Title: SYSTEM AND METHOD FOR ASSIGNING FREQUENCY RESOURCES IN A THREE-HOP REPEATER

Abstract: A system and method for allocating frequency resources in a three-hop repeater are disclosed. Bandwidth can be allocated asymmetrically, and in non-contiguous blocks for the required bandwidth for a transmission operation. Bandwidth is dynamically allocated on an as-needed basis.

FIG. 1
SYSTEM AND METHOD FOR ASSIGNING FREQUENCY RESOURCES IN A THREE-HOP REPEATER

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority under 35 U.S.C. §119(e) to Provisional Application No. 62/074,553, filed November 3, 2014, titled "SYSTEM AND METHOD FOR ASSIGNING FREQUENCY RESOURCES IN A THREE-HOP REPEATER," the disclosure of which is hereby incorporated by reference herein in its entirety.

BACKGROUND

[0002] Three-hop repeaters have proven to be effective instruments in combating weak or no coverage in various environments, such as residential homes and small businesses. A three hop repeater consists of two radiating elements: a donor element and a server element. In one implementation of such a system, the donor element is called a network unit, because this unit connects to a signaling network, and the server element is called a coverage unit, because this unit provides signal coverage inside of a home or business. The donor and server elements are typically separated in distance to allow the repeater to have higher gain than can be achieved in the case of repeater where the donor and server elements are close together or even integrated into one enclosure.

[0003] The connection between the donor and server elements can be made using any one of a number of different means. For example, the link can be made using a fiber cable, a copper cable, or wirelessly. In many cases, the available bandwidth on the connection between the donor and server is limited. Typically the way in which the repeater will deal with this is to have less relay bandwidth. Further, conventional repeater systems allocate bandwidth in a symmetrical way on the link between the donor and server elements to ensure than any service offered in the downlink is also offered in the uplink direction.
SUMMARY

[0004] This document discloses a system and method to optimize all available resources on the link between the donor and server elements in a three-hop repeater to achieve the maximum relay bandwidth and system utility.

[0005] The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] These and other aspects will now be described in detail with reference to the following drawings.

[0007] FIG. 1 illustrates a three-hop repeater system for assigning frequency resources.

[0008] FIG. 2 shows an exemplary method for assigning frequency resources.

[0009] FIG 3 shows an exemplary method for de-assigning frequency resources.

[0010] Like reference symbols in the various drawings indicate like elements.

DETAILED DESCRIPTION

[0011] This document describes a system and method for assigning frequency resources in a three-hop repeater, to optimize all available resources on the link between the donor and server elements of the three-hop repeater to achieve the maximum relay bandwidth and system utility.

[0012] FIG. 1 illustrates a three-hop repeater system100 for spectrum allocation between a donor element 110 and a server element 15 of the three-hop repeater system 100. The donor element 110, which is also referred to as the network unit, sends and receives
signals from a signaling network 130, for example a cellular phone network. The server unit 115, which is also referred to as the coverage unit, sends and receives signals from a mobile device 140, such as a cellular phone. The bandwidth on the link 120 between the donor 110 and server 115 can be allocated asymmetrically, as opposed to allocating bandwidth in a symmetrical way on this link 120. Further, bandwidth in any direction does not need to be allocated in a contiguous block. Accordingly, the required relay bandwidth can be allocated in more than one block and "re-assembled" in either the donor 110 or server 115 system.

[0013] Bandwidth is allocated dynamically on an as needed basis, for example in the system shown in FIG. 1. In other words, not all frequencies may need to be relayed at all times if the system is able to detect the need to relay a frequency in real time and act accordingly. When additional relay bandwidth is needed on link 120, the repeater can find an available spectrum and allocate this available spectrum to link 120 to be used to relay signals through the repeater. For example, the repeater can use spectrum in an approximate 3650-3700MHz range as part of the relay spectrum used in link 120. As such, the availability check can include a check for other interfering signals in this bandwidth prior to allocation to link 120. This check for interference can be done by the donor system or server system and in some cases the system that conducts the interference check is the one attempting to send or retrieve information. Finally, the system may also be required to register the location of the transmitter, such as if required by FCC regulation.

[0014] An example of how the system operates is discussed with respect to the system 100 shown in FIG 1. In this case, the system 100 operates as follows. The booster 105 will attempt to allocate two 40MHz blocks 124 between 5470 and 5850MHz to relay 80MHz of CMRS (commercial mobile radio service) bandwidth in the downlink direction on link 120. If only one block of 40MHz could be found in this frequency range due to spectrum congestion, the spectrum in the 3650-3700MHz range 122 will be used on link 120. Before accessing the spectrum in the 3650-3700MHz range 122, the system will scan for interference and also automatically register the device for operation in this band at this location by contacting a database designated by the FCC to store the location of transmitters.
in this frequency band. The large amount of spectrum is required in the downlink to ensure
that all CMRS services are made available to handsets in the area with weak or no coverage.

[0015] In the uplink direction (handset 140 to base station 115), less spectrum is
required as a limited number of handsets 140 in the coverage area of the booster 105 does not
use all the available spectrum resources. The system 100 will allocate one 40MHz spectrum
block in the 5150-5350MHz band 123 to uplink transmissions on link 120. A second band in
the 3500-3650MHz range 121 will be reserved in case more than 40MHz of uplink
bandwidth is required. This reservation will be made by scanning for interference and also
checking a database to see what spectrum is available at this location, and registering as a
transmitter in this area.

[0016] The system 100 will monitor all uplink frequencies that are assigned to the
CMRS provider, and upon detecting activity in any band, dynamically use the 40MHz
spectrum in the 5GHz band to relay the signal to the base station over link 120. Should more
than 40MHz of uplink bandwidth be required, the system will dynamically start using the
spectrum in the 3500-3650MHz range in blocks of 5MHz as a "spill-over" frequency
resource.

[0017] FIG. 2 shows an exemplary method 200 for assigning frequency resources in a
booster system. In this method 200, the system described is similar to that shown in FIG. 1,
and is, for example, a three-hop repeater. In either a downlink direction or an uplink
direction on the middle hop of the three-hop repeater, in which the middle hop is between a
network unit (i.e. donor unit or element) and a coverage unit (i.e. server unit or element), a
band is selected for a transmission operation, in 210. In some implementations, the band is
selected from an unlicensed or general use band of frequencies. Once a band is selected for
the transmission operation, the selected band is scanned for interference, in 220. In this way,
the system can select the band that yields the best signal, as described above with respect to
FIG. 1. Following scanning the band for interference, an allocation of a center frequency of
the selected band can be made dynamically, and the required bandwidth can also be allocated
at this time, in 230. For example, dynamic allocation can mean that the actual frequencies
used on link 120 could be different every time the spectrum is allocated based on changing
interfering conditions and spectrum bandwidth requirements. In each allocation, the system can make a spectrum and bandwidth allocation that will optimize the overall system performance. The required bandwidth can be allocated in one or more noncontiguous blocks of spectrum. The system also registers either the network unit or the coverage unit for the transmission operation, in 240, as required.

For example, when spectrum is dynamically allocated and the total potential relay bandwidth is larger than the available spectrum on the middle hop of a three hop repeater, more frequency resources can be available to relay signals in the downlink direction than in the uplink direction on the middle hop of the repeater. As such, as much frequency resources as possible can be allocated to the downlink direction as this would allow the largest number of handsets to receive signal coverage. In the uplink direction, frequency resources are only required when an uplink transmission is in progress and hence the allocation of frequency resources can be made dynamically. However, if no frequency allocation can be made in the uplink direction, such as due to lack of available interference free spectrum, the allocated frequency resources in the downlink direction can be de-allocated and relaying of the paired downlink spectrum can be stopped in order to prevent different path loss between the base station and the handset in the uplink and downlink directions.

FIG 3 shows an exemplary method 300 for de-assigning frequency resources in a booster system. In this method 300, the system described is similar to that shown in FIG. 1, and is, for example, a three-hop repeater. The three-hop repeater can detect the need for uplink frequency resources by detecting the start of an uplink transmission on an uplink frequency in 310. The repeater can attempt to dynamically allocate spectrum to relay the uplink transmission using a method such as the one described in 200. If no spectrum is available to relay the uplink transmission, the paired downlink signal can be identified, as in 330. As shown in 340, the downlink frequency resources can be de-allocated and the downlink relaying can be stopped.
Although a few embodiments have been described in detail above, other modifications are possible. Other embodiments may be within the scope of the following claims.
CLAIMS

What is claimed is:

1. A method of assigning frequency resources in a three-hop repeater, in either a downlink direction or uplink direction on a middle hop of the three-hop repeater, the middle hop being between a network unit and a coverage unit, the method comprising:
   selecting a transmission band for a transmission operation;
   scanning the transmission band for interference to the transmission operation;
   and
   dynamically allocating a center frequency and a required bandwidth for the transmission operation within the transmission band, the allocation being based on a lowest interference within the transmission band.

2. The method in accordance with claim 1, wherein the middle hop of the three-hop repeater uses an unlicensed or general use band of frequencies.

3. The method in accordance with claim 1, wherein the middle hop of the three-hop repeater uses a licensed band of frequencies that requires registration of either the network unit or coverage unit for the transmission operation.

4. The method in accordance with claim 2, wherein the required bandwidth is allocated in one or more noncontiguous blocks of spectrum of the unlicensed or general use band of frequencies.

5. A method of dynamically assigning frequency resources in a three-hop repeater in the uplink direction on a middle hop of the three-hop repeater, the middle hop being between a network unit and a coverage unit, the method comprising:
   detecting a need to assign frequency resources based on a detection of uplink traffic;
   selecting a transmission band for a transmission operation;
scanning the transmission band for interference to the transmission operation; and

dynamically allocating a center frequency and a required bandwidth for the transmission operation within the transmission band, the allocation being based on a lowest interference within the transmission band.

6. The method in accordance with claim 5, wherein the middle hop of the three-hop repeater uses an unlicensed or general use band of frequencies.

7. The method in accordance with claim 5, wherein the middle hop of the three-hop repeater uses a licensed band of frequencies that requires registration of either the network unit or coverage unit for the transmission operation.

8. The method in accordance with claim 6, wherein the required bandwidth is allocated in one or more noncontiguous blocks of spectrum of the unlicensed or general use band of frequencies.

9. A method for dynamically de-assigning frequency resources in a three-hop repeater in the downlink direction on a middle hop of a three-hop repeater, the middle hop being between the network unit and coverage unit for boosting and relaying signals between the network unit and the coverage unit, the method comprising:

detecting a need to assign frequency resources in the uplink direction based on a detection of uplink traffic;

if no additional frequency resources are available in the uplink direction for a transmission operation, finding frequency resources currently assigned in the downlink direction to relay a downlink signal for whose paired uplink transmission no frequency resources was available; and

de-assigning the frequency resources in the downlink direction so that the downlink signal is no longer boosted.
10. The method in accordance with claim 9, wherein the middle hop of the three-hop repeater uses an unlicensed or general use band of frequencies.

11. The method in accordance with claim 9, wherein the middle hop of the three-hop repeater uses a licensed band of frequencies that requires registration of either the network unit or coverage unit for the transmission operation.

12. The method in accordance with claim 10, wherein a required bandwidth is allocated in one or more noncontiguous blocks of spectrum of the unlicensed or general use band of frequencies.
121
1 or 2 Blocks of 5MHz each if needed
Handset to Base Station direction

122
1 Block of 40MHz if needed to achieve 80MHz
Base station to handset direction

123
1 or 2 blocks of 40MHz
Handset to Base Station Direction

124
1 or 2 blocks of 40MHz
Base Station to Handset Direction

130
Unlicensed and/or general use bands

140
Cell Frequency bands (e.g. AWS, PCS, Cellular)

FIG. 1
210
Select a band for a transmission operation in either a downlink direction or uplink direction on a middle hop of a three-hop repeater.

220
Scan the selected band for interference.

230
Dynamically allocate a center frequency of the selected band and required bandwidth for the transmission operation. The required bandwidth can be allocated in one or more noncontiguous block of spectrum.

240
Register either the network unit or the coverage unit of the three-hop booster for the transmission operation.

FIG. 2
300

310
Detect the need to assign frequency resources on the middle hop of a three-hop repeater to relay transmissions in the uplink direction.

320
Attempt to allocate relay spectrum using the method 200.

330
If no spectrum is available to be assigned, identify the paired downlink signal for whose active uplink transmission no relay bandwidth could be assigned on the middle hop of the repeater.

340
De-assign the spectrum allocated in the downlink direction on the middle hop of the repeater, thereby stopping relaying of the specific downlink and uplink transmissions for which no frequency resources could be dynamically allocated.

FIG. 3
INTERNATIONAL SEARCH REPORT

PCT/US2015/058893

A. CLASSIFICATION OF SUBJECT MATTER

According to International Patent Classification (IPC) and national classification and IPC

INVI. H04W72/04 H04W72/08

ADD.

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:

**A** document defining the general state of the art which is not considered to be of particular relevance

**E** 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

**S** document member of the same patent family

Date of the actual completion of the international search 12 January 2016

Date of mailing of the international search report 30/03/2016

Name and mailing address of the ISA/

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Authorized officer

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Form PCT/ISA/210 (second sheet) (April 2005)
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This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

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

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

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

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

see additional sheet

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

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

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

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

1-8

Remark on Protest

□ The additional search fees were accompanied by the applicant’s protest and, where applicable, the payment of a protest fee.

□ The additional search fees were accompanied by the applicant’s protest but the applicable protest fee was not paid within the time limit specified in the invitation.

□ No protest accompanied the payment of additional search fees.
This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-8
   transmission band selection and allocation based on interference measurements

2. claims: 9-12
   asymmetric frequency band distribution between uplink and downlink by de-allocation of downlink frequencies to be allocated to uplink frequencies based on uplink traffic load needs.
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