

DESCRIPTION**ROAMING IN TELECOMMUNICATIONS SYSTEMS****5 Technical Field**

The present invention relates to roaming in telecommunications systems, particularly but not exclusively, in digital paging systems.

Background Art

10 In the case of single operator, single frequency paging system, a large radio coverage area is divided into a plurality of sub-areas and a subscriber can elect the or those sub-areas in which he/she wants to be paged, a charge being made for each sub-area. Accordingly a subscriber knows in advance in which sub-areas he/she is contactable when roaming. When two
15 or more independent operators are using a single channel then it may be necessary for an operator to include some form of operator identifier in a paging signal so that a subscriber registered with one operator can distinguish a paging signal being addressed to his/her terminal from a signal being sent to a similarly addressed subscriber unit belonging to another
20 system. The transmission of an operator identity can also be used by a pager to distinguish between one network and another thus avoiding it listening to the wrong network thereby saving battery current.

 In some countries a block of frequencies (or channels) has been allocated to paging with competing operators being allocated one or more
25 channels from the block. A terminal unit belonging to a subscriber who is roaming within the geographical area, has to be able to detect the channel(s) assigned to an operator and select the or those channel(s) being applied in each area. Additionally if an operator is allocated an extra channel the terminal unit needs to be able to acquire the channel whenever appropriate.

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Disclosure of Invention

An object of the present invention is to facilitate roaming by subscribers in the coverage area of a telecommunications system.

According to one aspect of the present invention there is provided a telecommunications system comprising a plurality of geographically separated primary stations, each primary station defining a coverage area, a plurality of
5 said primary stations being operated as a network, and at least one transportable secondary station, characterised in that each primary station is adapted to transmit an announce channels message containing information about the radio channels available on the network to which it belongs, and
10 in that the secondary station has means for receiving the announce channels message and for selecting one of the channels indicated in said message.

According to a second aspect of the present invention there is provided a secondary station for use in a telecommunications system comprising a plurality of geographically separated primary stations being
15 operated as a network, wherein each primary station is adapted to transmit an announce channels message containing information about the radio channels available on its network, the secondary station comprising signal receiving means, means for storing details about channels belonging to the network and means responsive to receiving the announce channels message
20 for selecting details of at least one of the channels contained in the storing means and conditioning the secondary station accordingly.

Brief Description of Drawings

The present invention will now be described, by way of example, with
25 reference to the accompanying drawings, wherein:

Figure 1 is a block schematic diagram of an embodiment of a wide area digital paging system,

Figure 2 illustrates an example of a cycle structure,

Figure 3 illustrates an example of a Batch Zero Marker,

30 Figure 4 illustrates an example of a roaming address code word,

Figure 5 illustrates an example of a sub-address code word,

Figure 6 illustrates an example of an announce channels message,

Figure 7 illustrates an example of four phase-offset areas,

Figure 8 is a table showing the phasing of three frequencies in adjacent areas,

5 Figure 9 illustrates an example of phase-offsetting over a large number of areas,

Figure 10 illustrates an example of five phase-offset areas operating on 4 channels, and

Figure 11 illustrates the sequence of frequencies used in Figure 10.

10 In the drawings the same reference numerals have been used to indicate corresponding features.

Modes for Carrying Out the Invention

15 The paging system shown in Figure 1 comprises a paging system controller (PSC) 10 which is connected by landline links to respective geographically separated primary stations PS1, PS2 and PS3. Each primary station comprises a transmitter which defines a respective coverage area CAR1, CAR2 and CAR3, which may overlap one or more adjacent coverage areas. The PSC10 may control the operation of the primary stations in any
20 one of a number of ways, for example single frequency quasi-synchronous operation, single frequency time-division cellular operation or multi-frequency operation. As will become evident in the following description the same geographical area may be covered by two or more networks, each with its own operator who has a PSC and geographically distributed primary stations
25 so arranged that the coverage areas due to the primary stations of one network are arranged differently from those of another network.

30 In Figure 1, subscribers owning secondary stations SS1, SS2 comprising for example digital pagers, are able to roam within a predetermined home area and be contactable by the primary station in that area. However if for example the secondary station SS1 should be capable of operating in other coverage areas then it is necessary for this to be

recorded in the PSC10. Furthermore the subscriber may want to be contactable in other geographical areas in which networks operated by other operators prevail. Each operator may have one or more channels allocated to its system and may have its own operator identity and area code. Also the
5 modes of operation may differ from one operator to another and each operator may be able to offer different grades of service, such as a standard, lower bit rate of service and one or more higher speed standards.

The secondary station SS1 has been shown in block schematic form. An antenna 12 is coupled to a receiver stage 14, the output of which is
10 supplied to a decoder 16. A microcontroller 18 is coupled by way of bidirectional links 19, 20 with the decoder 16. The microcontroller 18 is operated in accordance with software held in a program store 22. An address store 24 containing the address(es) given to the secondary station is coupled to the microcontroller 18. A RAM 26 for storing data messages
15 received from a primary station is coupled to the microcontroller 18. The latter has an output coupled to a LCD driver 28 which in turn is coupled to a LCD panel 30. A keypad 32 is coupled to the microcontroller to provide a man/machine interface. An acoustic transducer 34 and a light emitter 36, such as a LED, are coupled to the microcontroller 18 which uses them as
20 alerting devices and, additionally, the light emitter 36 may be used to forward optically messages stored in the RAM 26 to say a printer or a personal computer. The receiver 14 is operated by the microcontroller 18 in accordance with a battery economising protocol and a battery economising stage 38 is coupled between the microcontroller 18 and the receiver 14.

25 A further memory 40, which may be part of the program memory 22, has a number of storage locations 42 to 52 for holding various data which has been written-in as part of the programming of the secondary station. The location 42 holds channel information. The location 44 stores Home Identity, that is Operator Identity and Area Code. This information is used by the
30 secondary station to determine when it is in its own coverage area, say CAR1, and when it is visiting or roaming in another coverage area and an

appropriate addressing mechanism can be used. Location 46 contains information relating to its Home Channel which is a pre-programmed channel. However roaming pagers in the same coverage area will have to select a channel dynamically. Location 48 holds Operator Identities and associated Area Codes which are valid for the secondary station when it is roaming away from its home area. In certain cases, the secondary station will have one programmed Operator Identity. However an operator may wish to use multiple Operator Identities in order to increase addressing capacity. Location 50 stores data relating to the decoding the Operator Identity and Area Code field contained in special code words such as a Batch Zero Marker used for batch identification as will be described later. Location 52 stores one or more channel scanning algorithms useable with different protocols.

The present invention will be described with reference to a paging protocol in which transmissions are made in cycles CYC (Figure 2). Each cycle comprises a plurality of batches B0, B1, B2, each batch comprises a synchronisation code word and a plurality of frames F0 to F27 and each frame comprises a plurality of code word periods, say 6, 8, 12 or 16 code words depending on the bit rate. The first code word in each batch is a synchronisation code word S and in the first batch B0 of a cycle, a code word called a Batch Zero Marker (BZM) is the first code word following the synchronisation code word. The BZM enables a secondary station to achieve cycle and batch synchronisation.

Figure 3 illustrates the format of a BZM which is a 32 bit code word. Bit 1 comprises a one bit flag having a value 0 to indicate an address code word. Bit 2 is a BZM flag which has a value 0 for a BZM and 1 for any other address code word. Bits 3 to 15 are allocated to the Operator Identity (AI) and the Area Code (AC) of the paging network. Bit 16 is used to indicate a cycle or batch mode of operation, with "0" being cycle mode. Bit 17 indicates whether or not a Batch Zero Message follows, with "1" indicating no following Batch Zero Message. A Batch Zero Message is used for the transmission of

system wide broadcast messages sent to all pagers on the network. Bits 18 to 21 of the BZM constitute a SUM field comprising a 4-bit checksum on the information in message code words. However for a BZM not followed by a Batch Zero Message, the SUM field comprises a 2 bit field indicating the number of repeats of a cycle and a 2 bit field indicating the repeat number. The remaining eleven bits comprise a 10 bit CRC and a 1 bit parity bit.

In operation a primary station PS transmits a sequence of messages which have been formatted and encoded to conform to the format shown in Figure 2. As the system currently being described is a synchronous system the transmission begins with a short preamble P which is immediately followed by the first batch B0 of the first cycle.

The receiver stage 14 (Figure 1) of a secondary station SS is energised to receive preamble which is used to achieve bit synchronisation. The preamble is followed by the first sync code word and this is followed by the BZM. Assuming that the sync code word and BZM have been received correctly, a check is made to see if the Operator Identity (AI) and Area Code (AC), bits 3 to 15 of the BZM, correspond the Home Operator Identity and Home Area Code which have been pre-programmed into the secondary station. If they do correspond then the transmission is treated as a local transmission and the secondary station follows the prevailing battery economy protocol which normally requires at least the receiver stage 14 of the secondary station to be powered down until just prior to the commencement of a predetermined frame of a batch. During the frame period, transmissions from the primary station are checked to see if any successfully received code words correspond to the address(es) allocated to the pager. Unless a message is concatenated with the address code word, the receiver stage 14 of the secondary station is powered down at the end of the frame period and an alerting device is energised, if appropriate. Otherwise the receiver remains energised until the end of the message has been indicated, for example, by an address code word or end of message code word, and then one or more of the alerting devices 34, 36 is or are

energised, if appropriate.

Alternatively if the Operator Identity and Area Code do not correspond to the Home Operator Identity and Home Area Code then the secondary stations knows that it is outside its home area. The primary station is also aware that it is transmitting to a roaming secondary station and in the predesignated frame it transmits a roaming address code word and a sub-address code word. Figures 4 and 5 illustrate respectively one example of each type of code word, each of which is 32 bits long. Considering the roaming address code word first, bit 1 is a flag having a value 0, indicating an address code word. Bits 2 to 7 are roaming flags and by setting all the bits to "1", an indication is sent that a roaming message follows. Bit 8 is reserved. Bits 9 to 21 indicate the Home Operator Identity and Area Code with which the secondary station is associated. Bits 22 to 31 are the CRC and bit 32 is the parity bit.

The sub-address code word (Figure 5) begins with a flag having a value 1 indicating that it is a message code word, bits 2 to 17 comprise address bits corresponding to the secondary station's address. Bits 18 to 21 constitute a SUM field consisting of a 4 bit checksum on the information in the message code words. Bits 22 to 31 comprise a 10 bit CRC and bit 32 comprises a parity check bit. The receiver stage 14 of a secondary station is energised for its predetermined frame and checks if the Home Operator Identity bits correspond to those stored in the secondary station and, if they do, it checks that the address in the sub-address code word corresponds to that given to the secondary station and, if so, it remains energised to receive a following message but otherwise it is de-energised at the end of its frame.

The description so far has assumed that the or each network is operating on one and the same frequency. However multi-frequency (or multi-channel) is also possible by pre-programming the secondary station with frequency information relating to all the available channels in the form of channel numbers.

Calls to a single channel secondary station are transmitted on the

pager's pre-programmed channel. Calls to a multi-channel secondary station in the secondary station's home area are transmitted on the secondary station's home channel.

5 For calls to a visiting multi-channel secondary station the method of channel selection makes use of an "Announce Channels" message which is transmitted intermittently on each channel belonging to the operator.

10 Figure 6 illustrates the Command Parameters in an "Announce Channels" message. The message begins with parameter A which comprises Operator Identity and Area Code which correspond to the same information given in the BZM. Parameter B gives the name given to the coverage (or paging) area. Parameter P is a single digit which defines the cycle phase in the specified area, as will be described later. The digit may have the following values and meanings:

	0	phase T
15	1	phase T +
	2	phase T ++
	3	undefined phase

20 Parameter D relates to the Transmission Off Period which is a number defining the transmission suspension period for the specified operator and area; viz

0	Unspecified period.
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The secondary station shall use a pre-programmed value, or default value if none is programmed,

1 to 32	Transmission Off Period.
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25 Parameter Q is an integer which defines the number of radio channels which are operational in the specified paging area and which are identified in a following list. Finally parameters $c_0, c_1 \dots c_{Q-1}$ each comprise a number defining a radio channel operational in the specified paging area.

30 The "Announce Channels" message is normally transmitted in a Batch Zero Message and informs pagers about the radio channels available in a specified network in a specified paging area. Not infrequently channel

information is given about the current area and the neighbouring areas. The message contains a list of Q channels c currently available to visiting pagers in that area, that is channels $c_0, c_1, \dots, c_{Q-1}$. Home secondary stations and visiting secondary stations may share the same channel. For a secondary station whose Address Code is Y , the channel shall be selected from the list as c_j , where $j = Y \text{ MOD } Q$.

For the sake of illustration, the following table shows examples for the case of up to 6 channels in a paging area ($Q = 1, 2, \dots, 6$).

Address code Y	$j = Y \text{ MOD } Q$					
	Q=1	Q=2	Q=3	Q=4	Q=5	Q=6
0	0	0	0	0	0	0
1	0	1	1	1	1	1
2	0	0	2	2	2	2
3	0	1	0	3	3	3
4	0	0	1	0	4	4
5	0	1	2	1	0	5
6	0	0	0	2	1	0
7	0	1	1	3	2	1
8	0	0	2	0	3	2
9	0	1	0	1	4	3
10	0	0	1	2	0	4
11	0	1	2	3	1	5
12	0	0	0	0	2	0
13	0	1	1	1	3	1
14	0	0	2	2	4	2
15	0	1	0	3	0	3
etc	etc	etc	etc	etc	etc	etc

Table 1: Channel Index Numbers Calculated From Address Code

With reference to the above table, it can be seen that if an Announce

Channels message is transmitted in which the number of channels Q is changed, all secondary stations will recalculate their channel number j, and some secondary stations will need to retune to a different channel.

5 In a simple example of an operator transmitting on 2 channels in each area then the secondary station can be instructed to look at its least significant bit and if it is zero, it tunes the first of the two channels, and if it is one, it tunes to the second of the two channels.

10 The Announce Channels message shall be used by the network to provide information to the secondary stations about adjacent paging areas. The secondary station may use this information to assist its channel scanning algorithm.

15 In operation a roaming secondary station on entering an area, scans the channels looking for a channel of an acceptable quality. It checks the BZM to see if the Operator Identity and Area Code correspond to an operator identity and area code stored in the memory location 48 (Figure 1). If a correspondence is found then the secondary station remains energised to receive the Announce Channels message and depending on the parameters in that message, the secondary station selects an appropriate channel and follows the battery economy protocol relating to the standard being propagated by that operator.

20 Depending on the network design and the level of roaming service which an operator wishes to offer to subscribers, it may not be necessary to have its cycle timing synchronised with corresponding transmissions on other channels. Alternatively, transmissions on different channels may be synchronised together to operate in a "phase-offset" mode. For flexibility, multi-channel secondary station should be capable of operating on non-phased and phased-offset networks.

25 In either case a multi-channel secondary station needs to have the capability to scan for a new channel when the signal quality of its current channel degrades. One possible method of determining the signal quality is to measure the bit error rate of, for example, the sync code word signals and

when it exceeds a threshold value, a channel search is instituted.

5 With networks which are not phase synchronised, a single channel or multi-channel secondary station may roam between networks or paging areas and will re-synchronise to a channel in each network or area that it encounters. This mode of operation is suitable for roaming between networks or paging areas which do not provide contiguous coverage, or in situations where the scanning time of the secondary station can be kept short so that calls are not missed, and in situations where there is no ambiguity about which area a secondary station should listen to.

10 Figures 7 and 8 illustrate an example of a phase-offset network and the phasing of three frequencies in adjacent areas. The phase-offset network comprises four areas AR1, AR2, AR3 and AR4. A primary station PAR1 in Area AR1 transmits on a frequency F1 in phase T and the phasing of the cycle is as shown in the top line of Figure 8. A primary station PAR2 in area AR2 transmits on a frequency F2 in phase T+ which is offset by one batch period relative to the phase T as shown in the second line of Figure 8. Primary stations PAR3 and PAR4 in non-contiguous areas AR3 and AR4 transmit on a frequency F3 in phase T++ which is offset by two batch periods relative to the phase T as shown in the bottom line of Figure 8.

20 The phasing provides soft handover between channels which enables a multi-channel secondary station to scan and synchronise onto a new channel before it has relinquished its current channel. In this way a secondary station can roam between the areas AR1 to AR4 and can remain constantly in communication. For roaming between many networks it is convenient to refer the phases to an absolute time reference, for example by using the GPS system.

25 Three phases are sufficient to enable even large networks to be planned as shown in Figure 9.

30 In order to inform a roaming secondary station of the phase of a channel in a specified paging area, the parameter P in the Announce Channels message is given the appropriate value as indicated above in the

description of Figure 6.

When a secondary station is in the middle of a service area it will receive only a signal from the local primary station and will be unable to hear signals from adjacent areas. In this case the pager can use the "other" two
5 batches, say batches B0 and B2 to monitor for signals on other frequencies received from other areas.

A secondary station is not restricted to monitoring two alternative frequencies. For example see Figure 10. While a secondary station is in the middle of area AR5 it will receive only frequency F1 but can scan frequencies
10 F2, F3, F4 as shown in Figure 11. If the secondary station is moving West (Figure 10) then it will eventually start to receive frequency F4. When it receives F4 it can stop examining other frequencies on the same phase i.e. frequency F2 in this example.

Therefore, when the secondary station is searching for active
15 frequencies for a particular phase it can cope with any number of frequencies. When the secondary station has found active frequencies which may carry its calls, it need only monitor three frequencies.

Note that the example in Figure 11 of alternately scanning frequencies F2 and F4 to look for signal activity is not the only scheme possible. In
20 Figure 11 the secondary station examines only one frequency per batch period. In fact the secondary station could search for signal activity on other frequencies at any time when it is not listening to its assigned batch on an active channel. Many frequencies could be scanned in this way. The secondary station will settle into monitoring three frequencies in the three
25 phase structure only when activity has been found on three valid frequencies.

By enabling secondary stations to select a channel from the Announce Channels message (Figure 6), the secondary stations can adapt to changing network configurations which gives the following benefits:

- a. The secondary stations are distributed approximately evenly across
30 the available channels in a paging area. This optimises the channel loading and therefore the grade of service.

- 5 b. The frequencies in an area can be changed, for example to overcome interference. (Note, this option is not applicable to secondary stations in a home area who have a pre-programmed home area frequency. However it is applicable in a home area when dynamic channel selection is used in the home area.
- 10 c. New frequencies can be added to a paging area to cope with increased traffic load. If desired, paging channels could be assigned to the busiest paging areas to match the traffic demand (dynamic channel allocation). In either case the secondary station calculates the new channel from the Announce Channels message.
- 15 d. New paging areas can be established. Existing secondary stations in service can use these new areas without having pre-programmed information about the channels in use. In operation the secondary stations receive the Announce Channels message, decodes it and memorises the data. When the secondary station next visits that area it is able to select the appropriate channel without first having to receive an Announce Channels message.

20 From reading the present disclosure, other modifications will be apparent to persons skilled in the art. Such modifications may involve other features which are already known in the design, manufacture and use of telecommunication systems and devices and component parts thereof and which may be used instead of or in addition to features already described herein. Although claims have been formulated in this application to particular combinations of features, it should be understood that the scope of the

25 disclosure of the present application also includes any novel feature or any novel combination of features disclosed herein either explicitly or implicitly or any generalisation thereof, whether or not it relates to the same invention as presently claimed in any claim and whether or not it mitigates any or all of the same technical problems as does the present invention. The applicants

30 hereby give notice that new claims may be formulated to such features and/or combinations of such features during the prosecution of the present

application or of any further application derived therefrom.

Industrial Applicability

- 5 Wide area digital paging systems and other types of cellular communications systems.**

**CLAIMS**

1. A telecommunications system comprising a plurality of geographically separated primary stations, each primary station defining a coverage area, a plurality of said primary stations being operated as a network, and at least one transportable secondary station, characterised in that each primary station is adapted to transmit an announce channels message containing information about the radio channels available on the network to which it belongs, and in that the secondary station has means for receiving the announce channels message and for selecting one of the channels indicated in said message.

2. A system as claimed in Claim 1, characterised in that the secondary station has means, which in response to receiving the announce channels message, dynamically determines which one of the radio channels in the network the secondary station should go to.

3. A system as claimed in Claim 1, characterised in that the number of channels in the network and/or the channel frequencies in the network are changed dynamically, and in that the secondary station has means, responsive to receiving the announce channels message, for dynamically determining which one of a plurality of the radio channels in the network the secondary station should go to.

4. A system as claimed in Claim 1, 2 or 3, characterised in that the announce channels message includes details of the operator identity and area code, and in that the secondary station includes storage means preprogrammed with at least one operator identity.

5. A system as claimed in any one of Claims 1 to 4, characterised in that the secondary station is programmed with a home operator identity



and a home area code and in that a primary station transmits a batch marking signal which includes an operator identity and an area code whereby the secondary station in response to recognising its home operator identity and home area code tunes to its pre-programmed home channel and refrains from scanning other channels.

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6. A system as claimed in Claim 5, characterised in that the secondary station is programmed with at least one other home operator identity and home area code and in response to detecting said at least one other home operator identity and home area code waits to receive the announce channels message from the respective operator before selecting a channel.

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7. A system as claimed in any one of Claims 1 to 6, wherein the system operates in accordance with a protocol comprising a succession of cycles, each cycle comprising a predetermined number of batches, each batch comprising a plurality of frames and each frame comprising a plurality of code words, characterised in that the announce channel message further comprises details of phasing applied to each channel.

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8. A system as claimed in Claim 7, characterised in that adjacent areas of the same network operate at a different frequency and in that the batch structure applied to each frequency is such that correspondingly identified batches are offset by one batch period, whereby a secondary station can make a soft handover between frequency channels without loss of data.

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9. A system as claimed in Claim 8, characterised in that the channels in each coverage area shall be assigned to a predetermined one of a plurality of phases so that no two channels have the same phase in contiguous overlapping geographical areas.



10. A secondary station for use in a telecommunications system comprising a plurality of geographically separated primary stations being operated as a network, wherein each primary station is adapted to transmit an announce channels message containing information about the radio channels available on its network, the secondary station comprising signal receiving means, means for storing details about channels belonging to the network and means responsive to receiving the announce channels message for selecting details of at least one of the channels contained in the storing means and conditioning the secondary station accordingly.

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