variable delay.

Maximum paging sensitivity is obtained by high antenna gain.

Selective paging, i.e. paging in preferred directions sectors or ranges, enhances capacity, e.g. first transmission in last reported direction. This saves unnecessary emission.

Power control avoids hard capacity limits and will therefore introduce soft degradation.

Standard hardware, as used for conventional methods, can be used.

The actual page time depends on data rate, number of data bits to be transferred.

Paging channels support nominal 600 b/s, but optionally (1/16, 1/8, 1/4, 1/2, 2, 4, 8) × 600 b/s.

The lower data rate, the higher sensitivity is obtained (in principle 3 dB is gained for each reduction of the data rate by a factor 2).

The paging channel is treated similarly to an adaptive air interface, see our above-mentioned patent application.

The invention provides increased sensitivity and less mobile station power and complexity.

No delay equaliser is needed for the paging channel, due to low data rates and narrow lobes.

Summary of the invention

Thus, the present invention provides a rotating lobe access method in a telecommunication system including at least one base station and a number of mobile stations and having antenna means supporting a number of horizontal lobes for communication between the base station and the mobile stations.

In accordance with the invention signals to and from the antenna means are modulated by a lobe shaping unit to bring the lobe to rotate, or appear to rotate, in a horizon-

tal plane. Also, rotations or sweeps in different vertical angles are possible.

In accordance with a preferred embodiment of the invention, the method uses separate transmission and reception lobes and the reception lobe is a delayed replica of the transmission lobe.

In a second aspect of the invention, the mobile station after achieving synchronisation with the base station transmission lobe, goes into a sleep mode.

In a further aspect of the invention, the base station estimates the position of a mobile station by determining the azimuth angle and the distance by timing the time delay of the mobile station reply.

Also, the mobile station is capable of calculating its position using triangulation by listening to at least two base stations for obtaining the azimuth angles and distances to the respective base stations.

Brief description of the drawings

The invention will be described in detail below with reference to the accompanying drawings in which

figure 1 is a schematic view of a rotating lobe as utilised in the present invention, and

figure 2 is state diagram of a sleep mode function having 3 levels in accordance with the invention.

Detailed description of preferred embodiments

The present invention provides an access method using a rotating lobe for the communication between the base station BS and the mobile stations MS. The downlink is carried out in one transmission lobe and the uplink is carried out in the same, or a somewhat delayed, receiving lobe. The mobile station gives fixed delay + variable delay. The fixed delay is set such that the mobile station responds in the correct time slot while the variable delay depends on the distance from the base station to the mobile station.

In the downlink, useful information is obtained from the MS reply, such as horizontal location information (azimuth), paging reply information, and distance information by timing the time delay.

The same idea can be applied in the uplink, in which case the MS access information is repeated in a number of intervals to be certain of hitting the rotating lobe, thereby making communication in the link possible.

In figure 1 a narrow lobe may be seen as rotating in the clockwise direction for communication with three mobile stations MS1, MS2, and MS3. The rotating lobe may be regarded as a continuously swept lobe or a switching between fixed lobes in different directions. Since the different lobes do not interfere with each other, the same frequency may be used, which greatly increases the available frequency spectrum.

The lobe is rotated using the following method. An antenna lobe is created using N antenna elements positioned either in a linear array or any other arrangement i.e. a conformal (non-linear) array. (See e.g. our above-mentioned patent application ANTENNA SYSTEM.)

A rotating lobe is created by using either a set of fixed coefficients which are applied sequentially or continuously variable coefficients. In both cases the varying coefficients bring the lobe to rotate or appear to rotate.

The rotation is performed in clockwise or counterclockwise direction. Also a pseudorandom sweep through all sectors can be performed by hopping through the sectors in pseudorandom order. This may reduce the risk of interference with neighbouring base station coverage areas.

The rotation is implemented by a weighting device called lobe shaping unit (LSU) in which N complex weighting coefficients, N magnitude and N phase weights, are multiplied with a signal going to (or coming in the reverse direction from) each of the N antenna elements. The N complex weighting coefficients are computed with the precondition of low side lobe levels.

The present invention may also support vertical lobes, that is lobes having different vertical angles for reaching different ranges from the base station, for introducing a further diversity or capacity increase.

The lobe forming results in the following properties:

Less C/I (carrier/interference) problem in a narrow lobe;

Less delay spread in a narrow lobe system relative wide broadcast modes;

Support for vertical lobes for different range areas;

Sectored lobe power control introduced resulting in that coverage area can be adapted to various traffic patterns.

In the downlink a quick mobile station location at first access request is obtained, the mobile response giving azimuth angle directly, and coarse distance to the mobile station. The base station may send, every 30th second or more frequently, its co-ordinates and azimuth angle. The mobile station can autonomously determine its position using triangulation by listening to at least two base stations. This is a location function, similar to the global positioning system (GPS).

Also the uplink is scanned, with a delay time td permitted. Lobe gains can be obtained this way and fast uplink acquisition.

Advanced sleep mode with burst duty cycles down to 0.5 ms/30 s is introduced to save battery power and spectrum. Figure 2 shows an example of a state diagram of the sleep mode function in accordance with the present invention. Assume that the mobile initially is in sleep mode. After receiving the first paging or acknowledgement message ACK M_1 which is short, 8-16 bits, the mobile station goes to an intermediate state and expects one or more new paging messages ACK M_2 to reach the final state, that is the session state, in order to receive the message proper. The first message ACK M_1 "awakes groups" of mobile stations, and the succeeding paging messages ACK M_2 completes the paging session. If the mobile station in the intermediate state receives a negative acknowledgement message NACK M_1 or in the final state receives a negative acknowledgement message NACK M_2 , the mobile station returns to the next lower level. The present invention proposes up to five levels of sleep mode states. The following features will be included:

Long delay power saving sleep mode;

Software controlled, 0.2-30 s, sleep time;

Sleep mode factor dependent on measured battery capacity left;

Sleep mode is dependent of the applied paging channel data rate;
Sleep mode listens in at least 3 levels of wake up;
Up to 5 pages sequentially until response is obtained.

Downlink

The paging, access or call set-up message is transferred in a short interval message time t_m . The message time is short compared to the dwell time t_{dw} of the lobe according to the following formulas

$$t_m < t_{dw}$$

$$t_{dw} = t_{sw}/N$$

where

N = number of sectors or lobes

t_{sw} = sweep time (= duration of one revolution)

Example: N = 64, t_{sw} = 480 ms, t_{dw} = 7.5 ms, i.e., t_m < 7.5 ms, t_m < 3.5 ms ($\approx t_{dw}/2$) preferred.

First a number of paging attempts are performed in the latest reported direction of the mobile station. If necessary, then a number of paging attempts are performed in a wider sector encompassing the sector of the latest reported direction. Finally, a paging attempt scanning a full horizontal revolution is performed, if none of the previous attempts are successful. This may be the case when a mobile station has moved outside its sector in sleep mode.

Power reduction in certain selected directions is proposed in order to save power and capacity. This deliberately reduces the coverage area, but reduces the interference in neighbouring areas, and acts as a soft limitation of the calling capacity.

The same frequency can be reused in different directions (sweeping lobes). Hence the capacity is increased.

Uplink

The receiving lobe is a delayed replica of the transmitting lobe. The delay is m lobe widths, or m dwell times, behind the transmitting lobe. The mobile station answering delay is adjusted accordingly.

The uplink is treated in the following fashion: the mobile station receiver duty cycle is low in order to save power. The mobile station listens to the closest base station for a long enough time to get lobe synchronisation timing information. Each mobile station is preferably provided with an internal frequency generator in order to generate a stable clock (± 10 ppm) to maintain the synchronisation. Following this phase, the mobile is ready to receive a message in the correct time slot, t_{dw} , long, of the rotating lobe.

The maximum delay thus created is one revolution, which is of the order of 0.5 s according to the example given above. By using two receivers, each having a separate receiving lobe, the delay will be reduced to half the revolution time.

Hand-off

The mobile station should of course be allowed to move between different lobes of the base station. The present invention provides "hand-off" between its lobes in analogy with hand-off between separate base stations. The invention proposes two kinds of hand-off (HO) schemes:

Hard Hand-Off (HHO) or hard sector hand-off, meaning HO to a new frequency when entering an adjacent sector. Conventional criteria such as signal strength, signal to interference, bit error rate (BER) are used;

Soft Sector Hand-Off (SSHO), meaning that the base station is switched to the new sector, if possible. In other words, this means that the base station frequency follows the moving mobile station. The scheme works only if the frequency to be switched over to the new sector is not used in that sector. If the frequency is not available a HHO is performed.

Thus, the present invention provides a rotating lobe access method having the advantages as stated above. The invention is only limited by the claims below.

CLAIMS

1. Rotating lobe access method in a telecommunication system including at least one base station and a number of mobile stations and having antenna means supporting a number of horizontal lobes for communication between the base station and the mobile stations, **characterised in** that signals to and from the antenna means are modulated by a lobe shaping unit to bring the lobe to rotate, or appear to rotate, in a horizontal plane.

2. Method according to claim 1, **characterised in** that the signals to and from the antenna means are multiplied by N complex weighting coefficients to create different lobes.

3. Method according to claim 1 or 2, **characterised in** that each lobe has a dwell time t_{dw} and a paging, access or call set-up message is transmitted in a message time t_m ,the duration of the message time being short compared to the dwell time, i.e. $t_m < t_{dw}$,and preferably $t_m <$ approx. $t_{dw}/2$.

4. Method according to claim 2, **characterised in** that fixed weighting coefficients are applied sequentially to the signals to and from the antenna means.

5. Method according to claim 2, **characterised in** that continuously variable weighting coefficients are applied sequentially to the signals to and from the antenna means.

6. Method in accordance with any one of claims 1 to 5, **characterised in** that the lobes are brought to rotate in a clockwise or counterclockwise direction.

7. Method in accordance with any one of claims 1 to 5, **characterised in** that the lobes are brought to sweep a revolution by hopping through sectors in a pseudorandom order.

8. Method in accordance with any one of the previous claims, **characterised in** that the antenna means supports at least two vertical lobes.

9. Method according to claim 8, **characterised in** that the antenna means supports an upper and a lower lobe, wherein the upper and lower lobes are swept successively in each sector.

10. Method in accordance with any one of the previous claims, characterised by using separate transmission and reception lobes.

11. Method according to claim 10, **characterised in** that

the reception lobe is a delayed replica of the transmission lobe.

12. Method in accordance with any one of the previous claims, **characterised in** that the mobile station after achieving synchronisation with the base station transmission lobe, goes into a sleep mode.

13. Method according to claim 12, **characterised in** that the mobile station keeps an internal clock for maintaining the synchronisation and only listens to the base station during the interval in which the base station transmission lobe is transmitted in the direction of the mobile station.

14. Method in accordance with any one of claims 12 or 13, **characterised in** that the sleep mode has at least three wake up levels, wherein the mobile station in the deepest level listens for group wake up calls, in the next level listens for an individual wake up call, and in the highest level listens to the message proper.

15. Method in accordance with any one of claims 12 or 14, **characterised in** that the sleep mode is dependent of the battery power remaining in the mobile station.

16. Method in accordance with any one of the previous claims, **characterised in** that the base station estimates the position of a mobile station by determining the azimuth angle and the distance by timing the time delay of the mobile station reply.

17. Method in accordance with any one of the previous claims, **characterised in** that a mobile station calculates its position using triangulation by listening to at least two base stations for obtaining the azimuth angles and distances to the respective base stations.

18. Method in accordance with any one of the previous claims, **characterised in** that paging directed to a mobile station is first performed in the latest reported direction of the mobile station.

19. Method according to claim 18, **characterised in** that first a number of paging attempts is performed in the latest reported direction of the mobile station, and if necessary, then a number of paging attempts is performed in a wider sector encompassing the sector of the latest reported direction, and if necessary, a paging attempt scanning a full

horizontal revolution is performed.

20. Method in accordance with any one of the previous claims, **characterised in** that the power emitted in each lobe of the base station is controlled to control the shape of the base station coverage area.

21. Method in accordance with any one of the previous claims, **characterised in** that paging channels support a variable data rate.

22. Method in accordance with any one of the previous claims, **characterised in** that, when a mobile station moves between different lobes of the base station, a hand-off between the lobes of the base station is performed.

23. Method according to claim 22, **characterised in** that the base station frequency follows the mobile station, if the frequency is not in used in the new sector.

24. Method according to claim 22, **characterised in** that the base station switches to a new frequency for the mobile station in the new sector.

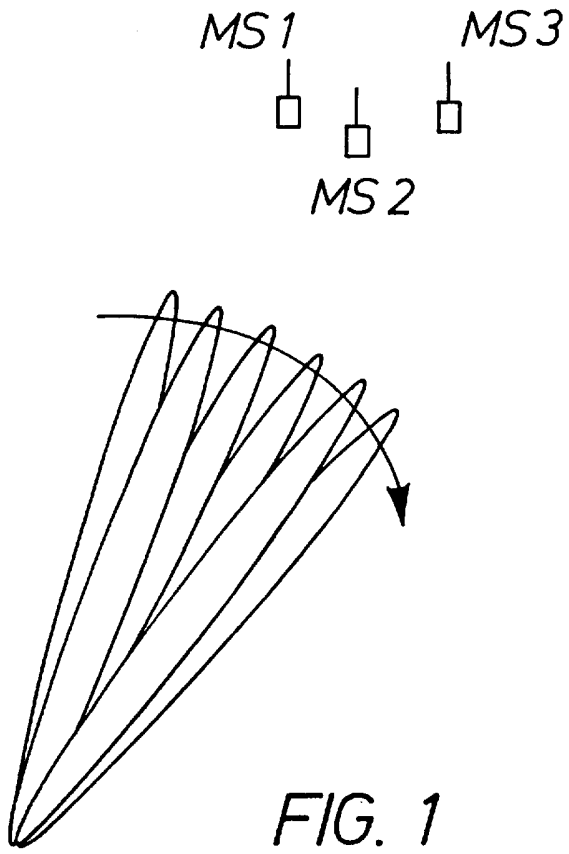
MS 1
MS 3
MS 2

FIG. 1

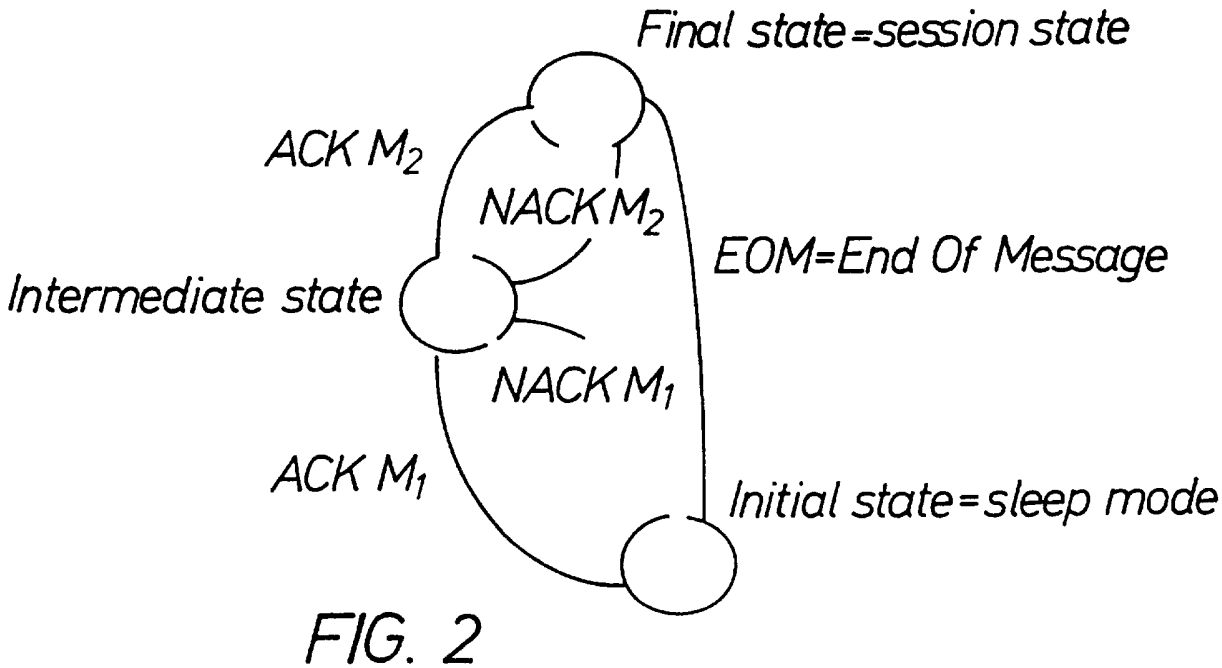
Final state=session state
ACK M_2
NACK M_2
EOM=End Of Message
Intermediate state
NACK M_1
ACK M_1
Initial state=sleep mode

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00502

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04Q 7/36, H04Q 7/38
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)

IPC6: H04Q

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5448753 A (KARL-AXEL AHL ET AL), 5 Sept 1995 (05.09.95)	1,3,6-11,20
Y	column 2, line 60 - column 4, line 10; column 4, line 23 - line 35, column 5, line 22 - line 26; column 5, line 46 - column 6, line 2; column 7 line 15 - line 18, fig. 10,18	2,4,5,12,13, 16-19,22-24
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X	US 5488737 A (STEVEN A. HARBIN ET AL), 30 January 1996 (30.01.96)	1
Y	column 3, line 26 - line 39; column 4, line 41 - line 48, figures 1a,2, abstract	12,13,16,17
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
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"P" document published prior to the international filing date but later than the priority date claimed
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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
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 July 1997	12 -07- 1997
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Peter Hedman Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00502

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB 2266998 A (MOTOROLA INC.), 17 November 1993 (17.11.93), figure 2, abstract	2,4,5
Y	WO 9323965 A1 (TELEFONAKTIEBOLAGET LM ERICSSON), 25 November 1993 (25.11.93), figure 2, abstract	18,19
Y	WO 9600484 A1 (TELEFONAKTIEBOLAGET LM ERICSSON), 4 January 1996 (04.01.96), page 3, line 11 - line 18; page 4, line 23 - page 5, line 2	22-24
Y	GB 2260050 A (NEC CORPORATION), 31 March 1993 (31.03.93), figure 1, abstract	16,17
Y	US 5109530 A (ROBERT E. STENGEL), 28 April 1992 (28.04.92), see whole document	12
Y	EP 0499440 A2 (NOKIA MOBILE PHONES LTD.), 19 August 1992 (19.08.92), column 1, line 38 - column 2, line 2; column 3, line 4 - line 8, abstract	12,13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00502

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 21
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

Neither the description, nor the claim, comprise a description on how the mentioned paging channels are supposed to be supporting a variable data rate.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

01/07/97

International application No.
PCT/SE 97/00502

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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