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ELECTRONIC RETAILING SYSTEMS INT'L INC. [/]; (). CARDANI, Lawrence, A. [/]; (). KELLEY, Ted [/]; (). CARDANI, Lawrence, A. [/]; (). KELLEY, Ted [/]; (). OPPEDAHL, Carl ; ().

Published

(54) **Title: TARGETED FREQUENCY SELECTION FOR TWO-WAY WIRELESS COMMUNICATION SYSTEM**
(54) **Titre: SELECTION DE FREQUENCE CIBLEE POUR SYSTEME DE COMMUNICATION BIDIRECTIONNEL SANS FIL**

(57) Abstract

Multiple previously successful frequencies (33) for a single electronic shelf label (ESL) are stored (35), and then this stored information in used to help select each frequency that may be attempted for communication with that ESL (10). Thus, the invention increases the probability of success for the second, third, fourth, etc. frequencies (34) that might be selected when attempting to communicate with an ESL (10). The host computer (1) is disposed to save multiple previously successful frequencies only for ESLs that have been difficult to communicate with (45). This optimization avoids unnecessarily storing multiple data items about previously successful frequencies (43) for ESLs with which it is easy to communicate.

(57) Abrégé

L'invention concerne un procédé consistant à mémoriser une pluralité de fréquences (33) qui se sont préalablement avérées valables pour une étiquette électronique de rayon (EER), et à utiliser cette information mémorisée pour contribuer à sélectionner chaque fréquence pouvant être essayée afin d'établir une communication avec cette étiquette (10) électronique de rayon. Cette invention permet ainsi d'accroître la probabilité de succès pour la seconde, troisième, quatrième fréquence (34) etc. pouvant être sélectionnée lors d'une tentative de communication avec une (10) électronique de rayon. L'ordinateur (1) hôte est conçu pour mémoriser une pluralité de fréquences préalablement valables uniquement pour les étiquettes électroniques pour lesquelles la communication a été difficile à établir (45). Cette optimisation permet d'éviter la mémorisation inutile de données multiples concernant des fréquences (43) préalablement valables pour les étiquettes électroniques avec lesquelles la communication est facile à établir.

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Published
With international search report.

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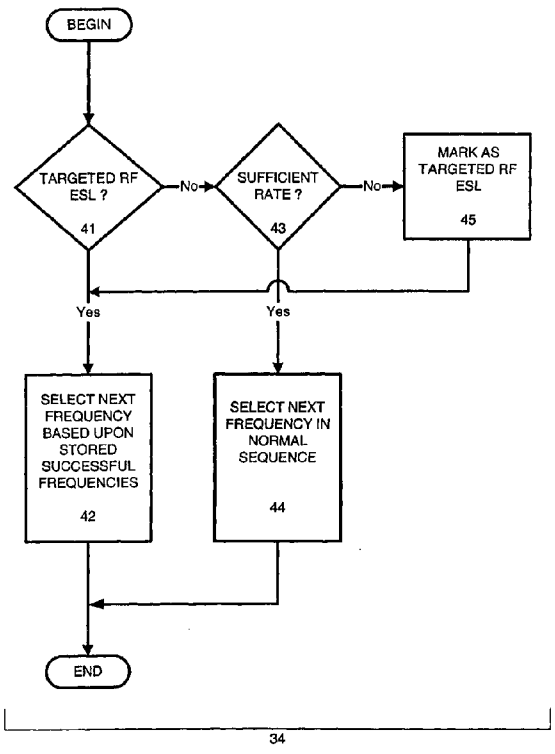
(57) Abstract

Multiple previously successful frequencies (33) for a single electronic shelf label (ESL) are stored (35), and then this stored information in used to help select each frequency that may be attempted for communication with that ESL (10). Thus, the invention increases the probability of success for the second, third, fourth, etc. frequencies (34) that might be selected when attempting to communicate with an ESL (10). The host computer (1) is disposed to save multiple previously successful frequencies only for ESLs that have been difficult to communicate with (45). This optimization avoids unnecessarily storing multiple data items about previously successful frequencies (43) for ESLs with which it is easy to communicate.



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Description

TARGETED FREQUENCY SELECTION FOR TWO-WAY WIRELESS COMMUNICATION SYSTEM

This application claims priority from US application number 60/125,001, filed March 18, 1999, which application is hereby incorporated herein by reference.

BACKGROUND

The invention relates generally to store price display systems controlled by a host computer that communicates pricing information to individually addressable price display devices through a low-power, wireless, two-way communication system, and relates more particularly to reducing communications problems by varying the frequency of signals used to communicate with ESLs.

An electronic shelf label (ESL) system comprises many individual, addressable ESLs in a store, typically 15,000 or more. ESLs might be located almost anywhere in a store, including, but not limited to, shelf edges, peghook displays, produce areas, free-standing display tables, display cases, wire bins, and other merchandising displays and fixtures.

A wireless ESL system typically comprises one or more ceiling mounted antennas (Cell Antennas) connected to transceivers that permit two-way communication between the host computer and the ESLs. Prior art systems for accomplishing this include, but are not limited to, those disclosed in World Intellectual Property Organization International Publication Number WO 96/27957, for International Application No. PCT/US96/03065 (the "'957 Publication"), entitled "LOW POWER TWO-WAY WIRELESS COMMUNICATION SYSTEM FOR ELECTRONIC SHELF LABELS", which is hereby incorporated herein by reference.

The propagation of wireless signals inside a store using a wireless ESL system can be affected by factors that can change over time, including, but not limited to the relative positions of Cell Antennas and ESLs; the type, quantity and location of merchandise in the store; the types and locations of merchandising displays and fixtures; the numbers and locations of customers; and the presence and locations of carts, baskets and other mobile objects.

The communications frequencies used in a wireless ESL system can strongly

influence the propagation of wireless signals inside a store.

In a first case, at a first time, it might be difficult to communicate with a particular ESL using a first communications frequency but easy to communicate with the same ESL using a second communications frequency. For example, and not by way of limitation, destructive interference arising from multipath propagation might interfere with transmissions to or from the ESL at the first frequency but not at the second frequency.

In a second case, a communications frequency that permits reliable communication with a particular ESL at one time might not permit reliable communication with the same ESL at a different time. For example, and not by way of limitation, moving objects in the store might create or destroy reflected propagation paths.

Prior art systems deal with multipath and other propagation problems in various different ways. A first general approach is to decrease cell size so that each ESL is reachable by more than one Cell Antenna. When a label is unresponsive in such a system (which may be due to multipath or other causes), the system then tries a different cell antenna. The assumption is that the physical objects giving rise to the multipath (or other) effect will be unlikely to give rise to a multipath node (or to have the same effect) for the different antenna. A second general approach, the "frequency agile" approach, is to establish several different frequencies to be used for the downlink and/or uplink and to change communications frequencies when problems are encountered. For example, the '957 Publication suggests two different methods for selecting a communications frequency

Method 1. a store's central computer could always try a particular frequency first for all ESLs, and then shift to a second frequency for any labels that failed to respond to the first frequency, and so on (See '957 Publication at page 30 lines 9-12); or

Method 2. a store's central computer could keep note, for each ESL, of the frequency that worked the last time that ESL was communicated with and each subsequent attempt to reach that ESL could start with the stored frequency (See '957 Publication at page 29 lines 11-18).

Unfortunately, these prior art examples of the frequency agile approach can result in various inefficiencies.

Method 1, always trying the same frequency first, can waste time (thereby reducing the effective bandwidth of the wireless system) if an ESL rarely or never is able to

communicate using that first frequency (or perhaps even the first several frequencies tried for each message). Method 2 improves upon Method 1, because Method 2 avoids repeatedly starting with a frequency that rarely or never works for a particular ESL. However, with Method 2, if the first frequency tried for a message does not work, then the second and subsequent attempts are no more likely to be successful than would be the second and subsequent attempts of Method 1. That is, Method 2 offers no suggestion of what frequency to try next if the first attempt fails. Consequently, while Method 2 improves the probability that the first frequency selected will be successful, it does not improve the probability that the second or subsequent frequency will be successful.

SUMMARY OF THE INVENTION

The invention improves upon the prior art Method 2 for the frequency agile approach by storing multiple previously successful frequencies for a single ESL and then using this stored information to help select each frequency that may be attempted for communication with that ESL. Thus, the invention increases the probability of success for the second, third, fourth, etc. frequencies that might be selected when attempting to communicate with an ESL.

The invention also improves upon the prior art by requiring the host computer to save multiple previously successful frequencies only for ESLs that have been difficult to communicate with. This optimization avoids unnecessarily storing multiple data items about previously successful frequencies for ESLs with which it is easy to communicate.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be described with respect to a drawing in several figures, of which

Fig. 1 shows in block diagram form exemplary components of the store electronic shelf label system;

Fig. 2 shows in perspective view an exemplary electronic shelf label;

Fig. 3 shows a flowchart for frequency-agile communication with an electronic shelf label in accordance with the invention; and

Fig. 4 shows a flowchart for selecting a next frequency in accordance with the

invention.

Where possible, like elements have been denoted with like reference numerals.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Fig. 1 provides context for the invention by showing a general overview of a typical store electronic shelf label system. In the embodiment shown in Fig. 1, a multiplicity of electronic shelf labels 10, 10' etc. are dispersed throughout the store. The ESLs are controlled by a store central computer 1. The central computer 1 contains records indicative of the information (e.g. price) that is to be displayed by each ESL. The central computer 1 is communicatively coupled with the multicell controller 3 by a bidirectional link 2. The multicell controller 3 is connected via multiple bidirectional data lines 4 to multiple cable interfaces 5. Each cable interface 5 is connected to a cell controller 7 by a bidirectional cable 6. Each cell controller controls a transmitting antenna 8 and a receiving antenna 12. The multiple pairs of antennas 8, 12 effectively divide the store into "cells". Each cell is served by one pair of antennas 8, 12. Transmitting antenna 8 sends wireless signals 9 to ESLs 10, 10', etc. Dotted lines 9 denote RF energy coupled through the air between the store transmit antenna 8 and an antenna within the ESLs 10, 10'. ESLs 10, 10', etc. receive wireless signals 9, process them, and transmit wireless signals 11 to receiving antenna 12. Dotted lines 11 denote RF energy coupled through the air between ESLs 10, 10' and store receiving antenna 12. Each cell controller 7, each antenna 8, 12, and each ESL 10, 10', etc., is capable of communicating using multiple different carrier frequencies. In a preferred embodiment, such communication is performed using a spread spectrum signal based upon a carrier frequency selected by central computer 1.

For purposes of this Application, the phrase "carrier frequency" in the context of a spread spectrum signal, means the frequency of the RF oscillator whose output is being spread. For example, and not by way of limitation, the phrase "carrier frequency" as used in this Application would mean the frequency of oscillator 10 in Fig. 1 of the '957 Publication.

Fig. 2 shows an electronic shelf label 10 with a liquid crystal display 21 suitable for displaying the price of an item offered for sale in a store. Each ESL 10 may be mounted next to a relatively unpredictable variety of metal and plastic store shelves, and may be attached

directly to a metal or plastic rail on the shelf edge. Each ESL 10 also contains a processor, a battery, an antenna, and analog circuitry relating to sending and receiving information via an antenna.

Fig. 3 shows a flowchart for frequency-agile communication with an ESL in accordance with the invention. In an exemplary embodiment, store central computer 1 selects 31 a first frequency. This selection could be done in any way, including, but not limited to, always selecting the same first frequency for all attempted communications or always selecting the last frequency that was successful in communicating between the applicable cell controller 7 and ESL 10.

Next, cell controller 7 attempts to communicate with ESL 10 by transmitting a message addressed to ESL 10 using the first frequency and then listening for a response from ESL 10.

If cell controller 7 receives a response from ESL 10, then central computer 1 determines 33 that the communication was successful and stores 35 information which indicates that cell controller 7 successfully communicated with ESL 10 using that frequency. (Note that different frequencies might work differently for different cell controllers even when communicating with the same ESL.) This information could be stored in any way that will later allow central computer 1 to recall what frequencies have been successful for communicating between cell controller 7 and ESL 10. For example, and not by way of limitation, this information could be stored as (i) a list, where each element of the list identifies at least a cell controller, an ESL and a successful frequency or (ii) a three dimensional array in which (a) the first dimension identifies a cell controller, the second identifies an ESL and the third identifies a frequency and (b) each cell in the array contains at least one element that is set to a specified value if communication between the applicable cell controller and the applicable ESL is successful at the applicable frequency. What is important is that central computer 1 is able to recall frequencies that have been successful for communicating between a particular cell controller and a particular ESL.

If cell controller 7 does not receive a response from ESL 10, then central computer 1 determines 33 that the communication was not successful and selects 34 a next frequency to try. (Fig. 4, discussed below, shows a flowchart for one method of making such a selection.) Cell controller 7 then attempts 32 to communicate with ESL 10 using the new frequency.

This process can be repeated as many times as necessary until cell controller 7 successfully communicates with ESL 10. Once the communication is successful, then, as described above, central computer 1 stores 35 information which indicates that cell controller 7 successfully communicated with ESL 10 using the last frequency tried.

In an alternative embodiment of the invention, the first frequency is selected using the method illustrated in Fig. 4. In another alternative embodiment, the first frequency is always selected based upon previously stored successful frequencies

Fig. 4 shows a flowchart for selecting a next frequency to use for communicating between a cell controller 7 and an ESL 10 in accordance with one embodiment of the invention.

First, central computer 1 examines information stored in its memory to determine 41 whether ESL 10 has previously been "marked" as a "Targeted RF ESL". For purposes of this application, an ESL is marked as a Targeted RF ESL if information stored in the system will cause the central computer 1 to determine that the ESL is so marked. For example, and not by way of limitation, central computer 1 might mark ESL 10 as a Targeted RF ESL by setting a bit in a binary array or by adding it to a list of ESLs. Note that if multiple cell controllers are able to communicate with a particular ESL, then that ESL might be a Targeted RF ESL with respect to one such cell controller but not the other.

If ESL 10 has been marked as a Targeted RF ESL, then central computer 1 selects 42 a next frequency to try based upon previously successful frequencies stored in central computer 1. For example, and not by way of limitation, the central computer could be programmed to select only frequencies that match predetermined selection criteria given the saved set of successful frequencies for ESL 10. For example, and not by way of limitation, the predetermined selection criteria could be limited to an exact match with a previously successful frequency or could be extended to include frequencies that are within a particular range of one of the saved successful frequencies.

If ESL 10 has not been marked as a Targeted RF ESL, then central computer 1 determines 43 whether the communication success rate between cell controller 7 and ESL 10 is sufficiently high. This determination could, for example, and not by way of limitation, be based upon an automated algorithm or user selection. For example, and not by way of limitation, a communications success rate could be deemed insufficient if some

predetermined percentage of attempted communications failed during some predetermined interval or if some predetermined number of attempted communications failed during some predetermined interval.

If the communication success rate is sufficiently high, then central computer 1 selects 44 the next frequency using a normal sequence of frequencies.

If the communication success rate is not sufficiently high, then central computer 1 marks 45 ESL 10 as a Targeted RF ESL and selects 42 a next frequency based upon previously successful frequencies stored in central computer 1 as described above.

In an alternate embodiment of the invention, the next frequency is always selected based upon previously stored successful frequencies for the applicable cell controller 7 and ESL 10, and steps 41, 43, 44 and 45 are eliminated.

Those skilled in the art will appreciate that numerous obvious modifications and variations could be made to the invention without departing from it in any way. All these obvious modifications and variations are intended to be encompassed within the scope of the claims.

Claims

CLAIMS

We claim

1. A method comprising

(a) for each of one or more successful frequencies

(i) transmitting a message addressed to a first address using such successful frequency as a carrier frequency,

(ii) receiving a reply to such message using such successful frequency as a carrier frequency, and

(iii) storing such successful frequency;

(b) selecting a first carrier frequency;

(c) transmitting a first message addressed to the first object using the first carrier frequency;

(d) listening for a reply to the first message using the first carrier frequency;

(e) not receiving a reply to the first message using the first carrier frequency;

(f) selecting a second carrier frequency based upon the successful frequencies.

2. The method of claim 1, wherein the second carrier frequency is one of the successful frequencies.

3. The method of claim 1, wherein the second carrier frequency differs by no more than a predetermined amount from at least one of the successful frequencies.

4. The method of claim 1, wherein the second carrier frequency is selected based upon more than one of the successful frequencies.

5. A method comprising

(a) for each of one or more successful frequencies

(i) transmitting a message addressed to a first address using such successful frequency as a carrier frequency,

(ii) receiving a reply to such message using such successful frequency as a carrier frequency, and

(iii) storing such successful frequency;

(b) after step a, selecting a next carrier frequency based upon the successful frequencies, where the next carrier frequency is not equal to a last carrier frequency used to receive a reply to a transmitted message addressed to the first address.

6. The method of claim 5, wherein the next carrier frequency is one of the successful frequencies.

7. The method of claim 5, wherein the next carrier frequency differs by no more than a predetermined amount from at least one of the successful frequencies.

8. The method of claim 5, wherein the next carrier frequency is selected based upon more than one of the successful frequencies.

9. A system comprising

a transmitter;

a receiver;

one or more storage elements, each of which contains information that identifies a frequency for which both

(i) the transmitter transmitted a message addressed to a first address using such frequency as a carrier frequency and

(ii) the receiver received a reply to such message using such frequency as a carrier frequency;

a control means, communicatively coupled to the transmitter, the receiver and the storage elements, for

(i) causing the transmitter to transmit a first message addressed to a first address using a first carrier frequency;

(ii) causing the receiver to listen for a reply to the first message using the first carrier frequency;

(iii) if no reply to the first message is received within a predetermined time interval after the first message is transmitted, causing the transmitter to transmit a second

message addressed to the first address using a second carrier frequency that is selected based upon the contents of the storage elements.

10. The system of claim 9, wherein the second carrier frequency is a frequency identified by information contained in one of the storage elements.

11. The system of claim 9, wherein the second carrier frequency differs by no more than a predetermined amount from a frequency identified by information contained in at least one of the storage elements.

12. The system of claim 9, wherein the second carrier frequency is selected based upon the contents of more than one of the storage elements.

13. A system comprising

a transmitter;

a receiver;

one or more storage elements, each of which contains information that identifies a frequency for which both

(i) the transmitter transmitted a message addressed to a first address using such frequency as a carrier frequency and

(ii) the receiver received a reply to such message using such frequency as a carrier frequency;

a control means, communicatively coupled to the transmitter and the storage elements, for causing the transmitter to transmit a message addressed to the first address using a next carrier frequency that both (i) is selected based upon the contents of the storage elements and (ii) is not equal to a last carrier frequency used by the receiver to receive successfully a response to a message addressed to the first address that was transmitted by the transmitter.

14. The system of claim 13, wherein the next carrier frequency is a frequency identified by information contained in one of the storage elements.

15. The system of claim 13, wherein the next carrier frequency differs by no more than a predetermined amount from a frequency identified by information contained in at least one of the storage elements.

16. The system of claim 13, wherein the next carrier frequency is selected based upon the contents of more than one of the storage elements.

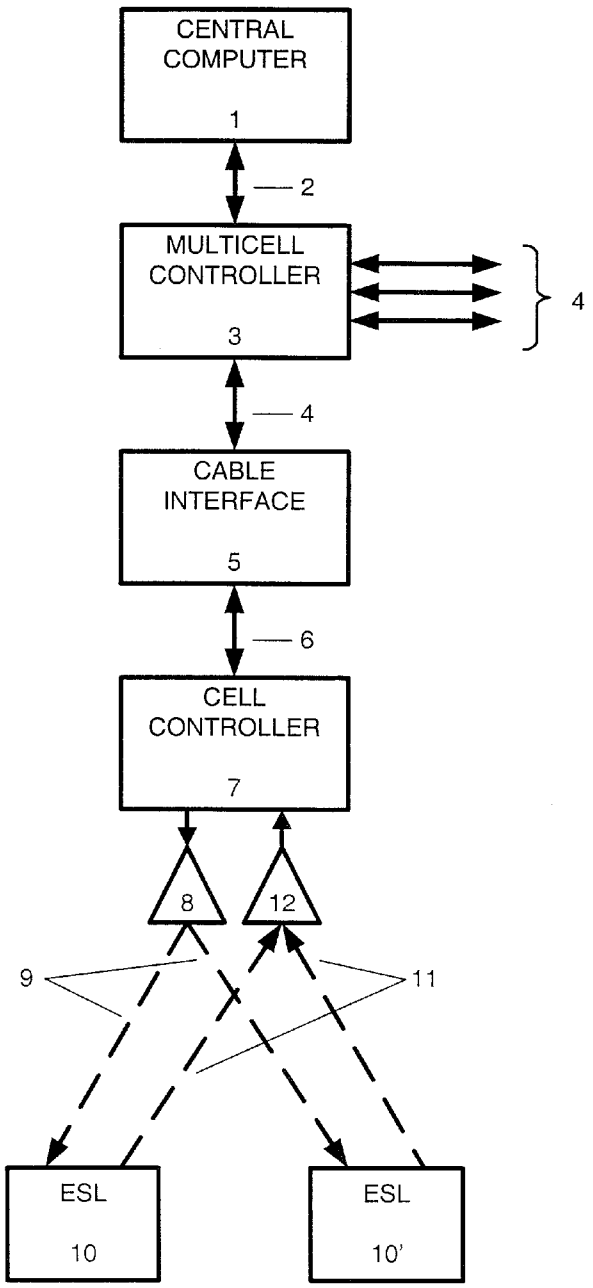
CENTRAL COMPUTER
1
2
MULTICELL CONTROLLER
3
4
4
CABLE INTERFACE
5
6
CELL CONTROLLER
7
8
12
9
11
ESL
10
ESL
10'

FIG. 1

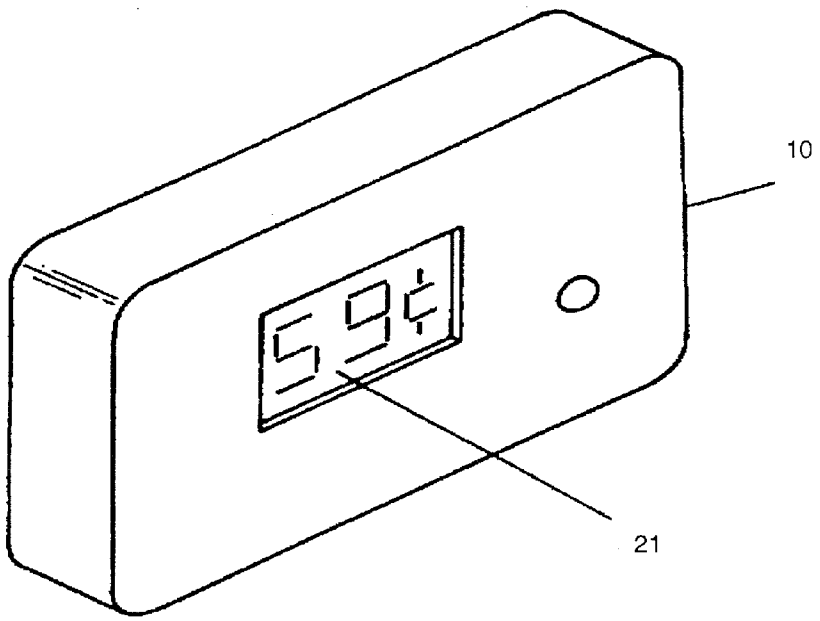

FIG. 2

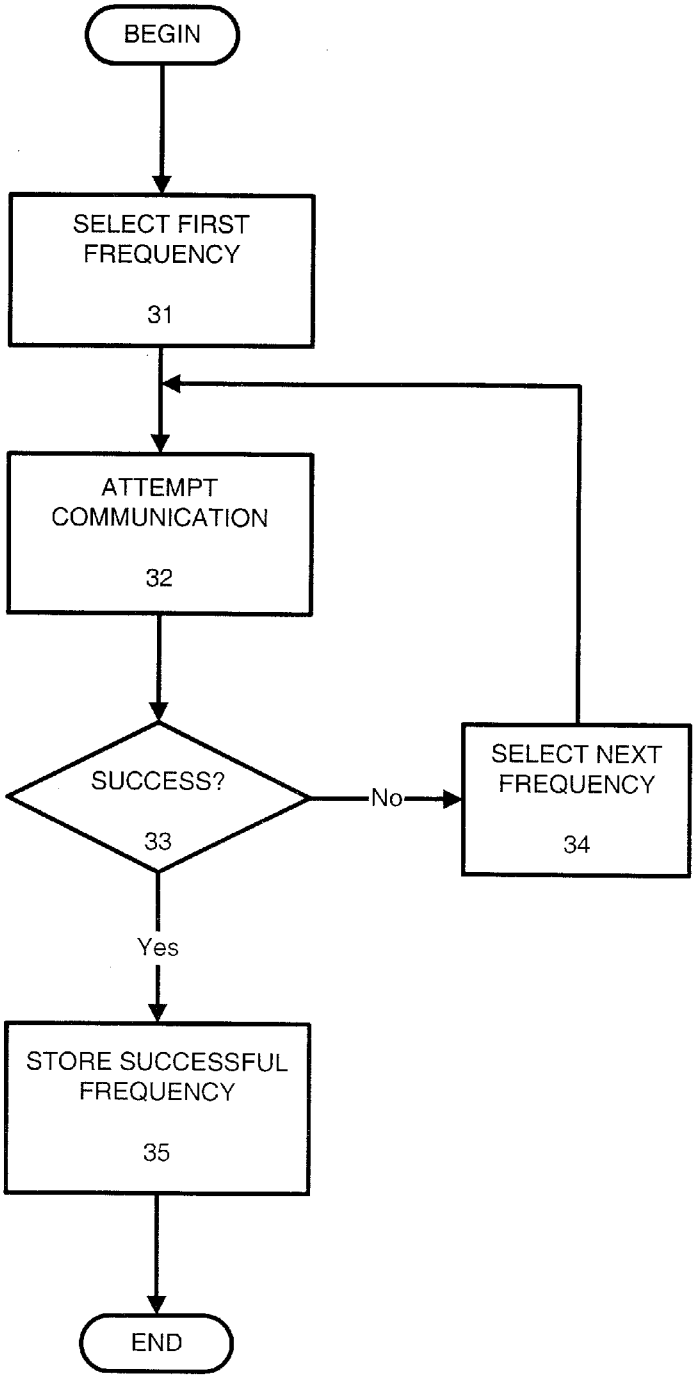
BEGIN
SELECT FIRST FREQUENCY
31
ATTEMPT COMMUNICATION
32
SUCCESS?
33
No
SELECT NEXT FREQUENCY
34
Yes
STORE SUCCESSFUL FREQUENCY
35
END

FIG. 3

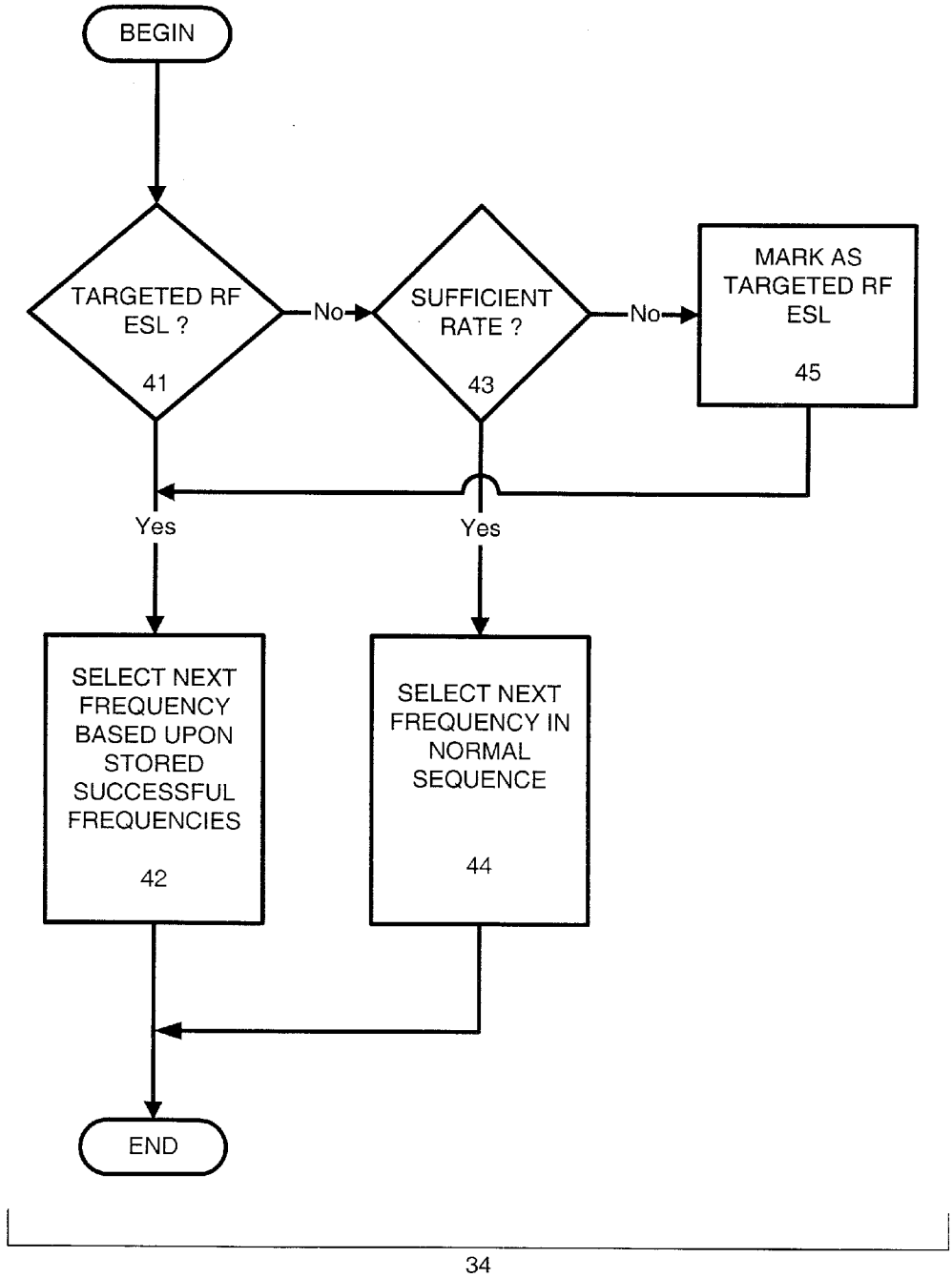
BEGIN
TARGETED RF ESL ?
41
No
SUFFICIENT RATE ?
43
No
MARK AS TARGETED RF ESL
45
Yes
Yes
SELECT NEXT FREQUENCY BASED UPON STORED SUCCESSFUL FREQUENCIES
42
SELECT NEXT FREQUENCY IN NORMAL SEQUENCE
44
END
34

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/06976

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :H04Q 7/20; H04B 1/38

US CL :455/450, 452, 447, 63, 67.3; 375/219

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)

U.S. : 455/450, 452, 447, 63, 67.3; 375/219

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)

EAST, WEST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,694,418 A (GOODWIN, III) 02 December 1997, abstract, figs. 2-3, col. 1: lines 32-62, col. 3: line 11 - col. 4: line 13.	1-16
Y	US 5,710,976 A (HILL et al) 20 January 1998, abstract, figs. 9-11, col. 1: line 59 - col. 2: line 25, col. 7: line 51 - col. 8: line 48).	1-16
A	US 5,418,839 A (KNUTH et al) 23 May 1995, abstract, figs. 5-6, col. 2: lines 61-64, col. 11: line 20 - col. 12: line 50.	1-16
A	US 5,475,868 A (DUQUE-ANTON et al) 12 December 1995, abstract, figs. 4-5, col. 2: lines 47 - 67, col. 3: lines 12-24, col. 6: lines 20-24.	1-16

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"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)	"&"	document member of the same patent family
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