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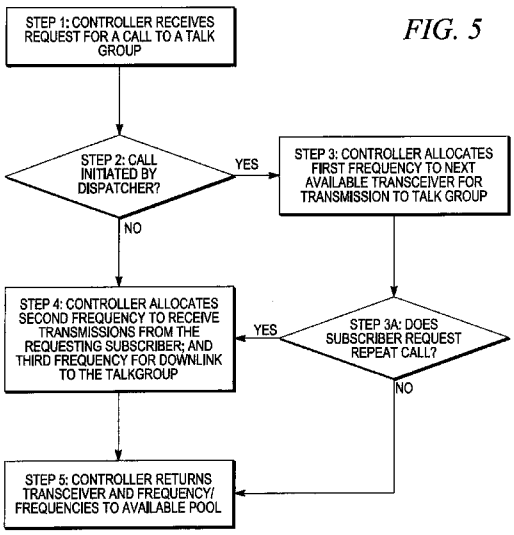


FIG. 5

(57) Abstract: A wireless communication system (300) and method for providing two-way trunked communication. A controller (305) allocates frequencies to a plurality of transceivers (312-324). For a call initiated by a dispatcher (330) of the system, the controller (305) assigns only a first frequency, for downlink communication from a transceiver (312) to mobile stations (350, 352). For a call initiated by a mobile station (350), the controller (305) assigns a second frequency for uplink communication from the mobile station (350) to a transceiver (312), and a third frequency for downlink communication of a repeat transmission from the transceiver (312) to mobile stations (350, 352). Frequency utilisation may be improved, particularly when a high proportion of call time is for dispatcher calls.

METHOD AND APPARATUS FOR FREQUENCY ALLOCATION IN A TRUNKED RADIO COMMUNICATION SYSTEM

FIELD OF THE DISCLOSURE

[0001] The present disclosure relates generally to trunked radio communication systems and more particularly to frequency allocation in a trunked radio communication system.

BACKGROUND

[0002] Many varieties of trunked two-way radio communications systems are known. FIG. 1 is a block diagram illustrating both a typical conventional radio system 101 and a trunked radio system 103.

[0003] In the conventional radio system 101, a plurality of mobile stations SU1, SU2,... SU9 are formed into talkgroups A, B or C. Each talkgroup uses a separate channel CH1, CH2 or CH3 for communication. Thus, each talkgroup is served by one channel.

[0004] In contrast, the trunked radio system 103 and its mobile stations SU1, SU2,....SU9 use a pool of channels CH1, CH2 and CH3. These channels can support a virtually unlimited number of talkgroups. Thus, all talkgroups may in fact be served by any channel, and may well be served by all channels at different times. The trunked radio system 103 works to take advantage of the probability that not all talkgroups will need a channel for communication at the same time. Estimates are made about how much load a typical user will present to the system, in terms of calls per hour and duration of each call.

[0005] For a given traffic load, the trunked radio system 103 requires fewer channels, since all talkgroups can be served by all channels. The number of trunked channels required to provide satisfactory service depends on: (i) the number of users; (ii) the traffic load that each will present; and (iii) the acceptable quality of service (QoS). With any given number of channels, the trunked radio system 103 can accommodate a much greater number of talkgroups than conventional radio systems, such as radio system 101. Hence, a primary benefit of a trunked radio

system is the efficient utilization of channels. The trunked radio system allows more users to carry on more conversations, over fewer distinct channels. This applies to data and/or voice calls.

[0006] As seen in FIG. 2, a trunked radio system can be either a `centralized trunked` radio system 201 or a `decentralized trunked` radio system 203.

[0007] A centralized trunked radio system 201 uses a dedicated or exclusive channel for communication between mobile stations and a central controller 205. This dedicated channel is often referred to as a control channel. The control channel communicates information about call set-up and `tear-down` between the mobile stations SU1...SU6 and the central controller 205. Other terms that sometimes refer to the central controller 205 include `trunking controller`, `site controller`, `resource allocator`, `channel allocator`, `controller`, and other like terms. The mobile stations SU1...SU6 constantly monitor the control channel for channel assignment instructions. In order to start a group call, i.e. a one-to-many call, a mobile station requests that a channel be allocated for its use. The central controller 205 then transmits instructions, which tell the mobile stations in the group to switch to a traffic channel CH1, CH2, CH3 or CH4 assigned for that call. A similar process is followed when a mobile station starts an individual call, i.e. a `one-to-one` call.

[0008] A decentralized trunked radio system 203, however, does not require the use of an exclusive channel CH1, CH2 or CH3. The intelligence or control function for assignment of a channel to a call remains in the mobile stations SU1...SU6. Thus, the decentralized trunked radio system 203 can co-exist with conventional users on the same channels, without the use of the control channel. When a call is initiated by a mobile station, the channel assignment is determined by the logic in the mobile stations, not by a controller. In operation, a mobile station scans the channels, finds an idle channel and starts a call on the idle channel. The disadvantage of the decentralized trunked radio system 203 is that the scan to find an idle channel significantly increases the access time, which often provides for unacceptably high latency delays during call set up.

[0009] In a trunked communication system, each call is assigned one channel. The channel comprises two frequencies. At a base station of the trunked communication system, one frequency is used to receive a call from a mobile station. This first frequency is referred to as the `Rx` or `receive` frequency. The function of the base station is to re-transmit the call to the other members of a talk group. A second frequency is used for that re-transmission. This second frequency is referred to as the `Tx` or `transmit` frequency.

[0010] As noted above, the number of trunked channels required to provide satisfactory service depends on the number of users, the traffic load that each will present, and the acceptable quality of service (QoS). However, there are times in most trunked radio systems where all available channels are in use. So a mobile station wishing to make a call will not receive a channel allocation. The proportion of time for which a mobile station will find that it cannot make a call is dependent on how many channels are available to the system. If the proportion of time is unacceptably high, then a known solution is to arrange for more channels to be available. However, there are in practice only a limited number of channels available to any one system. Obtaining the use of extra channels for one trunked system may, for example, mean either extra expense, or that another trunked system has fewer channels available.

[0011] Henceforth the term `mobile station` will be used for any wirelessly linked mobile communication device that may be linked to the trunked wireless communication system discussed in the remainder of this description. The mobile station may be a phone, mobile or portable radio, a smartphone, or another wirelessly linked mobile communication device.

[0012] Published patent application EP-A-1718010 provides scheduling of uplink resources for a mobile station in a wireless communication system supporting VoIP. A base station is notified by a mobile station when the data rate of the mobile station changes.

[0013] Accordingly, there is a need for a method and apparatus for frequency allocation in a trunked radio communication system.

BRIEF DESCRIPTION OF THE FIGURES

[0014] The accompanying figures, where like reference numerals refer to identical or functionally similar elements throughout the separate views, together with the detailed description below, are incorporated in and form part of the specification. The figures serve to further illustrate embodiments of concepts that include the claimed invention, and explain various principles and advantages of those embodiments.

[0015] FIG. 1 is a block diagram illustrating both a conventional radio system and a conventional trunked radio system.

[0016] FIG. 2 is a block diagram illustrating both a conventional centralized trunked radio system and a conventional decentralized trunked radio system.

[0017] FIG. 3 is a block diagram illustrating a trunked radio system in accordance with an embodiment.

[0018] FIG. 4 is a table showing an example of an operating state of the trunked radio system of an embodiment.

[0019] FIG. 5 is a flowchart showing a sequence of steps for call set up in accordance with an embodiment.

[0020] FIG. 6 is a flowchart showing a sequence of steps for call set up and tear down in accordance with an embodiment.

[0021] FIG. 7 is a table showing the efficiency increases that may be achieved.

[0022] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions of some of the elements in the figures may be exaggerated relative to other elements to help to improve understanding of embodiments of the present invention.

[0023] The apparatus and method components have been represented where appropriate by conventional symbols in the drawings, showing only those specific details that are pertinent to understanding the embodiments of the present invention so as not to obscure the disclosure with details that will be readily apparent to those of ordinary skill in the art having the benefit of the description herein.

DETAILED DESCRIPTION

[0024] A wireless communication system provides two-way communication, with a network of the wireless communication system comprising a controller operable to allocate frequencies in the system, and a plurality of transceivers. The controller is operable to:

(i) Assign only a first frequency for a call initiated at an element of the network. The first frequency enables downlink communication from a transceiver of the network to one or more mobile stations.

(ii) Assign second and third frequencies for a call initiated by a mobile station. The second frequency enables uplink communication from the mobile station to a transceiver of the network. The third frequency enables downlink communication from a transceiver of the network to one or more mobile stations.

[0025] Also disclosed is a method of frequency allocation in a wireless communication system providing two-way trunked communication. A network of the wireless communication system comprises a controller and a plurality of transceivers. The method comprises:

(i) For a call initiated at an element of the network, assigning only a first frequency, the first frequency enabling downlink communication from a transceiver of the network to one or more mobile stations.

(ii) For a call initiated by a mobile station, assigning second and third frequencies, the second frequency enabling uplink communication from the mobile station to a transceiver of the network, and the third frequency enabling downlink communication from a transceiver of the network to one or more mobile stations.

[0026] The method and apparatus described above demonstrate that there was a potential to improve frequency utilization, relative to conventional trunked wireless communication systems, by focusing on efficient frequency allocation. The resulting wireless communication system and method use different frequency allocations to support different types of call. System availability and channel

utilization may thereby be enhanced. In particular, one type of call made within a wireless communication system may involve a dispatcher, who works from a dispatch console. The dispatcher may place a call in which the dispatcher addresses all members of a talk group. The system and method support such a call with a different frequency allocation than in conventional systems. Multiple dispatchers may want to place calls simultaneously, to different talk groups.

[0027] With conventional systems, a request for a call from a dispatcher will be met by a controller assigning a channel for that call to take place. The channel will comprise a transmit frequency and a receive frequency. The transmit frequency is used by a base station, particularly a transceiver of a base station, to transmit the voice or data from the dispatcher to the talk group. The receive frequency is available for any subscriber who is a member of the talk group, who wishes to call the group at any time, for example when the dispatcher has finished speaking, or has finished transmitting data.

[0028] The controller of the disclosed method and system operates by assigning only a transmit frequency, when the controller receives a request for a call from a dispatcher. The transmit frequency is then used by a transceiver to transmit the voice or data from the dispatcher to the talk group. However, no receive frequency is assigned at the time point when the controller receives the request for a call from a dispatcher. Thus one frequency has been saved, i.e. a frequency has not been allocated that would have been allocated with conventional approaches. This saved frequency is then available to increase frequency availability within the trunked system. For example, the saved frequency is available to support another dispatch call elsewhere within the trunked wireless communication system, for which no frequency might have been available at a very busy period. Alternatively, the saved frequency is available to be used as one of a pair of frequencies, when a talk group is taking part in a call where both a receive frequency and a transmit frequency are required.

[0029] This arrangement offers the possibility of supporting a given number of calls with fewer frequencies than would be required with conventional approaches. This may allow either or both of the following:

(i) The trunked system may support a given number of mobile subscribers using fewer frequencies, i.e. the total allocation of frequencies to the system may be lower, thereby saving frequencies; or

(ii) The proportion of the time for which no free frequency is available, and hence a call cannot be made within the system, may be lower than the proportion with conventional systems that have the same total allocation of frequencies.

[0030] FIG. 3 is a block diagram of a wireless communication system 300 in accordance with a first embodiment. Wireless communication system 300 is shown in operation at a given point in time. Multiple voice or data calls are taking place within, and to, talk groups.

[0031] Central controller 305 of the wireless communication system 300 is connected to a set of transceivers 312-324. The connection to two of the transceivers 312 and 314 is shown by partial link 308, which in fact connects controller 305 to all the transceivers 312-324 that are shown on FIG 3. Central controller 305 is also connected to dispatch console 330. In an alternative arrangement, central controller 305 and dispatch console 330 may be a single unit. Dispatch console 330 is one example of a control element within a network`s infrastructure that can initiate calls. A dispatcher may use an input device 332, such as a keypad/mouse and a screen.

[0032] First transceiver 312, second transceiver 314, third transceiver 316, fourth transceiver 318, fifth transceiver 320 and sixth transceiver 322 are shown on FIG 3. However, the set of transceivers 310 may comprise more transceivers than these. Central controller 305 is also connected to a further transceiver 324, whose operation is dedicated to a control channel used within the system. The control channel is available to all mobile subscribers, in all talk groups. In order to explain the embodiment of FIG 3 clearly, each transceiver shown in FIG 3 is a circuit

element that can both receive and transmit signals. However, the receivers and transmitters may also be constructed as entirely independent elements. So, in its most general form, the wireless communication system can be implemented with a set of `transceivers`, any of which may comprise either just a transmitter, or just a receiver, or both a transmitter and a receiver.

[0033] In operation, first transceiver 312 is currently supporting a one-to-many call. Mobile station 350 is in a call to the remainder of a talk group 352, to which mobile station 350 belongs, using first transceiver 312. The remainder of talk group 352 may be a single mobile subscriber, but may include a plurality of mobile subscribers as shown in FIG 3. First transceiver 312 receives on frequency Rx1 from mobile station 350. First transceiver 312 transmits on frequency Tx1 to the remainder of the talk group 352.

[0034] Similarly, second transceiver 314 is currently supporting a one-to-many call. Mobile station 354 is in a call to the remainder of a talk group 356, to which mobile station 354 belongs, using second transceiver 314. The remainder of talk group 356 may be a single mobile subscriber, but may include a plurality of mobile subscribers as shown in FIG 3. Second transceiver 314 receives on frequency Rx2 from mobile station 354. Second transceiver 314 transmits on frequency Tx2 to the remainder of the talk group 356.

[0035] Third transceiver 316 is only transmitting. The transmission is on frequency Tx3 to a talk group 360, of which mobile station 358 is a member and is shown separately. The remainder of talk group 360 may be a single mobile subscriber, but may include a plurality of mobile subscribers as shown in FIG 3. Third transceiver 316 is transmitting a dispatch call from an operator of console 330. However, no receive frequency has been allocated to transceiver 316. Thus there is currently no frequency on which transceiver 316 could receive from a member of talk group 360, such as mobile station 358.

[0036] Fourth transceiver 318, fifth transceiver 320 and sixth transceiver 322 are currently neither transmitting nor receiving. Control channel transceiver 324 is transmitting on frequency Txcc, and receiving on frequency Rxcc.

[0037] In FIG 3, first transceiver 312 and second transceiver 314 are operating analogously to conventional systems. However, third transceiver 316 is only using one frequency Tx3, and that is to transmit the call from the dispatcher. There is no receive frequency assigned to third transceiver 316 by controller 305. The frequency that has thus been `saved`, is now available for other uses within the wireless communication system.

[0038] The embodiment of FIG 3 has both a receiver and a transmitter in each of first transceiver 312 to sixth transceiver 322. However, in an alternative embodiment, at least one of these transceivers, such as fifth transceiver 320 for example, may comprise only a transmitter or a receiver.

[0039] The controller 305 may be operable to carry out any or all of the following: (i) Programming a base station, by configuring its receive and transmit frequencies when a new call is initiated or ended; (ii) Selecting a preconfigured base station, when a new call is initiated or ended; (iii) Inhibiting a receiver in a base station which is not using its receiver, when it handles a downlink call; (iv) Inhibiting a receiver and transmitter on a free base station, so it can program any free frequency on any base station without possible interference; (v) Keeping a receive frequency programmed, even when it is not used for the configured amount of time, to avoid changing the base station or frequencies for calls that are performed one after another; (vi) Commanding a mobile station (subscriber) to tune to appropriate frequencies, so the mobile station can hear a call of interest and may also respond to this call on an assigned frequency, or initiate a new call on the control channel.

[0040] As described above, the wireless communication system 300 may comprise transceivers usable for dispatch calls and for `repeat calls` from one member of a talk group. However, where multi-site calls take place in a wireless communication system, the transceivers at `destination only` sites may be configured to use only one frequency. Thus, at a destination only site, one or more transceivers would only be assigned a transmit frequency. Such transceiver(s) would operate as explained above for transceiver 316 in figure 3.

[0041] FIG. 4 is a table showing an example of an operating state of the trunked radio system 300. The operating state shown in FIG 4 is not that described above with reference to FIG 3. However, the hardware elements available in FIG 3 are used to support the operation shown in FIG 4. In the operating state shown in the table of FIG 4, all the transceivers 312-324 of FIG 3 are in use. First transceiver 312, third transceiver 316, fourth transceiver 318 and sixth transceiver 322 each have a transmit frequency and a receive frequency allocated to them. However, second transceiver 314 and fifth transceiver 320 each only have a transmit frequency assigned to them. The second column lists the current activity for each transceiver. Notably, second transceiver 314 and fifth transceiver 320 are each saving one frequency. This can be seen by viewing the third and fourth columns of the table. The `saved` frequencies are frequencies that would have been allocated to second transceiver 314 and fifth transceiver 320 with conventional systems, even during the transmission from a dispatcher to the group.

[0042] The advantage offered is clear from the final row of the table of FIG 4. Only twelve frequencies are required for the system to operate. With a conventional approach, fourteen frequencies would have been required. In conventional systems, if only twelve frequencies in total had been available to the wireless communication system, then at least one of the calls listed in the second column of the table could not have taken place. There would not have been a pair of frequencies available to support a channel for that communication. For example, transceiver 322 might have been unable to service the call shown in the table of FIG 4.

[0043] FIG 5 shows a method in accordance with an embodiment. The following steps are shown in FIG 5:

Step 1: The controller 305 receives a request for a call to a talk group.

Step 2: The response to the request depends on the nature of the call. In order to respond appropriately to the request for a call, the method involves a determination of whether or not the call was initiated by a dispatcher, wishing to set up a call. If the call request originates with a dispatcher, then the method moves to

step 3. If the call request does not originate with a dispatcher, then the method moves to step 4 rather than step 3.

Step 3: The controller 305 allocates a first frequency to the next available transceiver, for downlink transmission to the talk group. Thus, at least for the first portion of the call, only this first frequency is required. Controller 305 also directs subscribers belonging to the talk group to tune to the first frequency, although the transceiver may also create these messages.

Step 4: Controller 305 allocates to the transceiver: a frequency for receiving transmissions from the subscriber; and a frequency for downlink transmissions to the talkgroup. These frequencies are referred to in FIG 5 as the `second` and `third` frequencies respectively. Controller 305 also directs subscribers belonging to the talk group to tune to the second and third frequencies, although the transceiver may also create these messages. Step 4 in fact covers multiple possibilities. Typically, the request is from a mobile station wishing to initiate a new call to a talk group of which it is a member. The uplink will therefore be used for transmissions from that mobile station to the transceiver. The transceiver will receive those transmissions on the `second` frequency. With this type of call, the transceiver will `repeat` the voice or data that it receives from the mobile station, i.e. it will re-transmit the voice or data to the other members of the talk group. It does this using the `third` frequency. For such a call, the second and third frequencies are assigned as soon as the mobile station requests the call. However, the request may be for a subscriber to make a call to a talkgroup that has already been listening to a dispatch call. The response to this situation is explained further with regard to step 3a below.

Step 3a: It is important to consider what will happen following step 3, once a dispatcher has finished transmitting voice or data to the members of a talk group. The decision box of Step 3a addresses this. One possibility is that the call will end. In this case, the method passes to step 5. In step 5, the controller will re-assign as `available` the first frequency and the transceiver that was allocated in step 3. Those resources may enter a pool of available frequencies and transceivers, for later use. However, when the dispatcher has finished transmitting, it is quite likely that a

mobile station will then wish to make a call, to the members of the talk group that the dispatcher has been addressing. Thus the method passes from decision box 3a to step 4. The call can then be supported through the following steps:

(i) The mobile station requests a call via the control channel. This request will be handled by transceiver 324 in FIG 3.

(ii) Controller 305 allocates both receive and transmit frequencies for the mobile station`s call. These may be the second and third frequencies identified in step 4 of FIG 5, i.e. both the assigned frequencies may differ from the `first` frequency used for the call from the dispatcher in step 3. In addition, a new transceiver may be assigned for the call. However, the controller may simply continue with the transceiver that was in use for the dispatch call.

[0044] In step 4, the transceiver may alternatively continue to use the `first` frequency from step 3 as its downlink frequency to the talkgroup. In this case, the transceiver may simply: (i) be assigned a new `second` frequency to receive the voice or data signal from the mobile station, for re-transmission to the rest of the group; and (ii) continue to use the first frequency, which had been assigned for the dispatch call, and transmit the `repeat` of the voice or data call to the rest of the talk group on that frequency. Effectively, the first frequency from step 3 would be used for the `repeat` transmission in place of the `third` frequency mentioned in step 4. The approach of re-using the first frequency is not shown in the wording of step 4 on FIG 5. The approach could be summarized as: Step 4: `Controller allocates second frequency to receive transmissions from the requesting subscriber, and commands transceiver to use first frequency for repeat transmissions to talk group`.

[0045] FIG 6 shows a typical sequence of events in a call. The events in FIG 6 correspond to two possible routes through the flowchart of FIG 5 which may arise. The steps are as follows:

Step 1: A request for a dispatch call is received by controller 305, from the operator of dispatch console 330.

Step 2: Controller 305 selects the next available transceiver, and allocates to it a single frequency, which is the `first` frequency of step 3 of FIG 5. The call from the dispatcher to the talk group may last several minutes. During this time, the needs of the caller (dispatcher) have been supported by the use of just one frequency.

Step 3: When a subscriber with a mobile communications unit realizes that the dispatcher has finished speaking, and has perhaps asked for comments, the particular subscriber wishes to speak either to the dispatcher or the rest of the talk group. The subscriber transmits a request on the control channel. This request is received by transceiver 324. Transceiver 324 passes the request to controller 305.

Step 4: Controller 305 selects new frequencies for the transceiver to receive voice and/or data from the subscriber, and to `repeat` transmit that call to the rest of the talk group. At this point, the `transmit` frequency that had been assigned in step 2 can be returned to the pool of available frequencies.

Step 5: Eventually, the call will end. The transmit and receive frequencies that were assigned in step 4 can also now be re-assigned to the pool of available frequencies. The transceiver can now be re-assigned to the pool of available transceivers.

[0046] FIG 6 shows one more possible sequence of events, in steps 4a and 5a.

Step 4a : A repeat call from a subscriber may start in step 4, but may at some later time point end and be replaced by a dispatch call. This may occur when a more important dispatch call must be made, which pre-empts a lower priority repeat call that is in progress. In this case, the frequency assigned to the transceiver for reception from the mobile station in step 4 can be re-assigned as available. Controller 305 commands the mobile stations to transmit on a control channel frequency, which gives them the possibility of requesting a repeat call again if the need arises.

Step 5a: At the end of the call that was set up in step 4a, the transmit frequency and the transceiver can be re-assigned as `available`.

[0047] The method may be implemented by providing a pool of N frequencies, which are available for trunked communication within the wireless communication system. Here N does not include the frequencies used for the control channel. Available frequencies are assigned from the pool of N frequencies, when either a first frequency is required, or a second frequency and a third frequency are required. This reduces the pool of available frequencies correspondingly, since the assigned frequencies must be removed from the pool of available frequencies, when they are assigned. When a call using the first, second or third frequency finishes, each frequency is returned to the pool of available frequencies.

[0048] The pool of transceivers then may comprise between [(N/2) +1] and N transceivers for trunked calls within the wireless communication system. There are then at least (N/2)+1 transceivers for calls, and a further transceiver, such as transceiver 324, for supporting control channel communications. If there are as many as N transceivers for calls, then there will always be a transceiver available for assignment from the pool of transceivers when a call is initiated, either at a control element of the network such as dispatch console 330, or by a mobile station. The assigned transceiver will be removed from the pool of available transceivers, when it has been assigned. However, that transceiver will be returned to the pool of available transceivers, when a call using the transceiver finishes.

[0049] It is instructive to compare the wireless communication system of FIG 3 in the states of operation described in relation to FIGs 3 and 4. In the state of operation in FIG 3, there are unallocated transceivers. Fourth transceiver 318, fifth transceiver 320 and sixth transceiver 322 are still available for new requests for calls. However, in the state of operation of FIG 4, all transceivers are in use. In the state of operation shown in FIG 4, there are ten frequencies in use for calls to talkgroups. These are the frequencies used by first transceiver 312 through to sixth transceiver 322, not those used by seventh transceiver 324. If the system of FIG 3 had for example N=11 frequencies available for calls on transceiver 312 through to sixth transceiver 322, then even though there is one unused frequency, there is no transceiver available to use it. If a new call request came in from either a dispatcher or a mobile

station, there would be no transceiver available to use it. Thus the number of transceivers can become a limit to the number of calls that can be made.

[0050] In a system where the transceivers each house both a receiver and a transmitter, the number of transceivers is statistically more likely to become a limiting factor where dispatch calls take up a large proportion of the total call time. Some information may already be known about the typical proportion of the total call time that will be used for dispatch calls, when a system is designed for a particular user. If so, this information can be used to plan how many transceivers to install in the system. The wireless communication system may be expandable, with extra transceivers used by the control element 305 when they are installed.

[0051] In general, the closer the number of transceivers to N, the greater the advantages in any given usage scenario. This becomes clear from the various numerical examples given below in the explanation of FIG 7. The greater the number of transceivers above (N/2)+1, the lower the chance at any given time that the system will not have a free transceiver available, even when there is a free frequency available.

[0052] As explained in connection with FIGs 5 and 6, for a call initiated at a control element of the network such as control console 330, when the downlink communication from the transceiver has been completed and a mobile station of a talk group requests a call, the step of assigning the third frequency for repeat transmission of the call from the mobile station via the transceiver to the talk group may involve a third frequency that is not the same as the first frequency.

[0053] A computer-readable storage device having stored thereon executable program code for programming signal processing logic to perform the method set forth in FIG. 5 or FIG. 6 may also be provided.

[0054] Tuning of the mobile stations

[0055] Various approaches to commanding the mobile stations may be employed. When re-tuning is necessary, the subscriber(s) may be directed to tune to another channel/frequency via a `channel change` command embedded in a TSBK/CSBK

frame. Controller 305 may provide the commands to the mobile stations. However, the transceiver handling a call may itself may be operable to generate `channel change` commands, for example when either a downlink call from a dispatcher or a repeat call starts. The commands sent to the mobile stations may be timed to reach the subscribers just before a downlink call transmission begins.

[0056] For a call initiated at an element of the network such as dispatch console 330, using a first frequency for downlink communication to one or more mobile stations of a talk group, the one or more mobile stations may be commanded to tune their transmit frequency to a control channel frequency used by transceiver 324 that provides control channel communication. Any incoming request for a call from a mobile station will be received by the transceiver 324 that provides control channel communication. Each mobile station may also be adapted to tune its transmit frequency to the receive frequency of control channel transceiver 324 automatically, for example every time that the mobile station stops transmitting a call.

[0057] When a repeat call is set up, the controller 305 may direct all the mobile stations of the talkgroup to tune to the assigned channel, i.e. to the second and third frequencies shown in step 4 of FIG 5. Such a repeat call may be started if a higher priority request for a call from a subscriber comes in, even though a lower priority downlink call for the talkgroup is already in progress. In this case, the controller 305 may only assign a new receive frequency, to the transceiver that was already in use. The transceiver would continue to transmit to the talkgroup on the same transmit frequency as before. The controller 305 would command each subscriber to tune its transmit frequency to the frequency on which the transceiver is now to receive. Each mobile station would continue to receive the downlink from the transceiver on the same transceiver transmit frequency as before.

[0058] The communication system may be adapted to employ a status symbol feature, which is termed `busy bits`. This symbol would prevent one or more mobile stations from starting to transmit, if a downlink call of higher priority is ongoing, or if another mobile station is currently transmitting. A further approach to prioritization may involve the system not granting a request for a call, received on

the control channel from a subscriber of a first call group, if a higher priority downlink call for that talkgroup is already in progress.

[0059] The system may be optimized to try and minimize the number of times that changes of assigned frequency are necessary. In order to do this, a `hang time` mechanism may be implemented. This allows a call that follows within a short time of a previous call to use the same frequency or frequencies as the previous call. This may have the advantage of reducing the signaling payload within the system. For example, the mobile stations of a talkgroup may not need to be informed of a new frequency for reception or for their transmissions, when a new call starts shortly after the previous one.

[0060] Tuning and control of the transceivers

[0061] Each transceiver may be arranged to notify the central controller 305 when a call ends. The control channel transceiver 324 may be arranged to inform controller 305 about requests for calls from mobile stations. As shown in FIG 3, both of these kinds of communication may take place via communication link 308, which may be either a wireless or a wired link. Link 308 may be an Internet Protocol link. Over such a link, each transceiver may be programmed as required using a `program tx/rx frequency` command. At points such as step 4a in FIG 6, the controller may use an `inhibit` command. So the transceiver that is used to both transmit and receive in step 4 of FIG 6 may, in step 4a, have its receive function inhibited by controller 305. In general, controller 305 may send an inhibit command to any transceiver that is not in use, thereby specifying that the receiver and/or transmitter of that transceiver remain unused.

[0062] Applications of the communication system and method

[0063] Any trunked mobile communication system where there are significant limitations on the number of available channels or frequencies may benefit from the approaches described above, including both TDMA and FDMA radio communication systems. A typical use is in public safety radio systems, such as those used by fire and rescue staff, and those used by the police. Use is also

possible with systems that employ `shared channels`, i.e. where frequencies are available to more than one communication system and each system has a non-exclusive usage right to the frequency. Application is possible to the `Astro` ™ system from Motorola Solutions, Inc™, plus the MOTOTRBO™, LTR/Passport™ and TETRA systems. Other possibilities exist as well.

[0064] One possible implementation is in radio systems that employ `fast frequency change`. These systems can change the frequency used by a transceiver within a time period of the order of 30ms. This agility results in the frequency changes appearing to the user to be seamless, when implementing the method of FIGs 5 and 6, for example. The fast frequency change may be used both when changing from one active receive or transmit frequency to another, or when inhibiting a transceiver`s receive or transmit frequency. Notably, fast frequency change and channel inhibit or `idle frequencies` are available in some known systems. However, applying them in combination to the systems described in the application may lead to additional benefits. The usual application of idle frequencies is in simplex communication, when the transmit frequency is the same as the receive frequency. In this situation, the base station changes its transmit frequency every time an outbound call is started or finished. The station transmit frequency is set to `Idle Frequency` when there is no call, and is set to transmit `Normal Frequency` when a call is ongoing. It is also notable that the `channel change` feature has been used in conventional systems to allow a user to choose the frequency on which a call is to be transmitted.

[0065] Improvements Provided.

[0066] The amount of improvement achieved depends on the type of radio system involved, and how that system is typically used. The two key issues are:

(i) The proportion of the time for which dispatch calls are made in the radio system, rather than repeat calls; and

(ii) The total number of frequencies available to the system.

The efficiency increase attainable generally increases as both (i) and (ii) above rise. However, the number of dispatch/console calls in the system depends on the particular usage of the system. This number can only be predicted, but not known with certainty, before a system is deployed. If a communication system is mainly used to convey information from a console operator to subscribers, then the ratio of console call duration to repeat call duration in the system is high, and very significant efficiency improvements may be realised. There may also be additional advantage achievable by employing a higher proportion of transceivers that only house a receiver or transmitter, rather than both. If subscribers often communicate with one another, and calls from console operators are short and/or rare, then less improvement may be attainable. These effects are clear from considering the following two illustrations. Examples 1 and 2 below show how the disclosed wireless communication system may have spare available capacity at a time when conventional systems would not. The simulations offer statistical estimates of how much better the performance of various communication systems would be.

[0067] Example 1: consider a wireless communication system providing two-way trunked communication, with a control channel and 20 frequencies available for communication. These twenty frequencies would support ten voice or data channels, in typical conventional systems. Assume also in this example that there are twenty transceivers for calls and one for the control channel. We can now consider a situation in which there are ten calls in progress. Five of these calls are calls from dispatchers at a console such as 330 in FIG 3. Five of the calls are `repeat` calls, in which a mobile station is communicating with other members of its talk group. With the approaches explained in the present application, ten transceivers and fifteen frequencies are in use. The `free frequencies` list therefore contains five free frequencies. In conventional systems, ten transceivers and all twenty frequencies would have been assigned, since the five calls from dispatchers would each have been assigned two frequencies.

[0068] In this example, if a request for another call arrives from a dispatcher at the console 330, then controller 305 initiates a call to the appropriate talkgroup. This

call requires only that one frequency be assigned, for transmissions from one transceiver. Thus the list of free frequencies now has only four frequencies on it. The list of free transceivers has nine entries. As part of call set-up, the controller 305 may: (i) Send the selected transmit frequency to the selected transceiver; (ii) direct each subscriber of the talk group to tune its receive frequency to the transmit frequency selected for the transceiver, using a `change channel` command on the control channel. At the end of this dispatch call, the transceiver may notify the controller 305 that the dispatcher has finished. Controller 305 may then: (i) Send a channel change command to the subscribers, via the transceiver, to change their receive frequency to the transmit frequency of the control channel; (ii) Configure the transmit frequency of the transceiver to zero, i.e. `inhibit`; and (iii) Add the released transceiver and frequency back into the respective lists of available resources.

[0069] Example 2: Consider a system in which there are forty frequencies. In conventional systems, there would be 20 channels available, using these 40 frequencies. Consider further a system in which the duration and frequency of console calls is equal to the duration and frequency of repeat calls from subscribers. Conventional systems would report that there are no free frequencies, if twenty calls are in progress. Each of the twenty calls would use one transceiver, and a channel with two frequencies. However, there are on average ten frequencies that are unused, in this situation. These are the frequencies that are assigned for reception by transceivers that are actually only involved in transmitting the console calls. So 25% of the 40 frequencies allocated to the system are unused. With the approach outlined in connection with FIGs 3-6, those ten frequencies are available for re-use. An analysis of the statistics of the conventional approach in this example shows that, for 99% of the time when the conventional system would say that it is `busy`, at least five frequencies that have been allocated for reception by a transceiver involved in a console call are in fact idle. It is this inefficiency that may now be eliminated, wholly or partially.

[0070] Simulations of operation

[0071] Several simulations have been provided to estimate the improvements that are achievable. FIG. 7 shows the simulation results in a table. In each of scenarios 1-3, a calculation has been performed to estimate the proportion of time for which the communication system would not be able to grant a new call request. In each scenario, a typical number of available channels and typical call rate has been selected. The standard deviation for the call rate has also been chosen. The conclusion column shows that in each of the three scenarios, improved system availability has been achieved, relative to conventional systems. The final scenario shows that the improvement is greatest on the system having the most channels. The improvement possible to a conventional system with 30 channels is so great that 23 channels could be made to provide greater system availability than before.

[0072] In the foregoing specification, specific embodiments have been described. However, one of ordinary skill in the art appreciates that various modifications and changes can be made without departing from the scope of the invention as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of present teachings.

[0073] The benefits, advantages, solutions to problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential features or elements of any or all the claims. The invention is defined solely by the appended claims including any amendments made during the pendency of this application and all equivalents of those claims as issued.

[0074] Moreover in this document, relational terms such as first and second, top and bottom, and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions. The terms "comprises," "comprising," "has", "having," "includes", "including," "contains", "containing" or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises, has, includes, contains a

list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. An element proceeded by "comprises ...a", "has ...a", "includes ...a", "contains ...a" does not, without more constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises, has, includes, contains the element. The terms "a" and "an" are defined as one or more unless explicitly stated otherwise herein. The terms "substantially", "essentially", "approximately", "about" or any other version thereof, are defined as being close to as understood by one of ordinary skill in the art, and in one non-limiting embodiment the term is defined to be within 10%, in another embodiment within 5%, in another embodiment within 1% and in another embodiment within 0.5%. The term "coupled" as used herein is defined as connected, although not necessarily directly and not necessarily mechanically. A device or structure that is "configured" in a certain way is configured in at least that way, but may also be configured in ways that are not listed.

[0075] It will be appreciated that some embodiments may be comprised of one or more generic or specialized processors (or "processing devices") such as microprocessors, digital signal processors, customized processors and field programmable gate arrays (FPGAs) and unique stored program instructions (including both software and firmware) that control the one or more processors to implement, in conjunction with certain non-processor circuits, some, most, or all of the functions of the method and/or apparatus described herein. Alternatively, some or all functions could be implemented by a state machine that has no stored program instructions, or in one or more application specific integrated circuits (ASICs), in which each function or some combinations of certain of the functions are implemented as custom logic. Of course, a combination of the two approaches could be used.

[0076] Moreover, an embodiment can be implemented as a computer-readable storage medium having computer readable code stored thereon for programming a computer (e.g., comprising a processor) to perform a method as described and

claimed herein. Examples of such computer-readable storage mediums include, but are not limited to, a hard disk, a CD-ROM, an optical storage device, a magnetic storage device, a ROM (Read Only Memory), a PROM (Programmable Read Only Memory), an EPROM (Erasable Programmable Read Only Memory), an EEPROM (Electrically Erasable Programmable Read Only Memory) and a Flash memory. Further, it is expected that one of ordinary skill, notwithstanding possibly significant effort and many design choices motivated by, for example, available time, current technology, and economic considerations, when guided by the concepts and principles disclosed herein will be readily capable of generating such software instructions and programs and ICs with minimal experimentation.

[0077] The Abstract of the Disclosure is provided to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in various embodiments for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separately claimed subject matter.

Claims

1. A method of frequency allocation in a wireless communication system providing two-way trunked communication, a network of the wireless communication system comprising a controller (305) and a plurality of transceivers (312-324), the method comprising:

(i) for a call initiated at an element (330) of the network, assigning only a first frequency, the first frequency enabling downlink communication from a transceiver (312) of the network to one or more mobile stations (350, 352); and

(ii) for a call initiated by a mobile station (350), assigning second and third frequencies, the second frequency enabling uplink communication from the mobile station (350) to a transceiver (312) of the network, and the third frequency enabling downlink communication from a transceiver (312) of the network to one or more mobile stations (350, 352).

2. A method in accordance with claim 1, wherein:

the element (330) of the network is a dispatch console of the trunked radio communication system; and

the call initiated at the element (330) of the network is a call from a dispatcher to at least one mobile station (350) of a talk group (352) of the wireless communication system.

3. A method in accordance with claim 1 or claim 2, wherein:

the call initiated by the mobile station (350) is a repeat call via the transceiver (312) to at least one other mobile station of a talk group (352) of the wireless communication system.

4. A method in accordance with any previous claim, further comprising:

providing a pool of N available frequencies for trunked communication within the wireless communication system (300);

assigning available frequencies from the pool of frequencies when either a first frequency, or a second frequency and a third frequency are required; and

removing frequencies from the pool of available frequencies, when the frequencies have been assigned.

5. A method in accordance with claim 4, further comprising:

when a call using a first, second or third frequency finishes, returning each frequency to the pool of available frequencies.

6. A method in accordance with claim 4 or claim 5, further comprising:

providing a pool comprising between (N/2) +1 and N transceivers (312-322) for trunked calls within the wireless communication system (300), together with a further transceiver (324) for providing control channel communications;

assigning an available transceiver (312) from the pool of transceivers when a call is initiated, either at an element (330) of the network or by a mobile station (350);

removing the transceiver (312) from the pool of available transceivers, when it has been assigned; and

returning the transceiver (312) to the pool of available transceivers, when a call using the transceiver finishes.

7. A method in accordance with any previous claim, further comprising, for a call initiated at an element (330) of the network, when the downlink communication from a transceiver (312) has been completed and a mobile station (350) of a talk group requests a call:

assigning the second frequency to enable uplink communication from the mobile station (350) to a transceiver (312); and

assigning the third frequency for repeat transmission of the call from the mobile station (350) via the transceiver (312) to the talk group (352), wherein the third frequency is not the same as the first frequency.

8. A method in accordance with any of claims 1-6, further comprising, for a call initiated at an element (330) of the network (300), when the downlink communication from a transceiver (312) has been completed and a mobile station (350) of a talk group (352) requests a call:

assigning the second frequency to enable uplink communication from the mobile station to a transceiver (312); and

assigning the third frequency for repeat transmission of the call from the mobile station (350) via the transceiver to the talk group (352), wherein the third frequency and the first frequency are the same.

9. A method in accordance with any previous claim, further comprising, for a call initiated at an element (330) of the network using a first frequency for downlink communication to one or more mobile stations (350) of a talk group (352):

the one or more mobile stations (350, 352) tuning their transmit frequency to a control channel frequency used by a transceiver (324) that provides control channel communication;

whereby a request from a mobile station (350) will be received by the transceiver (324) that provides control channel communication.

10. A method in accordance with claim 1, further comprising, if a higher priority request for a call from a mobile station (350) comes in, when a lower priority downlink call for a talkgroup is already in progress using a transceiver (312):

assigning only a second frequency, to the transceiver (312) that was already in use, enabling uplink communication from the mobile station (350) to the transceiver; and

commanding each mobile station to tune its transmit frequency to the second frequency;

whereby the transceiver (312) continues to transmit to the talkgroup on the first frequency, and the mobile stations of the talk group (352) continue to receive the downlink from the transceiver (312) on the first frequency.

11. A method in accordance with any previous claim, further comprising sending an inhibit command to any transceiver (318) that is not in use, thereby specifying that the receiver and/or transmitter of that transceiver remain unused.

12. A wireless communication system (300) providing two-way trunked communication, a network of the wireless communication system comprising a controller (305) operable to allocate frequencies in the wireless communication system and a plurality of transceivers (312-324), the controller (305) being operable to:

(i) assign only a first frequency for a call initiated at an element (330) of the network, the first frequency enabling downlink communication from a transceiver (312) of the network to one or more mobile stations (350, 352); and

(ii) assign second and third frequencies for a call initiated by a mobile station (350), the second frequency enabling uplink communication from the mobile station (350) to a transceiver (312) of the network, and the third frequency

enabling downlink communication from the transceiver (312) of the network to one or more mobile stations (350, 352).

13. A wireless communication system (300) in accordance with claim 12, wherein:

the element (330) of the network is a dispatch console of the trunked radio communication system; and

the call initiated at the element of the network is a call from a dispatcher to at least one mobile station (350) of a talk group (352) of the wireless communication system.

14. A wireless communication system (300) in accordance with claim 12 or claim 13, wherein:

the call initiated by the mobile station (350) is a repeat call via the transceiver (312) to at least one other mobile station of a talk group (352) of the wireless communication system.

15. A wireless communication system (300) in accordance with any of claims 12-14, wherein the wireless communication system is operable to:

(i) assign frequencies from a pool of N available frequencies when either a first frequency, or a second frequency and a third frequency are required;

(ii) remove frequencies from the pool of available frequencies, when the frequencies have been assigned; and

(iii) return each frequency to the pool of available frequencies, when a call using a first, second or third frequency finishes.

16. A wireless communication system (300) in accordance with any of claims 12-15, further comprising:

a pool of available transceivers (312-322) for trunked calls within the wireless communication system, the pool comprising between (N/2) +1 and N transceivers (312-322), together with a further transceiver (324) for providing control channel communications; and

the controller (305) is operable to remove an available transceiver (312) from the pool of available transceivers (312-322) and to assign the transceiver (312), when a call is initiated, either at an element (330) of the network or by a mobile station (350), and to return the transceiver (312) to the pool of available transceivers, when a call using the transceiver (312) finishes.

17. A wireless communication system (300) in accordance with any of claims 12-16, wherein the controller (305) or the transceiver (312) is operable, for a call initiated at an element (330) of the network using a first frequency for downlink communication to one or more mobile stations of a talk group (350, 352), to:

instruct the one or more mobile stations to tune their transmit frequency to a control channel frequency used by a transceiver (324) that provides control channel communication, whereby a request from a mobile station (350) will be received by the transceiver (324) that provides control channel communication.

18. A wireless communication system (300) in accordance with any of claims 12-17, wherein:

the wireless communication system (300) is a fast frequency change system, operable to apply fast frequency changes to changes from one active receive or transmit frequency to another, and/or when inhibiting the receive or transmit frequencies of a transceiver (318).

19. A wireless communication system (300) in accordance with any of claims 12-18, wherein:

at least one transceiver (320) in the network comprises only a transmitter or a receiver.

20. A computer-readable storage device having executable program code stored therein for programming signal processing logic to perform a method of frequency allocation in a wireless communication system providing two-way trunked communication, the wireless communication system (300) comprising a

control element (330), a plurality of transceivers (312-324) and a plurality of mobile stations, the method comprising:

(i) for a call initiated at a control element (330) of the network, assigning only a first frequency, the first frequency enabling downlink communication from a transceiver (312) of the network to one or more mobile stations (350); and

(ii) for a call initiated by a mobile station (350), assigning second and third frequencies, the second frequency enabling uplink communication from the mobile station (350) to a transceiver (312) of the network, and the third frequency enabling downlink communication from a transceiver (312) of the network to one or more mobile stations (350).

AMENDED CLAIMS
received by the International Bureau on 27 September 2012 (27.09.2012)

CLAIMS

1. A method of frequency allocation in a wireless communication system providing two-way trunked communication, a network of the wireless communication system comprising a controller (305) and a plurality of transceivers (312-324), the method comprising:

(i) for a call initiated at an element (330) of the network, assigning, by the controller (305), only a first frequency, the first frequency for downlink communication from a transceiver (312) of the network to one or more mobile stations (350, 352); and

(ii) for a call initiated by a mobile station (350), assigning, by the controller (305), second and third frequencies, the second frequency for uplink communication from the mobile station (350) to a transceiver (312) of the network, and the third frequency for downlink communication from a transceiver (312) of the network to one or more mobile stations (350, 352).

2. A method in accordance with claim 1, wherein:

the element (330) of the network is a dispatch console of the trunked radio communication system; and

the call initiated at the element (330) of the network is a call from a dispatcher to at least one mobile station (350) of a talk group (352) of the wireless communication system.

3. A method in accordance with claim 1 or claim 2, wherein:

the call initiated by the mobile station (350) is a repeat call via the transceiver (312) to at least one other mobile station of a talk group (352) of the wireless communication system.

4. A method in accordance with any previous claim, further comprising:

providing a pool of N available frequencies for trunked communication within the wireless communication system (300);

assigning available frequencies from the pool of frequencies when either a first frequency, or a second frequency and a third frequency are required; and

removing frequencies from the pool of available frequencies, when the frequencies have been assigned.

5. A method in accordance with claim 4, further comprising:

when a call using a first, second or third frequency finishes, returning each frequency to the pool of available frequencies.

6. A method in accordance with claim 4 or claim 5, further comprising:

providing a pool comprising between (N/2) +1 and N transceivers (312-322) for trunked calls within the wireless communication system (300), together with a further transceiver (324) for providing control channel communications;

assigning an available transceiver (312) from the pool of transceivers when a call is initiated, either at an element (330) of the network or by a mobile station (350);

removing the transceiver (312) from the pool of available transceivers, when it has been assigned; and

returning the transceiver (312) to the pool of available transceivers, when a call using the transceiver finishes.

7. A method in accordance with any previous claim, further comprising, for a call initiated at an element (330) of the network, when the downlink communication from the transceiver (312) has been completed and a mobile station (350) of a talk group requests a call:

assigning the second frequency for uplink communication from the mobile station (350) to the transceiver (312); and

assigning the third frequency for repeat transmission of the call from the mobile station (350) via the transceiver (312) to the talk group (352), wherein the third frequency is not the same as the first frequency.

8. A method in accordance with any of claims 1-6, further comprising, for a call initiated at an element (330) of the network (300), when the downlink communication from the transceiver (312) has been completed and a mobile station (350) of a talk group (352) requests a call:

assigning the second frequency for uplink communication from the mobile station to the transceiver (312); and

assigning the third frequency for repeat transmission of the call from the mobile station (350) via the transceiver to the talk group (352), wherein the third frequency and the first frequency are the same.

9. A method in accordance with any previous claim, further comprising, for a call initiated at an element (330) of the network using a first frequency for downlink communication to one or more mobile stations (350) of a talk group (352):

the one or more mobile stations (350, 352) tuning their transmit frequency to a control channel frequency used by a transceiver (324) that provides control channel communication;

whereby a request from a mobile station (350) is received by the transceiver (324) that provides control channel communication.

10. A method in accordance with claim 1, further comprising, if a higher priority request for a call from a mobile station (350) comes in, when a lower priority downlink call from the transceiver (312) of the network for a talkgroup is already in progress:

assigning only a second frequency, to the transceiver that was already in use, for uplink communication from the mobile station to the transceiver; and

commanding each mobile station to tune its transmit frequency to the second frequency;

whereby the transceiver continues to transmit to the talkgroup on the first frequency, and the mobile stations of the talk group (352) continue to receive the downlink from the transceiver on the first frequency.

11. A method in accordance with any previous claim, further comprising sending an inhibit command to any transceiver (318) that is not in use, thereby specifying that the receiver and/or transmitter of that transceiver remain unused.

12. A wireless communication system (300) providing two-way trunked communication, a network of the wireless communication system comprising a controller (305) operable to allocate frequencies in the wireless communication system and a plurality of transceivers (312-324), the controller (305) being operable to:

(i) assign only a first frequency for a call initiated at an element (330) of the network, the first frequency for downlink communication from a transceiver (312) of the network to one or more mobile stations (350, 352); and

(ii) assign second and third frequencies for a call initiated by a mobile station (350), the second frequency for uplink communication from the mobile station (350) to a transceiver (312) of the network, and the third frequency for downlink communication from the transceiver (312) of the network to one or more mobile stations (350, 352).

13. A wireless communication system (300) in accordance with claim 12, wherein:

the element (330) of the network is a dispatch console of the trunked radio communication system; and

the call initiated at the element of the network is a call from a dispatcher to at least one mobile station (350) of a talk group (352) of the wireless communication system.

14. A wireless communication system (300) in accordance with claim 12 or claim 13, wherein:

the call initiated by the mobile station (350) is a repeat call via the transceiver (312) to at least one other mobile station of a talk group (352) of the wireless communication system.

15. A wireless communication system (300) in accordance with any of claims 12-14, wherein the wireless communication system is operable to:

(i) assign frequencies from a pool of N available frequencies when either a first frequency, or a second frequency and a third frequency are required;

(ii) remove frequencies from the pool of available frequencies, when the frequencies have been assigned; and

(iii) return each frequency to the pool of available frequencies, when a call using a first, second or third frequency finishes.

16. A wireless communication system (300) in accordance with any of claims 12-15, further comprising:

a pool of available transceivers (312-322) for trunked calls within the wireless communication system, the pool comprising between (N/2) +1 and N transceivers (312-322), together with a further transceiver (324) for providing control channel communications; and

the controller (305) is operable to remove an available transceiver (312) from the pool of available transceivers (312-322) and to assign the transceiver (312), when a call is initiated, either at an element (330) of the network or by a mobile station (350), and to return the transceiver (312) to the pool of available transceivers, when a call using the transceiver (312) finishes.

17. A wireless communication system (300) in accordance with any of claims 12-16, wherein the controller (305) or the transceiver (312) is operable, for a call initiated at an element (330) of the network using a first frequency for downlink communication to one or more mobile stations of a talk group (350, 352), to:
instruct the one or more mobile stations to tune their transmit frequency to a control channel frequency used by a transceiver (324) that provides control channel communication, whereby a request from a mobile station (350) will be received by the transceiver (324) that provides control channel communication.

18. A wireless communication system (300) in accordance with any of claims 12-17, wherein:

the wireless communication system (300) is a fast frequency change system, operable to apply fast frequency changes to changes from one active receive or transmit frequency to another, and/or when inhibiting the receive or transmit frequencies of a transceiver (318).

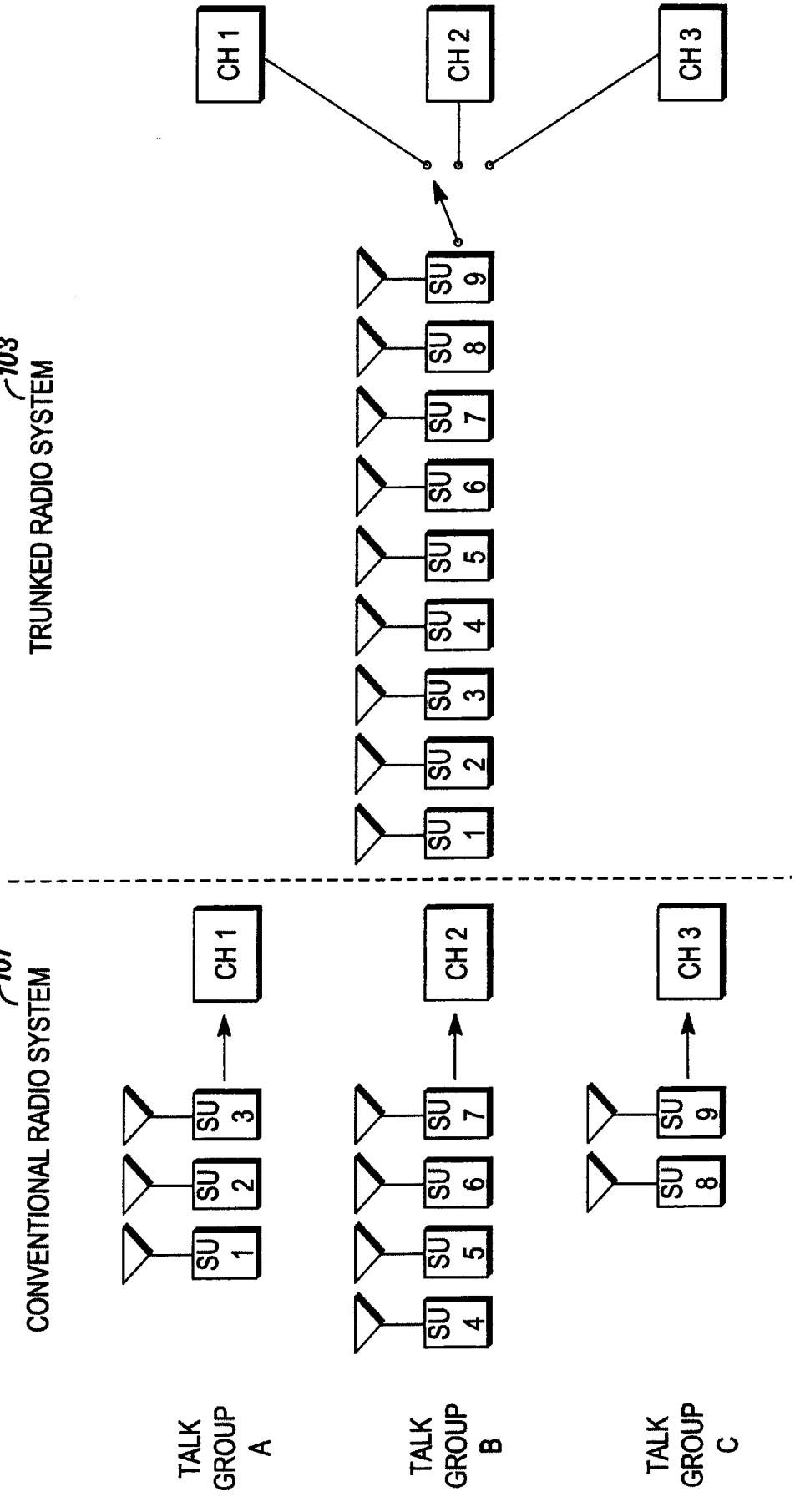
19. A wireless communication system (300) in accordance with any of claims 12-18, wherein:

at least one transceiver (320) in the network is assigned only a transmit frequency.

20. A computer-readable storage device having executable program code stored therein for programming signal processing logic to perform a method of frequency allocation in a wireless communication system providing two-way trunked communication, the wireless communication system (300) comprising a control element (330), a plurality of transceivers (312-324) and a plurality of mobile stations, the method comprising:

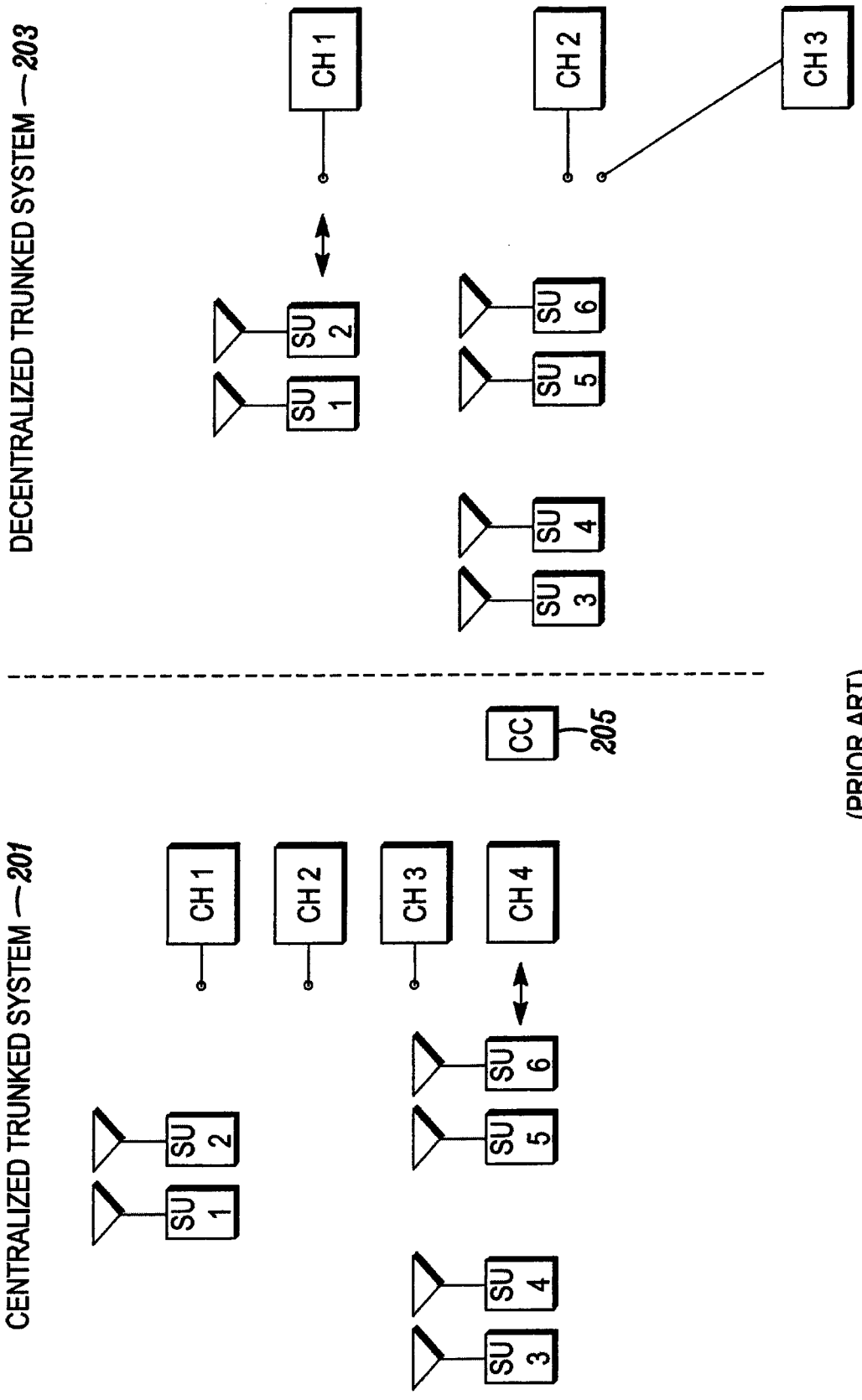
(i) for a call initiated at a control element (330) of the network, assigning, by the controller (305), only a first frequency, the first frequency for downlink communication from a transceiver (312) of the network to one or more mobile stations (350); and

(ii) for a call initiated by a mobile station (350), assigning, by the controller (305), second and third frequencies, the second frequency for uplink communication from the mobile station (350) to a transceiver (312) of the network, and the third frequency for downlink communication from a transceiver (312) of the network to one or more mobile stations (350).



(PRIOR ART)

FIG. 1



(PRIOR ART)

FIG. 2

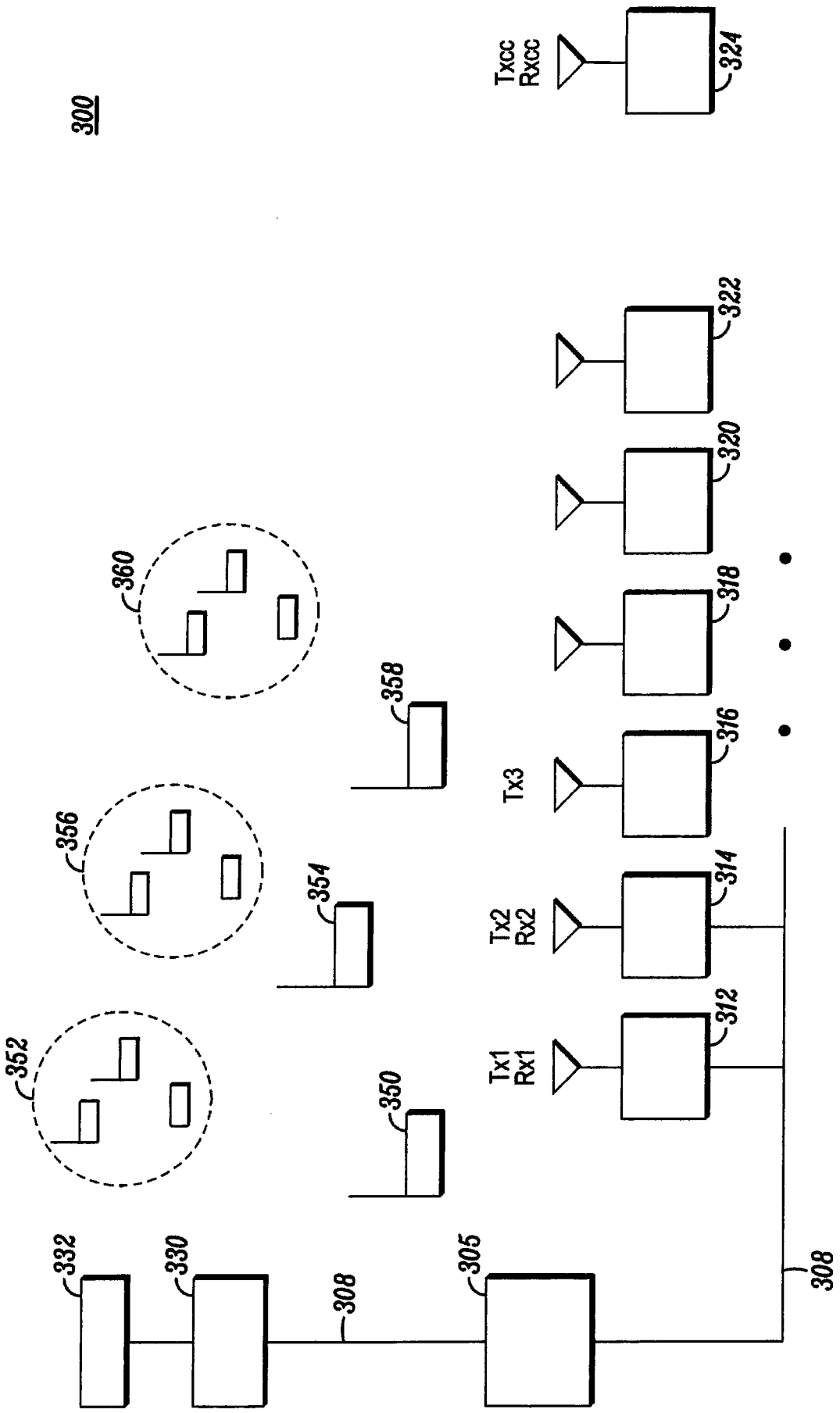

300
Txcc
Rxcc
324
322
320
318
316
Tx3
314
Tx2
Rx2
312
Tx1
Rx1
350
352
354
356
358
360
305
308
330
332
308

FIG. 3

TRANSCEIVER	CURRENT ACTIVITY	TRANSMIT FREQUENCY ASSIGNED TO TRANSCEIVER?	RECEIVE FREQUENCY ASSIGNED TO TRANSCEIVER?
312	SUPPORTING CALL FROM A SUBSCRIBER UNIT TO A TALK GROUP	YES	YES
314	TRANSMITTING CALL FROM A DISPATCH CONSOLE/ A DISPATCHER TO A TALK GROUP	YES	NO
316	SUPPORTING CALL FROM A SUBSCRIBER UNIT TO A TALK GROUP	YES	YES
318	SUPPORTING CALL FROM A SUBSCRIBER UNIT TO A TALK GROUP	YES	YES
320	TRANSMITTING CALL FROM A DISPATCH CONSOLE/ A DISPATCHER TO A TALK GROUP	YES	NO
322	SUPPORTING CALL FROM A SUBSCRIBER UNIT TO A TALK GROUP	YES	YES
324	RECEIVES REQUESTS FOR CALLS FROM SUBSCRIBERS, E.G. THOSE TUNED TO DISPATCHER CALLS	YES	YES
TOTAL NUMBER OF FREQUENCIES		SEVEN	FIVE

FIG. 4

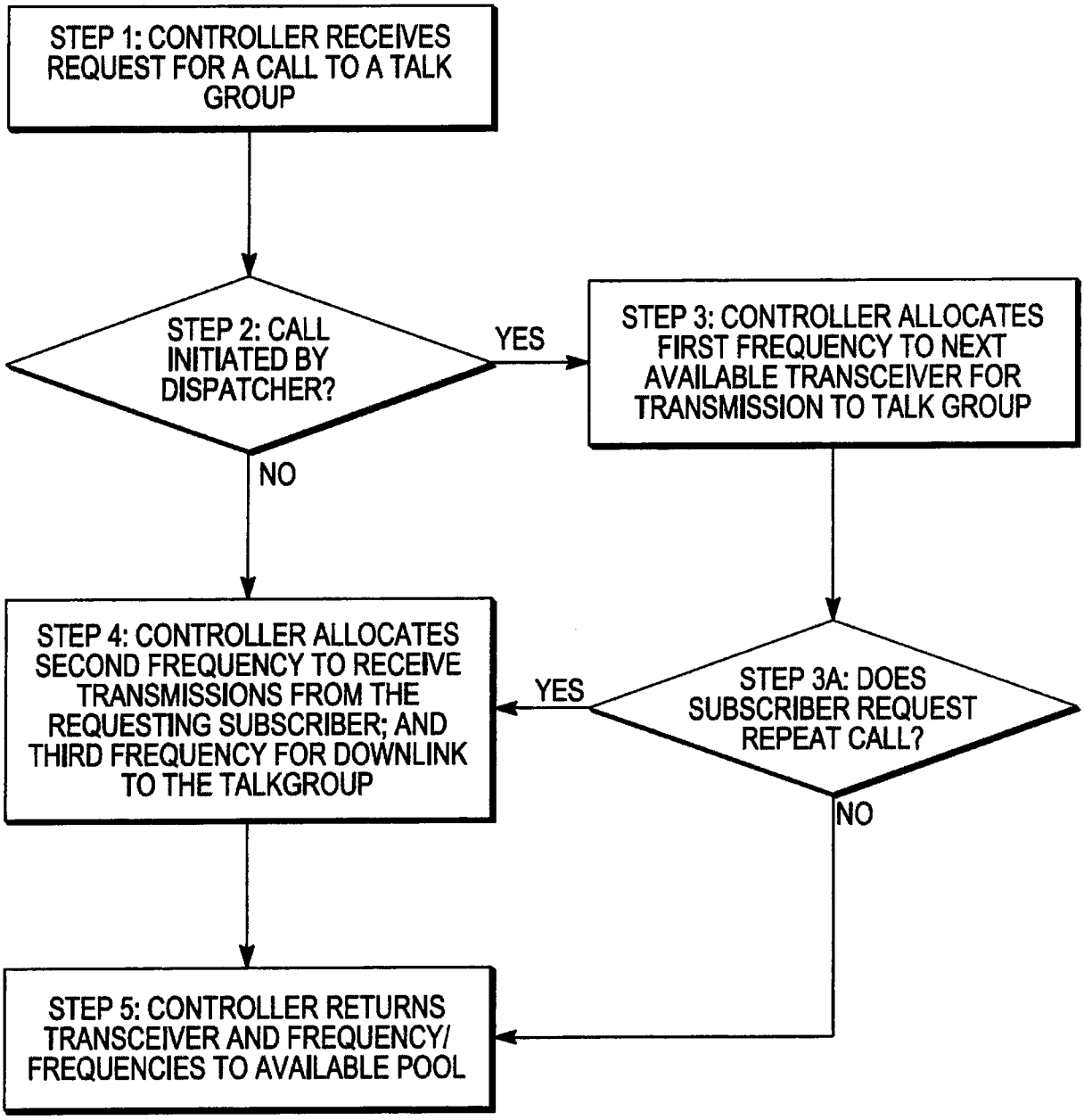

STEP 1: CONTROLLER RECEIVES REQUEST FOR A CALL TO A TALK GROUP
STEP 2: CALL INITIATED BY DISPATCHER?
YES
STEP 3: CONTROLLER ALLOCATES FIRST FREQUENCY TO NEXT AVAILABLE TRANSCEIVER FOR TRANSMISSION TO TALK GROUP
NO
STEP 4: CONTROLLER ALLOCATES SECOND FREQUENCY TO RECEIVE TRANSMISSIONS FROM THE REQUESTING SUBSCRIBER; AND THIRD FREQUENCY FOR DOWNLINK TO THE TALKGROUP
YES
STEP 3A: DOES SUBSCRIBER REQUEST REPEAT CALL?
NO
STEP 5: CONTROLLER RETURNS TRANSCEIVER AND FREQUENCY/ FREQUENCIES TO AVAILABLE POOL

FIG. 5

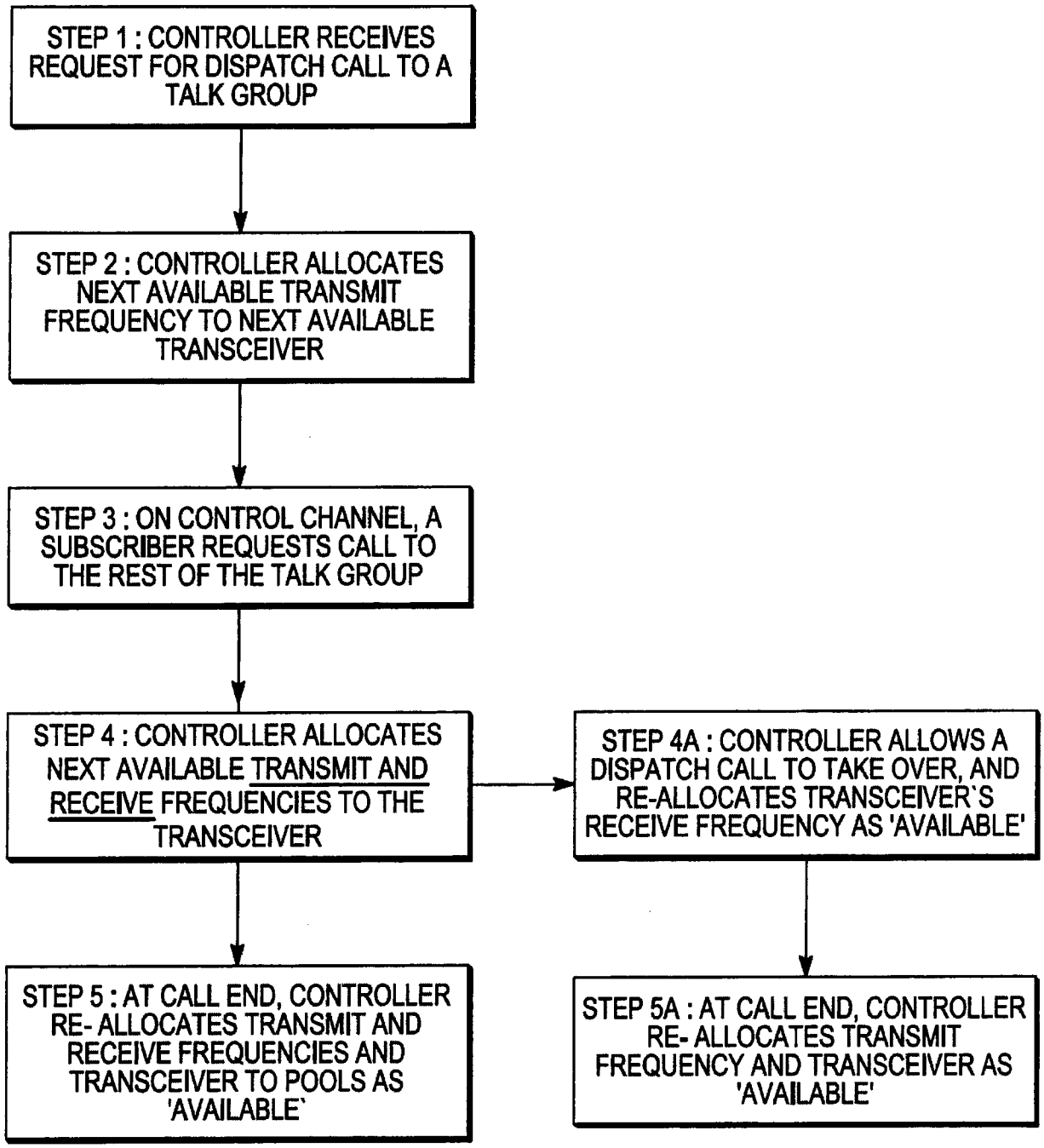

STEP 1 : CONTROLLER RECEIVES REQUEST FOR DISPATCH CALL TO A TALK GROUP
STEP 2 : CONTROLLER ALLOCATES NEXT AVAILABLE TRANSMIT FREQUENCY TO NEXT AVAILABLE TRANSCEIVER
STEP 3 : ON CONTROL CHANNEL, A SUBSCRIBER REQUESTS CALL TO THE REST OF THE TALK GROUP
STEP 4 : CONTROLLER ALLOCATES NEXT AVAILABLE TRANSMIT AND RECEIVE FREQUENCIES TO THE TRANSCEIVER
STEP 4A : CONTROLLER ALLOWS A DISPATCH CALL TO TAKE OVER, AND RE-ALLOCATES TRANSCEIVER`S RECEIVE FREQUENCY AS 'AVAILABLE'
STEP 5 : AT CALL END, CONTROLLER RE- ALLOCATES TRANSMIT AND RECEIVE FREQUENCIES AND TRANSCEIVER TO POOLS AS 'AVAILABLE`
STEP 5A : AT CALL END, CONTROLLER RE- ALLOCATES TRANSMIT FREQUENCY AND TRANSCEIVER AS 'AVAILABLE'

FIG. 6

MEAN NUMBER OF SIMULTANEOUS CALLS IN SIMULATION SCENARIO	NUMBER OF CHANNELS AVAILABLE	PROPORTION OF TIME FOR WHICH CONVENTIONAL COMMUNICATION SYSTEM WOULD BE UNAVAILABLE	PROPORTION OF TIME FOR WHICH SYSTEM WOULD NOW BE UNAVAILABLE	CONCLUSION
SCENARIO 1 : MEAN OF 6 CALLS STANDARD DEVIATION OF 3.9 IN CALL PATTERN	(I) 14 CHANNELS	1.06%	0.05%	IMPROVEMENT SUCH THAT 11 CHANNELS PROVIDE BETTER QUALITY OF SERVICE (QOS) THAN 14 CHANNELS WITH CONVENTIONAL SYSTEM
	(II) 11 CHANNELS	6.17%	0.99%	
SCENARIO 2 : MEAN OF 10 CALLS STANDARD DEVIATION OF 6.45 IN CALL PATTERN	(I) 24 CHANNELS	1.00%	0.035%	IMPROVEMENT SUCH THAT 19 CHANNELS PROVIDE BETTER QUALITY OF SERVICE (QOS) THAN 24 CHANNELS WITH CONVENTIONAL SYSTEM
	(II) 19 CHANNELS	6.05%	0.75%	
	(III) 18CHANNELS	8.19%	1.26%	
SCENARIO 3 : MEAN OF 13 CALLS STANDARD DEVIATION OF 7.8 IN CALL PATTERN	(I) 30 CHANNELS	1.06%	0.29%	IMPROVEMENT SUCH THAT 23 CHANNELS PROVIDE BETTER QUALITY OF SERVICE (QOS) THAN 30 CHANNELS WITH CONVENTIONAL SYSTEM
	(II) 23 CHANNELS	7.91%	1.03%	

TABLE SHOWING RESULTS FOR THREE SIMULATION SCENARIOS

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/PL2011/000119

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W84/08 H04W72/04
ADD.

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)
H04W

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 practicable, 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.
X	EP 1 804 530 A1 (HUAWEI TECH CO LTD [CN]) 4 July 2007 (2007-07-04) paragraphs [1], [16], [20]	1-20
A	GB 2 268 027 A (MOTOROLA INC [US]) 22 December 1993 (1993-12-22) abstract page 4, lines 4-25; page 5, line 26 - page 6, line 14; page 11, lines 10-28	1-20
A	US 5 363 427 A (EKSTROM TERRY G [US] ET AL) 8 November 1994 (1994-11-08) col. 2, lines 16-47, col. 3, lines 25-63; claim 1	1-20
A	EP 1 718 010 A2 (SAMSUNG ELECTRONICS CO LTD [KR]) 2 November 2006 (2006-11-02) cited in the application abstract	1-20

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

☒ See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent 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	Date of mailing of the international search report
1 June 2012	11/06/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Delucchi, Cecilia

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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