

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
8 February 2001 (08.02.2001)

PCT

(10) International Publication Number
WO 01/10155 A1

(51) International Patent Classification⁷: **H04Q 7/36,**
H04B 7/26

(IT). **PAROLARI, Sergio** [IT/IT]; Via Canaletto, 14,
I-20133 Milano (IT).

(21) International Application Number: PCT/EP00/07119

(74) Agent: **GIUSTINI, Delio**; Siemens Information and Com-
munication Networks S.p.A., Cascina Castelletto, I-20019
Settimo Milanese (IT).

(22) International Filing Date: 24 July 2000 (24.07.2000)

(25) Filing Language:

English

(81) Designated States (*national*): CA, CN, JP, US.

(26) Publication Language:

English

(84) Designated States (*regional*): European patent (AT, BE,
CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC,
NL, PT, SE).

(30) Priority Data:

MI99A001710

30 July 1999 (30.07.1999) IT

(71) Applicant (*for all designated States except US*):
**SIEMENS INFORMATION AND COMMUNI-
CATION NETWORKS S.P.A.** [IT/IT]; Viale Piero e
Alberto Pirelli, 10, I-20126 Milano (IT).

Published:

— With international search report.

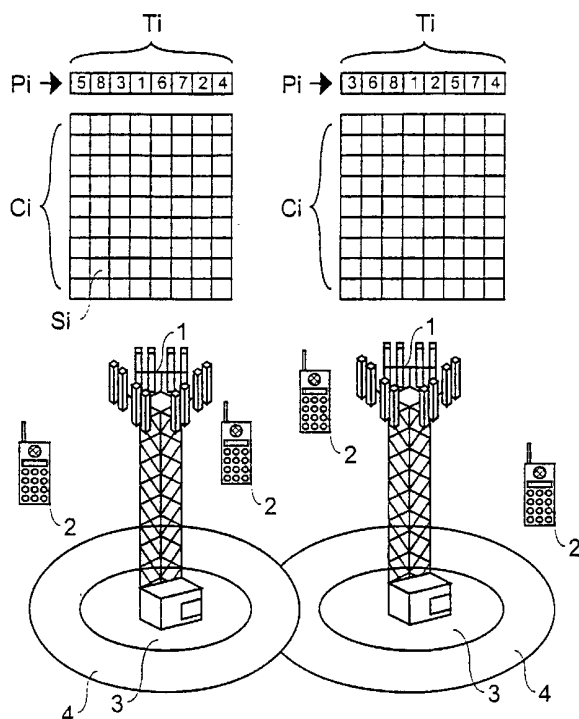
— Before the expiration of the time limit for amending the
claims and to be republished in the event of receipt of
amendments.

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **MARGHERITA,**
Fulvio [IT/IT]; Via Giacomo Puccini, 18, I-80127 Napoli

*For two-letter codes and other abbreviations, refer to the "Guid-
ance Notes on Codes and Abbreviations" appearing at the begin-
ning of each regular issue of the PCT Gazette.*

(54) Title: METHOD AND SYSTEM FOR DYNAMIC ALLOCATION OF RADIO CHANNELS IN DIGITAL TELECOMMU-
NICATION NETWORKS



(57) Abstract: Method for the dynamic allocation of radio channels (Ci) in digital telecommunication networks with time division duplex access, whose radio signals are divided into frames having pre-determined duration and each frame is subdivided into a pre-determined number of time intervals (Ti) which are assigned priority values (Pi) based on measures of channel interference and/or quality (Ci), each communication service (Sx) employing a particular number (Rx) of said channels (Ci) at a time. This method includes at least a measurement of the signal attenuation (PLx) with which said communication service (Sx) has been requested, as well as the allocation of said number (Rx) of channels (Ci) of the communication service (Sx) in a time interval (Tx) having an increasing priority value (Pi) with the attenuation (PLx) of the relevant signal, in order that the services employing said number (Rx) of channels (Ci) are allocated in time intervals (Ti) having increasing priority values (Pi) with the attenuation of the relevant signal.

WO 01/10155 A1

METHOD AND SYSTEM FOR DYNAMIC ALLOCATION OF RADIO CHANNELS IN DIGITAL TELECOMMUNICATION NETWORKS

5 Field of the Invention

The present invention relates to a method for the dynamic allocation of radio channels in digital telecommunication networks, in particular with time division duplex access or TDD (*Time Division Duplex*), such as for instance mobile telecommunication networks belonging to DECT or UTMS-TDD standards. The present invention relates also to a system implementing this method.

10 It is well known that in mobile telecommunication networks with TDD access, the transmission and reception of radio signals from and to the base stations do not occur at the same time, but are alternated in a continuous sequence of periods having pre-determined duration, each of them called *frame* and opportunely coded and identified by the system. In particular, each frame is divided into a pre-determined number of time intervals or *timeslots*, they too having pre-determined duration, part of which is destined to transmission and part to the reception of the signals from base station to user equipment. Each one of these timeslots can also be subdivided into a plurality of *codes* representing the elementary resources (channels) assigned in the communication.

20 At each communication service between a mobile unit and a base station one or more channels of a particular time slot are generally assigned, which contains at most N_{max} channels, according to the requested transmission speed.

Background art

25 The selection of said timeslot is made through a dynamic channel allocation procedure based on priority values P_i calculated for each timeslot. In this procedure disclosed in the article by Y. Furuya and Y. Akaiwa under the title "Channel Segregation, A distributed Adaptive Channel Allocation Scheme for Mobile Communication Systems", Second Nordic Seminar on digital Land Mobile Radio Communication, 14-16 October 1986", pp 311-315, the control processor of the base station performs at each service request, a calculation of the priority values P_i on the basis of interference and/or quality measures of the channels, so that the timeslots available for the allocation of channels result only those whose priority value is higher than a given pre-set threshold value P_t . The calculation of priority values P_i of each

timeslot after k service requests is generally made through the following iterative formula:

$$Pi(k) = \frac{Ns_i(k)}{k} = \frac{\sum_{a=1}^k s_i(a)}{k} = \frac{k-1}{k} Pi(k-1) + \frac{s_i(k)}{k};$$

where k is the number of connection service requests from the moment of system starting, $Ns_i(k)$ is the number of successful connections and $s_i(k)$ is a logic function returning 0 or 1 on the basis of the negative or positive result of the connection, respectively.

Observing such formula, it can be noticed that at starting, with small k values, the calculation of priority values very quickly adapts to the network characteristics, but results slowed when k values increase, therefore the above mentioned method known for the allocation of channels shows a high risk for connection losses in case the network traffic distribution suddenly changes, for instance when number of connection service requests occur, concentrated in time.

Summary and scope of the Invention

Object of the present invention is therefore that to give a method for the dynamic allocation of channels which is free from this drawback, as well as a system implementing this method. Said object is attained with a method and a system whose main characteristics are specified in claims 1 and 12, respectively, while additional characteristics which are believed to be novel are specified in the appended claims.

The method according to the present invention results much more rapid than the known methods, since a partial re-ordering of channels allocated in the different timeslots is made, that is, at each service requests, only the services employing the same number of channels of the requested service are re-ordered.

Moreover, the quality of channels allocated through the method according to the present invention is generally bettered compared to that of the channels allocated through the known methods. In fact, at equal number of allocated channels, the services with signals having high attenuation values or *pathloss* are allocated in timeslots having high priority values, so that the allocated channels can be shared in the different timeslots in the best way according to the quality of the relevant signals.

Another advantage of the method according to the present invention is represented by the use of a new kind of formula for the calculation of priority values which, contrarily to the above mentioned formula of the known type, enables to

discretionary adjust the system adaptation speed to the contingent situation of the network traffic, that is to the interference and/or quality variations of the channels.

A further advantage of the method according to the present invention is represented by the fact that said allocation and release algorithms can be structured in such a way to give preference, if necessary, to the services employing a low or high number of channels.

Brief description of figures

The present invention together with further advantages and characteristics thereof may be understood by those skilled in the art making reference to the following detailed description taken in conjunction with the accompanying drawings in which:

- figure 1 shows a partial block diagram of a system implementing the method according to the present invention;
- figure 2 shows a flow chart of an allocation algorithm of an embodiment of the method according to the present invention; and
- figure 3 shows a flow chart of a release algorithm of an embodiment of the method according to the present invention.

Detailed description of a preferred embodiment of the Invention

Making reference to figure 1, it can be noticed that a system implementing the method according to the present invention includes in a known way, a plurality of base stations 1 belonging to a digital telecommunication network with time division duplex access, such as for instance a mobile telecommunication network belonging to the UTMS standard, which communicate through radio signals with a plurality of user equipment 2. One or more channels C_i of a timeslot T_i are generally assigned to each communication service S_i made by base stations 1 (only 8 timeslots T_i of communications originated by the user equipment 2 are shown in the figure, for representation simplicity). Furthermore, a univocal priority value P_i is assigned to each timeslot T_i which, however, can vary in time according to the result of a known formula of the type described above or of a new formula which shall be described here after. Said priority values P_i are based on interference and/or quality measures of communication channels C_i between base stations 1 and user equipment 2.

According to a preferred embodiment of the invention the interference and/or quality measures of channels are made measuring the "path loss", that is the attenuation of the signal transmitted by the user equipment 2. According to the invention, the communications with higher path loss are allocated in timeslots with

higher priority P_i , that is in channels capable of ensuring a better transmission quality. On the contrary, communications with lower "path loss" are allocated in timeslots with lower priority P_i , that is in channels capable of ensuring a lower quality.

5 Tentatively said situation has been represented in figure 1 where for each station 1 a first coverage area 3 and a second coverage area 4 are represented. In figure 1 it is assumed that users located in the coverage area 4 are more distant from the relevant base station 1 and therefore communications shall be reasonably characterised by a higher "path loss" (they shall therefore be assigned a timeslot having higher priority P_i), while the users in coverage area 3 are closer to the relevant
10 base station 1 and therefore their communications shall be reasonably characterised by a lower "path loss" (they shall therefore be assigned a timeslot having lower priority P_i).

Now, making reference also to figure 2, we notice that an embodiment of the method according to the present invention includes an allocation algorithm, which is
15 started for instance on the moment a mobile unit 2 requests a service S_x requiring the use of a given number R_x of channels C_i to a base station 1. The base station 1 measures the level and therefore the path loss PL_x of the signal with which the mobile unit 2 has requested said service S_x on the receipt channel. On the basis of the path loss measured value PL_x , the base station 1 attempts to allocate the R_x channels C_i in
20 the timeslot having an increasing priority value P_i with the same attenuation PL_x , in order that user equipment 2 transmitting signals having a high path loss use timeslots having a high priority value.

To this purpose, it is searched, starting from timeslots having higher priority values P_i , a timeslot T_x having R_x free channels C_i . If said timeslot T_x does not exist,
25 the base station 1 refuses the requested service S_x to the mobile unit 2. If on the contrary said timeslot T_x is found, the base station 1 searches, if existing, a timeslot where at least a service employing R_x channels C_i is allocated among the timeslots with priority value P_i higher than that of the timeslot T_x . This search is made through a scanning based on a variable T cyclically decreased by one unit. If the variable T is
30 zeroed, the requested service S_x is allocated in the timeslot T_x . If on the contrary a timeslot T is found where at least a service with R_x channels C_i is allocated a search is made among all the services employing R_x channels C_i and are in the same timeslot T , the service S_y showing the lower path loss PL_m . At this point, the base station 1 compares the value of the lower path loss PL_m found with that of the PL_x path loss of

the signal with which the mobile unit 2 has requested the service S_x to base station 1. If the PL_x path loss value is lower than that of the PL_m path loss, the requested service S_x is allocated in the timeslot T_x having Rx free channels C_i , otherwise it is allocated in the same the service S_y employing Rx channels C_i and showing the PL_m path loss. In this last case, since a service having Rx channels C_i in the timeslot T got free, the algorithm described up to now is reiterated starting from this last timeslot, which is then identified as timeslot T_x in the reiteration of the algorithm itself, that is $T_x = T$.

When the service S_x is released, for instance after the interruption of a communication between mobile unit 2 and base station 1 or due to the transfer of a communication between two base stations 1, it is possible to employ a release algorithm of essentially inverse type compared to the one described above to free the timeslots T_i with low priority values P_i .

Making reference to figure 3, we see that an embodiment of the method according to the present invention includes a release algorithm, which is started for instance on the moment at which a service S_x employing Rx channels C_i is released by a timeslot T_x . The base station 1 attempts therefore to allocate the Rx free channels C_i to a service S_y employing Rx channels C_i in the timeslot having the highest priority value P_i among those having lower priority value compared to that of the timeslot T_x . To this purpose, the base station 1 searches, if existing, a timeslot where at least a service employing Rx channels C_i is allocated, among the timeslots with priority value P_i lower than that of the timeslot T_x . This search is made through a scanning based on a variable T cyclically decreased by one unit. If said timeslot T is found, the service S_y characterised by the highest path loss amongst all the services employing Rx channels C_i in timeslot T is allocated in the timeslot T_x . In this last case, since a service having Rx channels C_i in the timeslot T has got free, the algorithm described up to now is reiterated starting from this last timeslot, which is then identified as timeslot T_x in the reiteration of the algorithm itself, that is $T_x = T$.

If the variable T is reset, the search can be terminated or, a service S_y employing a number of channels C_i lower than Rx newly searched among all the timeslots with a priority value P_i lower than that of the last timeslot T_x released. Said research is made through an additional scanning based on a variable R cyclically decreased by one unit. Once this last variable is reset, the algorithm is terminated.

Other embodiments of the method according to the present invention can possibly include variants of said release algorithm, always started on the moment on

which a service S_x employing R_x channels C_i is released by a timeslot T_x . For instance, instead of searching first the services S_y employing R_x channels C_i among all the timeslots having a priority value P_i lower than that of the timeslot T_x , to pass then to the search of services S_y employing a number of channels C_i lower than R_x always
 5 among all the same timeslots, it is possible to search the service S_y characterised by the maximum attenuation employing a number of channels C_i equal to or even lower than R_x in all the timeslots having lower priority value P_i compared to that of the timeslot T_x . With this algorithm, active services can therefore be reordered according to PLx attenuation values and increasing priority P_i values, irrespective of the number of
 10 channels C_i they employ.

At each allocation and/or release of a service, the priority values P_i assigned to the timeslots T_i can be recalculated. In place of the known algorithm based on the formula

$$P_i(k) = \frac{k-1}{k} P_i(k-1) + \frac{s_i(k)}{k},$$

15 in another embodiment of the method according to the present invention it is possible to employ the following formula in which the past experience $P_i(k-1)$ and the current situation $s_i(k)$ maintain a constant weight during the time:

$$P_i(k) = \lambda P_i(k-1) + (1-\lambda)s_i(k),$$

,where λ is a memory factor included between 0 and 1, which can be freely selected according to the weight one wants to assign to the past experience or to the
 20 contingent situation. It is therefore clear that if λ tends to 0 or to 1, the priority values P_i vary in a quicker or lower way, respectively, depending on the interference and/or quality measures of channels C_i by the base station 1.

A further development of this other embodiment can consist in calculating $s_i(k)$ not on the basis of the simple statistics of the successful connections compared to total
 25 connections, but on the basis of the following formula:

$$s_i(k) = \frac{N_{free_i}(k)}{N_{max} - N_{used_i}(k)};$$

in which $N_{free_i}(k)$ is the number of channels C_i which can be allocated with a good quality in timeslot i , N_{max} is the maximum number of channels (or codes) available per timeslot and $N_{used_i}(k)$ is the number of channels currently already allocated in the
 30 timeslot i .

Other embodiments and/or additions of the present invention may be made by those skilled in the art without departing from the scope thereof.

CLAIMS

1. Method for the dynamic allocation of radio channels (Ci) in digital telecommunication networks with time division duplex access, in which radio signals are divided into frames having a pre-determined duration and each frame is divided into a pre-determined number of timeslots (Ti) which are assigned priority values (Pi) based on interference and/or quality measures of channels (Ci), each communication service (Sx) employing a particular number (Rx) of said channels (Ci) at a time, characterized in that it includes the following operational steps:
 - 5
 - 10
 - 15
 - 20
 - 25
 - 30
2. Method according to the previous claim, characterized in that at each request for a communication service (Sx) the services employing the same number (Rx) of channels (Ci) of the requested service (Sx) are reordered in such a way that the attenuation (PLx) increases with priority values (Pi).
3. Method according to one of the previous claims, characterized in that it includes an allocation algorithm including the following operational steps:
 - 25
 - 30

4. Method according to the previous claim, characterized in that said algorithm is reiterated according to the result of said comparison between the attenuation values of the signals of the requested communication service (Sx) and of the communication service (Sy) found with this search.
- 5 5. Method according to claim 3 or 4, characterized in that it is searched, starting from timeslots with priority values (Pi) higher than that of the timeslot (Tx) found with this first search, the communication service (Sy) whose signals show the lower attenuation (PLm) among the communication services having the same number (Rx) of channels (Ci) allocated in the same timeslot (Tx).
- 10 6. Method according to one of the previous claims, characterized in that at each release of a communication service (Sx) are reordered according to increasing priority values (Pi) the services employing the same number (Rx) of channels (Ci) of the service released (Sx).
7. Method according to the previous claim, characterized in that it includes a release
15 algorithm including the following operational steps:
 - searching, among the timeslots with priority values (Pi) lower than that of the timeslot (Tx) of the released service (Sx), a timeslot (T) in which at least a communication service having the same number (Rx) of channels (Ci) of the communication service released (Sx) is allocated;
 - 20 - allocating in the timeslot (Tx) of the released communication service (Sx) the communication service (Sy) characterised by the highest attenuation among all the services employing Rx channels (Ci) in the timeslot (T) found with this research.
8. Method according to the previous claim, characterized in that it includes a release
25 algorithm including the following additional operational steps:
 - searching, among the timeslots with priority values (Pi) lower than that of the timeslot (Tx) of the released communication service (Sx), a timeslot (T) in which at least a communication service employing a number of channels (Ci) lower than that of the communication service released (Sx) is allocated;
 - 30 - allocating in the timeslot (Tx) of the released communication service (Sx) the communication service (Sy) characterised by a higher attenuation amongst all the services employing a number of channels (Ci) lower than that of the communication service released (Sx) and which are allocated in the timeslot (T) found with this search.

9. Method according to claim 7 or 8, characterised in that said algorithm is reiterated starting from the timeslot of the last communication service released (Sy).

10. Method according to one of the previous claims, characterized in that at each allocation and/or release of a service, the priority values (Pi) assigned to the timeslots (Ti) are re-calculated on the basis of the following formula:

$$Pi(k) = \lambda Pi(k-1) + (1-\lambda) s_i(k),$$

where k is the instant at which the service is allocated or released, $s_i(k)$ is a logic function returning a number between 0 and 1 on the basis of the negative or positive result, respectively, of these requests for connection services and λ is a memory factor included between 0 and 1.

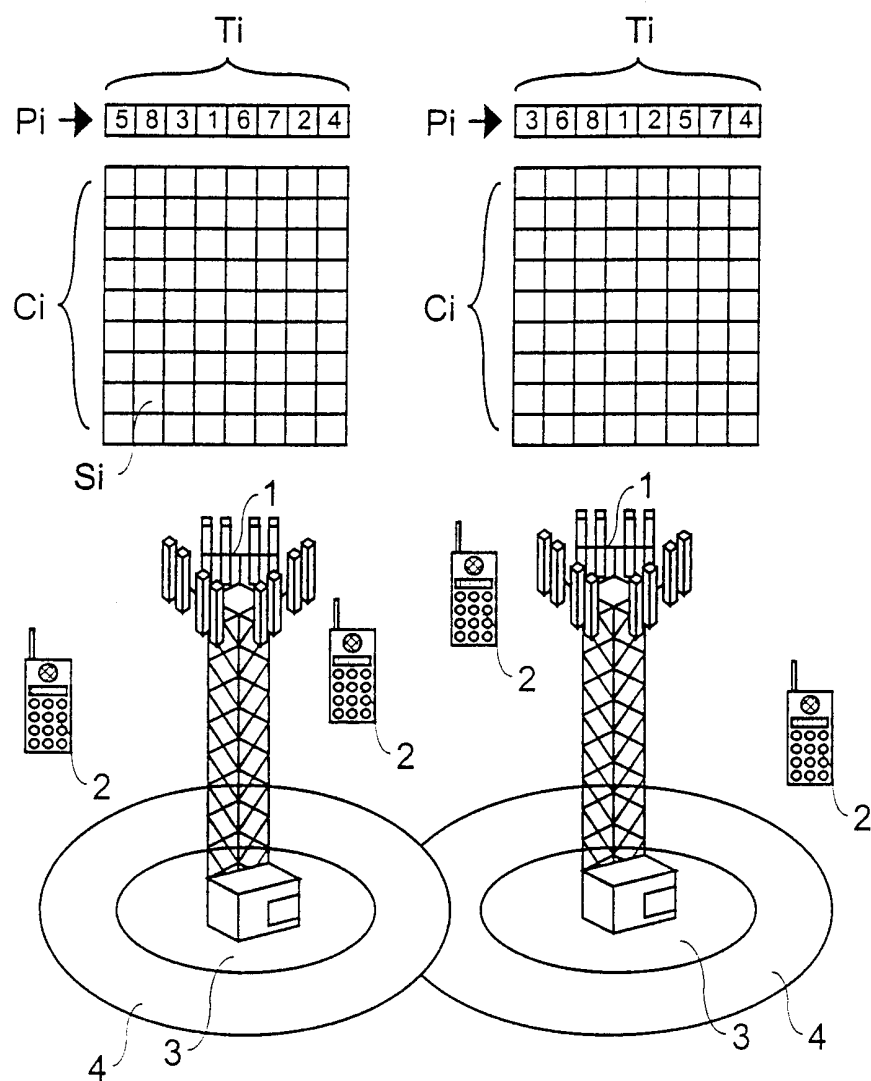
11. Method according to the previous claim, characterized in that $s_i(k)$ is defined by the following formula:

$$s_i(k) = \frac{N_{free_i}(k)}{N_{max} - N_{used_i}(k)};$$

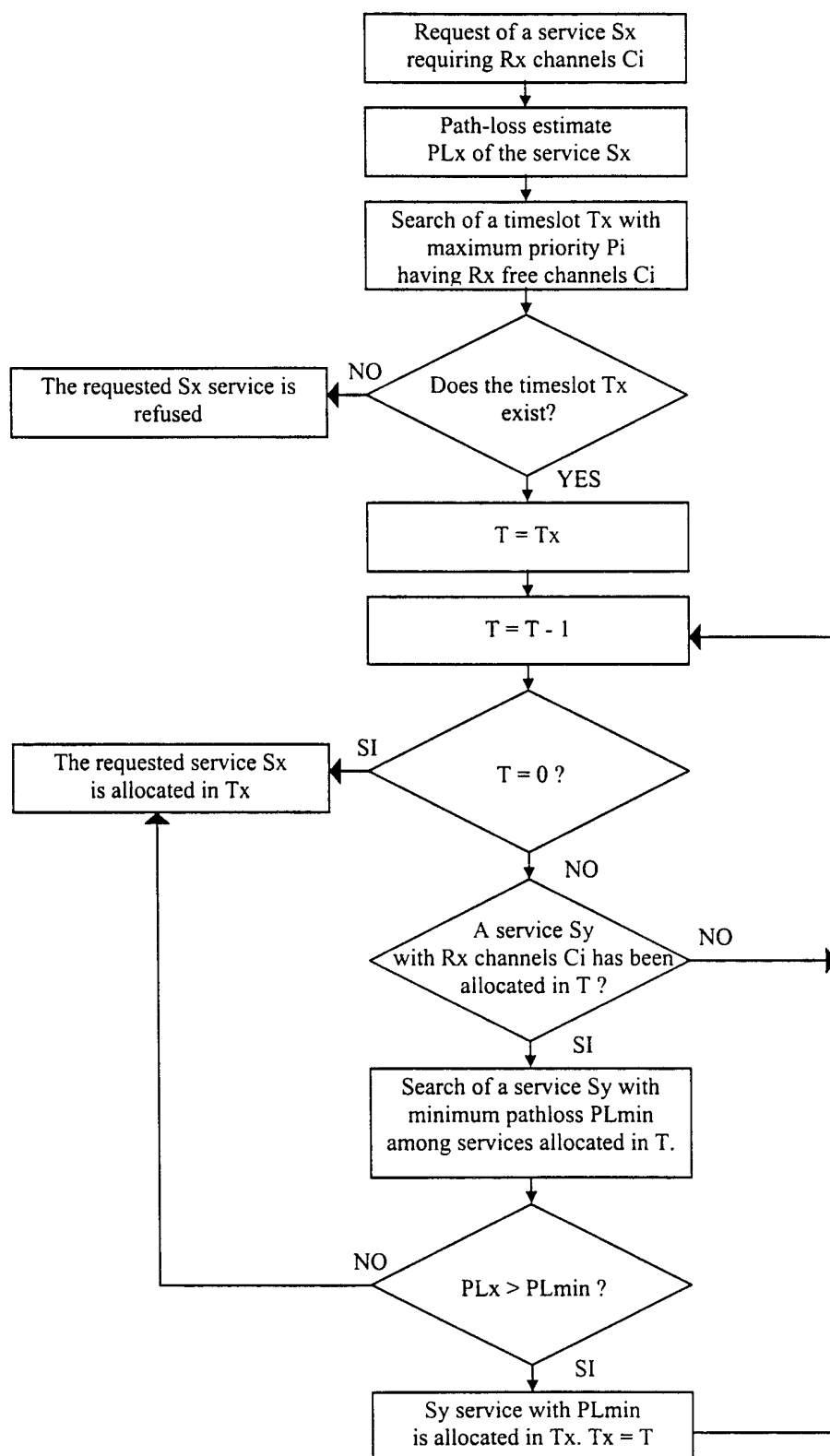
in which $N_{free_i}(k)$ is the number of channels Ci that can be allocated with a good quality in the timeslot i, N_{max} is the maximum number of channels (or codes) available for each timeslot and $N_{used_i}(k)$ is the number of channels presently already allocated in timeslot i.

12. System for the dynamic allocation of radio channels (Ci) in digital telecommunication networks with time division duplex access, in which radio signals are divided in frames having pre-determined duration and each frame is divided into a pre-determined number of timeslots (Ti) which are assigned priority values (Pi) based on interference and/or quality measures of channels (Ci), each communication service (Sx) employing a particular number (Rx) of said channels (Ci) at a time, characterized in that at least one base station (1) for the reception and transmission of radio signals to a plurality of user equipment (2) includes means for the measurement of the path loss (PLx) of the signal with which said communication service (Sx) has been requested, as well as a control processor suitable to implement the method according to one of the previous claims.

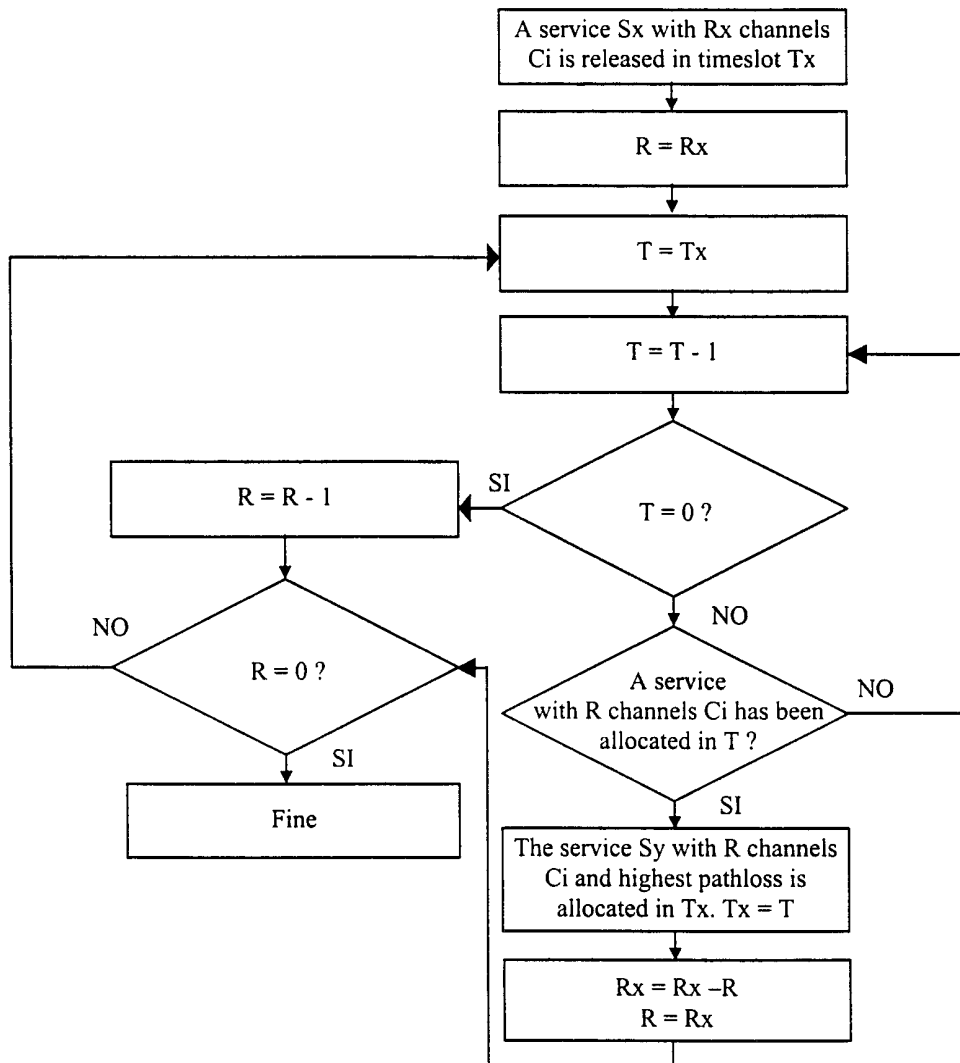
1/3

***Fig. 1***

2/3

**Fig. 2**

3/3

***Fig. 3***

INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 00/07119

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/36 H04B7/26

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 7 H04Q 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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 98 59517 A (TELEFONAKTIEBOLAGET LM ERICSSON) 30 December 1998 (1998-12-30) page 3, line 23 -page 9, line 22 ---	1,12
A	EP 0 876 008 A (SIEMENS AKTIENGESELLSCHAFT) 4 November 1998 (1998-11-04) column 3, line 7 - line 15 column 4, line 51 -column 5, line 37 column 6, line 42 - line 58 ---	1,12
A	WO 98 24258 A (TELEFONAKTIEBOLAGET LM ERICSSON) 4 June 1998 (1998-06-04) page 16, line 21 -page 27, line 21 -----	1,12

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in 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* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *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

13 December 2000

Date of mailing of the international search report

20/12/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Behringer, L.V.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 00/07119

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9859517 A	30-12-1998	AU 7948698 A CN 1268279 T EP 0976290 A	04-01-1999 27-09-2000 02-02-2000
EP 0876008 A	04-11-1998	NONE	
WO 9824258 A	04-06-1998	US 5956642 A AU 724424 B AU 5142898 A BR 9713290 A CN 1245623 A EP 0941625 A HU 0000424 A	21-09-1999 21-09-2000 22-06-1998 26-10-1999 23-02-2000 15-09-1999 28-06-2000