

Description

The present invention relates to a mobile radio communication system and, more particularly, to a radio channel control system for a small-zone mobile communication system, e. g. a portable telephone system or a cordless telephone system.

Radio channel control methods known in the mobile communications art may generally be classified into two types, i. e. , a centralized control type in which a base station collectively supervises channels which are assigned to a group of mobile stations associated therewith, and a decentralized control type in which each of mobile stations selects an available channel independently of the others. A personal radio system is one of applications of the decentralized control type method.

A domestic maritime mobile radiotelephone system installed by NTT (Japan) is another application which employs a multi-channel cyclic switching principle, i. e. , assigns no exclusive common control channels and allows pilot signals to be sent on desired channels.

The channel control for the above-mentioned personal radio system is performed using exclusive common control channels. The problem with such a manner of channel control is that where base stations are so distributed as to provide continuity among different zones as viewed in a plane such as for portable telephones, cochannel interference occurs in overlapping areas of nearby zones where the desired-to-undesired signal (DU) ratio is comparatively low, making it difficult to set up a call. The cochannel interference has customarily been coped with by providing each mobile station with a carrier sensing capability, which allows the mobile station to sense presence/absence of a radio wave.

Meanwhile, the radio channel control elaborated for the domestic maritime mobile radiotelephones assigns different channels to different zones because the zones are each comparatively wide. This successfully eliminates the cochannel interference. However, in a system in which the individual zones are very small such as a portable telephone system or a cordless telephone system, it is significantly difficult to set up a channel arrangement which promotes efficient use of frequencies partly because each zone is not circular but rather linear and partly because base stations cannot be located in adequate places.

US-A-4 267 141 relates to a system in which a mobile subscriber station is coupled by a radio link with an individually associated stationary relay station directly connected to a telephone network. The two stations are able to communicate with each other, over a radius of about 50 metres, on any of 40 channels available to all the posts of subscriber and relay stations in the neighborhood. In the idle

state of the post receivers in both stations continuously scan the available channels to determine their free or busy condition. To make an outgoing call a transmitter of the subscriber station sends out a predetermined code word which is picked up by the receiver of the associated relay station in its scanning operation and, upon verification by a code comparator, initiates the emission of a hand-shake signal to the subscriber station whereupon the channel is seized to let the call proceed over the network.

WO-A-83/02380 describes a system for wireless transmission of telephone calls between a stationary unit connected to a mobile telephone set at a short distance from the stationary unit. For providing connections between the wireless telephone set and the stationary unit the speech channels are scanned and when an idle channel is found an individual call code and the number of the idle channel are transmitted on a signalling channel. Thereupon connection is made between the telephone set and the stationary unit via the given speech channel. In the case that a certain channel number suggested by one unit is not acceptable to the other unit, another idle channel number is suggested and as soon as the channel number can be accepted by both units the call is connected.

It is therefore an object of the present invention to provide a radio channel control method for a mobile communication system which efficiently uses frequencies and promotes the ease of channel assignment.

It is another object of the present invention to provide a radio channel control method for a mobile communication system which eliminates cochannel interference to allow a call to be set up with ease.

It is another object of the present invention to provide a radio channel control method for a mobile communication system which prevents a plurality of base stations to be connected to a single mobile station.

It is another object, of the present invention to provide a generally improved radio channel control method for a mobile communication system.

The above objects are solved by the features of the claim.

In accordance with the present invention, a radio channel control method for a small-zone mobile communication system in which a plurality of base stations share a plurality of channels and each selects any of the channels for setting up a call independently of the others, e. g. a portable telephone system or a cordless telephone system, is disclosed. Installed in each of all the base stations are a transceiver, free to use all the channels, a device capable of identifying channels on which radio waves have reached the own station based

on reception sensitivity, a device for selecting a channel, a device for transmitting a pilot signal and others, and a device for setting up a call. The channel for a pilot signal is adequately changed to shorten a duration of cochannel interference. Connection of multiple base stations to a single mobile station is eliminated by causing each base station to add to the pilot signal identification data which is particular to the base station.

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description taken with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view of a mobile communication system to which the present invention is applicable;

Fig. 2 is a block diagram of a base station, included in the system of Fig. 1;

Fig. 3 is a block diagram of a mobile station also included in the system of Fig. 1;

Fig. 4 is a flowchart demonstrating a channel selection procedure performed by the system of Fig. 1;

Fig. 5 is a timing chart representative of an exemplary operation in accordance with a radio channel control method of the present invention; and

Fig. 6 is a schematic view of a system construction in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Fig. 1 of the drawings, a mobile communication system to which the present invention is applicable is shown. As shown, the system includes base stations 21, 22, 23, 24, 25, 26 and 27 which cover radio zones 11, 12, 13, 14, 15, 16, and 17, respectively. Designated by the reference numerals 31, 32, 33 and 34 are mobile stations, or portable transceivers. Fig. 1 shows for simplicity only seven radio zones and four mobile stations which are in communication.

Referring to Fig. 2, each of the mobile stations, like an automobile telephone or a cordless telephone, comprises a transmitter 41, a receiver 42, a controller 43, an antenna 44, an antenna duplexer 45, a handset 46, and a frequency synthesizer capable of being tuned to any desired channel. As shown in Fig. 3, each of the base stations is provided with essentially the same construction as the mobile stations except that it is connected to a public telephone network and, therefore, provided with a line control 49 in place of the handset 46. The line control 49 is connected to a telephone

circuit. In each of the base stations and mobile stations, a timer for counting time is usually installed in a controller 47 and is implemented either by software or by hardware. The base stations and mobile stations perform carrier sensing using their receivers 42.

Referring to Fig. 4, there is shown a flowchart representative of an algorithm with which each base station may select a channel. Specifically, each of the base stations 21-27 shown in Fig. 1 operates as demonstrated by the flowchart in order to allow its associated mobile station to communicate therewith. In the condition shown in Fig. 1, assuming that a radio wave emitted in any one of the seven zones can reach all the other zones as well even if the field intensity may be low, all the base stations need to select channels having frequencies other than f_1 , f_2 , f_3 and f_4 . In this illustrative mobile communication system, each base station has the capability for selecting a channel independently of the others so that some of the base stations may possibly select the same channel. The present invention contemplates to settle a problematic situation which will be given rise to by such cochannel interference.

Usually, in the decentralized type control, a base station determines which ones of the channels that are shared by all the base stations are being used by the nearby base stations using a known carrier sense principle, i. e. by checking whether radio waves are received or not. While carrier sense is usually performed in the vicinity of a base station, a mobile station is used in locations which are remote from a base station. Hence, perfect carrier sensing is unattainable. In accordance with the method of the present invention, when a predetermined period of time expires before a radio wave is received over a channel which is being used as a control channel, it is decided that a signal is under interception due to interference and the control channel is replaced by another. While a conversation is held, it is impossible to see if interference exists in terms of time only and, hence, another suitable means such as sensing a beat signal is required. In accordance with the present invention, therefore, channel switching is not effected while a conversation is under way.

Referring to Fig. 5, there is shown a specific example in which base stations #11 and #12 are provided and to which five channels having frequencies f_1 - f_5 are assigned. The reference numeral 1 designates a duration for which the station #11 uses the channel with the frequency f_1 for a conversation; 2, 5 and 10 designate respectively durations for which the station #11 uses the channels with the frequencies f_2 and f_4 for the transmission of pilot signals; 3, 6 and 9 designate respectively durations for which the station #12 uses the chan-

nels with the frequencies f_2 , f_4 and f_5 for the transmission of pilot signals; and 4 and 8 designate respectively durations for which the station #12 uses the channels with the frequencies f_3 and f_5 for conversations. The reference numerals 9 and 8 show a particular situation wherein during transmission of a pilot signal over the channel f_5 a signal emitted from a mobile station has arrived on that channel f_5 to set up a communication. Further, the reference numeral 7 designates a period of time over which the stations #11 and #12 have selected the same channel (one with the frequency f_4) simultaneously to use it for the transmission of pilot signals.

In the above conflicting condition, the method of the present invention causes the station #12 to switch the channel from f_4 to f_2 upon elapse of a predetermined period of time T. Therefore, the duration of the conflict on the same channel is short enough for a time diversity effect to be achieved.

Referring to Fig. 6, a system construction in accordance with the present invention is shown. As shown, base stations 61-64 are located in radio zones 51-54, respectively. The reference numerals 71 and 72 each designate a channel whose frequency is f_1 and available for the transmission of a pilot signal. Designated by the reference numeral 81 is a mobile station. In the illustrated particular condition, two base stations 62 and 64 are emitting pilot signals at the same time on the same channel (with the frequency f_1). As the mobile station 81 in the illustrated location transmits a signal, the two base stations 62 and 64 receive it at the same time. However, since each of the pilot signals contains an identification data, or number, which is particular to the associated base station, the signal from the mobile station 81 is accompanied by the signal received by the own station, i. e., #2 or #4. This allows only one of the base stations 62 and 64 to respond to the mobile station 81, that is, prevents the two stations #2 and #4 to connect themselves concurrently to one mobile station 81.

A practical procedure for origination of a call in accordance with the method of the present invention is as follows. A mobile station first tunes itself to a particular control channel which is being activated by a decentralized base station. This particular channel is a one which has a carrier propagating thereover and is modulated by a pilot signal. Then, as the user of the mobile station off-hooks, the mobile station sends a call origination signal to the base station and, after establishment of a loop with the latter, a dial signal. After the base station has connected the calling mobile station to a called station, the user is allowed to hold a conversation with a person at the called station.

Meanwhile, what is necessary for reception of a call is to see where the mobile station is located. In an automobile telephone system or the like, a particular radio zone in which a mobile station is located is usually determined by either one of two approaches: one in which a telephone exchange memorizes a location of the mobile station which is filed, and the other in which all the base stations call up the mobile station at the same time so that one of them may receive a response from the mobile station. Any one of the two approaches is applicable to the present invention. Once the location of the desired mobile station is known, the particular base station may connect the called station to a calling station for a conversation. As previously described in relation to the origination of a call, the mobile station will receive the call while having tuned itself to a channel associated with the particular base station.

In summary, it will be seen that a radio channel control method for a mobile communication system of the present invention achieves various advantages as enumerated below:

- (1) The channel for the transmission of a pilot signal is adequately changeable to shorten the duration of cochannel interference;
- (2) Simultaneous connection of a plurality of base stations to a single mobile station is eliminated by causing each base station to add identification data particular thereto to a pilot signal; and
- (3) The above advantages in combination realize a system which is cost-effective, facilitates channel assignment, and promotes efficient use of frequencies.

Claims

1. A radio channel control method for a mobile communication system in which a plurality of base stations (21-27; 61-64) share a plurality of channels (f_1 - f_5) and each selects any of the channels for setting up a call with any one of a plurality of mobile units (31-33; 81) independently of the other base stations, said radio channel control method comprising the steps of:
 - (a) scanning all the channels at a time of channel selection;
 - (b) selecting one channel out of the channels which show no reception sensitivity while excluding the channels which show reception sensitivity;
 - (c) transmitting a pilot signal on the selected channel;
 - (d) adding to the pilot signal identification data representative of the base station (21-27; 61-64);

nels with the frequencies f_2 , f_4 and f_5 for the transmission of pilot signals; and 4 and 8 designate respectively durations for which the station #12 uses the channels with the frequencies f_3 and f_5 for conversations. The reference numerals 9 and 8 show a particular situation wherein during transmission of a pilot signal over the channel f_5 a signal emitted from a mobile station has arrived on that channel f_5 to set up a communication. Further, the reference numeral 7 designates a period of time over which the stations #11 and #12 have selected the same channel (one with the frequency f_4) simultaneously to use it for the transmission of pilot signals.

In the above conflicting condition, the method of the present invention causes the station #12 to switch the channel from f_4 to f_2 upon elapse of a redetermined period of time T. Therefore, the duration of the conflict on the same channel is short enough for a time diversity effect to be achieved.

Referring to Fig. 6, a system construction in accordance with the present invention is shown. As shown, base stations 61-64 are located in radio zones 51-54, respectively. The reference numerals 71 and 72 each designate a channel whose frequency is f_1 and available for the transmission of a pilot signal. Designated by the reference numeral 81 is a mobile station. In the illustrated particular condition, two base stations 62 and 64 are emitting pilot signals at the same time on the same channel (with the frequency f_1). As the mobile station 81 in the illustrated location transmits a signal, the two base stations 62 and 64 receive it at the same time. However, since each of the pilot signals contains an identification data, or number, which is particular to the associated base station, the signal from the mobile station 81 is accompanied by the signal received by the own station, i. e., #2 or #4. This allows only one of the base stations 62 and 64 to respond to the mobile station 81, that is, prevents the two stations #2 and #4 to connect themselves concurrently to one mobile station 81.

A practical procedure for origination of a call in accordance with the method of the present invention is as follows. A mobile station first tunes itself to a particular control channel which is being activated by a decentralized base station. This particular channel is a one which has a carrier propagating thereover and is modulated by a pilot signal. Then, as the user of the mobile station off-hooks, the mobile station sends a call origination signal to the base station and, after establishment of a loop with the latter, a dial signal. After the base station has connected the calling mobile station to a called station, the user is allowed to hold a conversation with a person at the called station.

Meanwhile, what is necessary for reception of a call is to see where the mobile station is located. In an automobile telephone system or the like, a particular radio zone in which a mobile station is located is usually determined by either one of two approaches: one in which a telephone exchange memorizes a location of the mobile station which is filed, and the other in which all the base stations call up the mobile station at the same time so that one of them may receive a response from the mobile station. Any one of the two approaches is applicable to the present invention. Once the location of the desired mobile station is known, the particular base station may connect the called station to a calling station for a conversation. As previously described in relation to the origination of a call, the mobile station will receive the call while having tuned itself to a channel associated with the particular base station.

In summary, it will be seen that a radio channel control method for a mobile communication system of the present invention achieves various advantages as enumerated below:

- (1) The channel for the transmission of a pilot signal is adequately changeable to shorten the duration of cochannel interference;
- (2) Simultaneous connection of a plurality of base stations to a single mobile station is eliminated by causing each base station to add identification data particular thereto to a pilot signal; and
- (3) The above advantages in combination realize a system which is cost-effective, facilitates channel assignment, and promotes efficient use of frequencies.

Claims

1. A radio channel control method for a mobile communication system in which a plurality of base stations (21-27; 61-64) share a plurality of channels (f_1 - f_5) and each selects any of the channels for setting up a call with any one of a plurality of mobile units (31-33; 81) independently of the other base stations, said radio channel control method comprising the steps of:
 - (a) scanning all the channels at a time of channel selection;
 - (b) selecting one channel out of the channels which show no reception sensitivity while excluding the channels which show reception sensitivity;
 - (c) transmitting a pilot signal on the selected channel;
 - (d) adding to the pilot signal identification data representative of the base station (21-27; 61-64);



(e) causing the mobile station (31-33; 81) to send to the base station (21-27; 61-64) a reply signal which is accompanied by the identification signal which is contained in the received signal; and
 (f) when said reply signal has not been received over a predetermined period of time over the channel used to transmit the pilot signal, selecting another channel or when said reply signal has been received, stopping transmission of the pilot signal and using the same channel for conversation.

Patentansprüche

1. Funkkanalsteuerungsverfahren für ein mobiles Kommunikationssystem, bei dem mehrere Basisstationen (21 bis 27; 61 bis 64) mehrere Kanäle (f_1 bis f_5) gemeinsam nutzen und jede einen der Kanäle zum Aufbauen einer Verbindung mit einer von mehreren Mobileinheiten (31 bis 33; 81) unabhängig von den anderen Basisstationen auswählt, wobei das Funkkanalsteuerungsverfahren die Schritte aufweist:
 - (a) Abtasten aller Kanäle zu einer Kanalauswahlzeit;
 - (b) Auswählen eines Kanals aus den Kanälen, die keine Empfangsempfindlichkeit aufweisen, unter Ausschuß der Kanäle, die eine Empfangsempfindlichkeit aufweisen;
 - (c) Übertragen eines Pilotsignals auf dem ausgewählten Kanal;
 - (d) Zufügen von Identifizierungsdaten zum Pilotsignal, die für die Basisstation (21 bis 27; 61 bis 64) repräsentativ sind;
 - (e) Veranlassen, daß die Mobilstation (31 bis 33; 81) zu der Basisstation (21 bis 27; 61 bis 64) ein Antwortsignal sendet, das von dem in dem Empfangssignal enthaltenen Identifizierungssignal begleitet wird; und
 - (f) Auswählen eines anderen Kanals, wenn das Antwortsignal nicht in einem vorbestimmten Zeitraum über den zur Übertragung des Pilotsignals verwendeten Kanal empfangen wurde, oder Anhalten der Übertragung des Pilotsignals und Verwenden des gleichen Kanals für ein Gespräch, wenn das Antwortsignal empfangen wurde.

Revendications

1. Procédé pour commander des canaux radio dans un système de communication mobile, dans lequel une multitude de stations de base (21 à 27 ; 61 à 64) se partagent une multitude de canaux (f_1 à f_5) et chacun sélectionne l'un quelconque des canaux pour établir un appel avec l'une quelconque d'une multitude d'unités

mobiles (31 à 33 ; 81) indépendamment des autres stations de base, le procédé de commande des canaux radio comprenant les étapes consistant à :

- (a) balayer tous les canaux au moment de la sélection du canal ;
- (b) sélectionner un canal parmi les canaux qui présente aucune sensibilité de réception tout en excluant les canaux qui montrent une sensibilité à la réception ;
- (c) transmettre un signal pilote sur le canal sélectionné ;
- (d) ajouter au signal pilote des données d'identification représentatives de la station de base (21 à 27 ; 61 à 64) ;
- (e) amener la station mobile (31 à 33 ; 81) à envoyer vers la station de base (21 à 27 ; 61 à 64) un signal de réponse qui est accompagné par le signal d'identification qui est contenu dans le signal reçu, et
- (f) lorsque le signal de réponse n'a pas été reçu pendant un intervalle de temps prédéterminé sur le canal utilisé pour émettre le signal pilote, sélectionner un autre canal ou lorsque le signal de réponse a été reçu, arrêter la transmission du signal pilote et utiliser le même canal pour la conversation.

