

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
29 March 2001 (29.03.2001)

PCT

(10) International Publication Number
WO 01/22747 A1

(51) International Patent Classification⁷: **H04Q 7/00**,
H04B 7/216

Joseph, M.; 276 Continental Lane, Schaumburg, IL 60194 (US). **VALENTINE, Matthew, F.**; 315 S. Benton, Palatine, IL 60067 (US).

(21) International Application Number: PCT/US00/24021

(22) International Filing Date: 31 August 2000 (31.08.2000)

(74) Agents: **HAAS, Kenneth, A.** et al.; Motorola Inc., Intellectual Property Dept., 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

(25) Filing Language: English

(81) Designated States (*national*): BR, JP, KR.

(26) Publication Language: English

(30) Priority Data:
09/400,747 22 September 1999 (22.09.1999) US

(84) Designated States (*regional*): European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

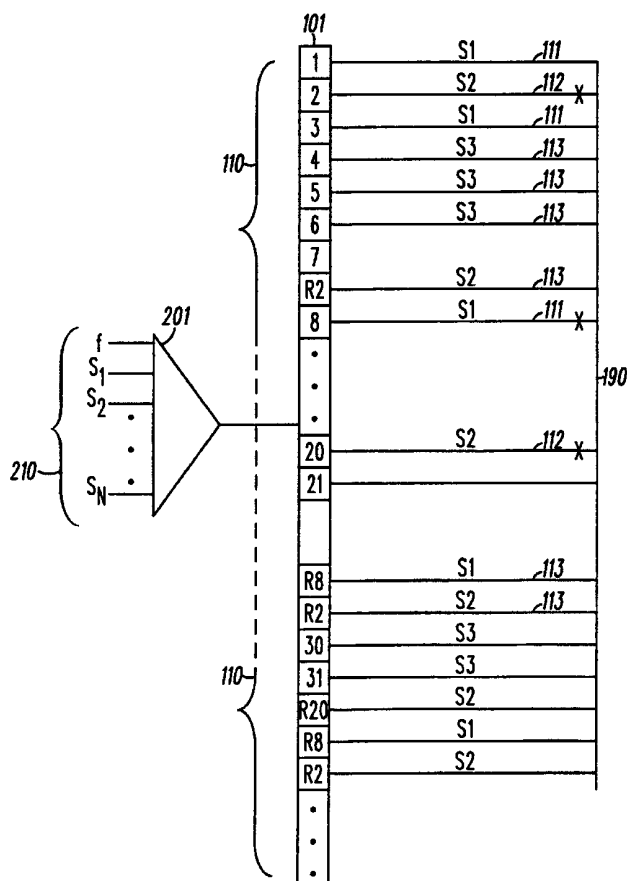
(71) Applicant: **MOTOROLA INC.** [US/US]; 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

Published:
— With international search report.

(72) Inventors: **HARRIS, John, M.**; 1108 W. Dickens Avenue #2, Chicago, IL 60614 (US). **LOVE, Robert, T.**; 817 S. Hough Street, Barrington, IL 60010 (US). **PETTINGER,**

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: SELECTING CHANNELS FOR RETRANSMISSION OF DATA PACKETS



(57) Abstract: In a communication system, a method and apparatus includes receiving a negative acknowledgement message from a remote unit (190) indicating reception failure of a packet of data. By comparing at a comparator (201) a link quality of a plurality of available channels (210) for transmission, at least one of the plurality of channels is selected based on the comparison. The selected channel is then used for retransmission of the packet of data. Accordingly, the retransmission of the failed packet of data has a better chance of being received at the remote unit since the selected channel may have a better link quality than the channel that was originally used for transmission. If there is any subsequent retransmission, the method is repeated.



WO 01/22747 A1

SELECTING CHANNELS FOR RETRANSMISSION OF DATA PACKETS

5 Related Field of the Invention

The invention relates to the field of communications, and more particularly, to efficient channel utilization in communication systems.

10 Background of the Invention

Communication systems, such as the commonly known code division multiple access (CDMA) 2000 which is the next generation of the commonly known system based on IS-95 CDMA standard, or wide-band CDMA (W-CDMA) which
15 is the next generation of the commonly known system based on the Global System Mobile (GSM) standards, include down-link communication to a number of mobile stations via fundamental and supplemental channels. Other types of down link channels, such as paging
20 channels or synchronization channels, may also be present. A base station may use the fundamental and supplemental channels to transmit data to a mobile station. Each base station may have access to at least one of several supplemental channels and one

-2-

fundamental channel, depending on the type of system and its requirements. The informations communicated in each channel are coded according to an orthogonal code selected from, for example, the Walsh codes. A
5 fundamental channel is typically used for voice communications, however, it may also be used for low bit rate data communications. Supplemental channels, typically, are used for data communications.

A data transmit session between a mobile station
10 and a base station may last as long as all the data in a block of data are transmitted to the mobile station. A block of data may be partitioned into a series of packets of data where each packet would have a serial or sequence number identifying the location of the
15 packet in the block of data. Each packet may be transmitted over a burst to the mobile station. After each burst of data is received at a mobile station, the mobile station is required to measure quality of the received data. If the measured quality, such as number
20 of errors in the burst, does not match a predetermined threshold, the mobile station after detecting reception failure transmits to the base station a negative acknowledgement (NAK) message indicating inadequate

-3-

reception quality. The base station, in proper time, retransmits the burst of data.

In case of a NAK condition, the base station retransmits only the packet of data that has been
5 identified in the NAK message. The base station may select the time for transmission of the NAK packet of data. There may be more than one packet of data in a queue for retransmission. The retransmitted packet of data has the same serial number even though it is
10 retransmitted out of order along with other remaining packets of data. For example, a data block may be partitioned into 50 packets of data, numbered from 1 to 50 consecutively. The base station begins transmitting the packets of data, starting with the first packet, on
15 at least one of the supplemental channels or the fundamental channels if the fundamental channel is free.

Data transmission and retransmission may be more apparent by making references to the FIG. 1. A block of
20 data 101 is partitioned into a number of data packets 110. The first packet has the serial number 1, and the second packet the serial number 2, and so on. As an example, the first packet is transmitted on a first supplemental (S1) channel 111, the second data packet

-4-

on a second supplemental (S2) channel 112, and the third packet is transmitted on a third supplemental (S3) channel 113. The base station typically is not limited to a selection of the supplemental channels. A
5 base station has access to all supplemental and the fundamental channels for transmitting a block of data on a series of bursts of data. The scenario shown in FIG. 1, although shows only three supplemental channels in use, is for illustration purpose only. The receiving
10 unit 190 after comparing quality of received data packet 2, retransmission of data packet 2 (R2), data packet 8, data packet 20, and data packet R8 may transmit a number of NAK messages to the base station after detecting each reception failure. Note, the NAK
15 messages, in this example, have been associated with supplemental channels 111 and 112 while every data packets transmitted on supplemental channel 113 have been received without any problem. Moreover, note that data packet 2 has been retransmitted twice and data
20 packet 8 once without adequate reception at the receiver 190.

Therefore, there is a need for a method and apparatus for selecting channels for retransmission of data packets in a communication system.

Brief Description of the Drawings

FIG. 1 depicts a data packet flow for transmission of a data block according to the prior art.

5 FIG. 2 depicts a data packet flow for transmission of a data block according to various aspects of the invention by including a comparator before selecting which channel is to be used for retransmission of a failed packet of data.

10

Detailed Description of the Preferred Embodiment(s)

According to various aspects of the invention, in a communication system, a method includes receiving a negative acknowledgement message from a remote unit, such as a mobile station, indicating reception failure of a packet of data. By comparing a link quality of a plurality of channels available for transmission, at least one of the plurality of channels is selected based on the comparison. The selected channel is then used for retransmission of the packet of data. Accordingly, the retransmission of the failed packet of data has a better chance of being received at the remote unit since the selected channel may have a better link quality than the channel that was

15

20

-6-

originally used for transmission. If there is any subsequent retransmission, the method is repeated.

According to various aspects of the invention, the quality of a channel may be determined based on at least one of frame erasure ratio, channel noise, cyclic redundancy check information, average energy to interference ratio, signal to noise ratio, and power level of the plurality of channels. Other qualities of measurements are also possible. In case there is more than one packet of data for retransmission, the plurality of retransmission packets of data are sorted according to a sequence number associated with each of the plurality of retransmission packets of data. Each packet of retransmission data is assigned a priority for retransmission. Where the available channels include a fundamental channel and at least a supplemental channel, the fundamental channel may be selected for retransmission of a retransmission packet of data that has a highest priority according to the selected priority.

Various aspects of the invention may be more apparent by making references to the FIG. 2. Similar to the flow shown in FIG. 1, there are several packets of data that have failed to be received at the receiver

-7-

190. For example, the data packet 2 transmitted on supplemental channel 112 failed to be received at the receiver 190. When a retransmission of the data packet (R2) is about to take place, the base station at a
5 comparator 201 compares link quality of all available channels 210 for retransmission of data packet 2. There may be a number of available channels for retransmission. Comparator 201 may be implemented via software or hardware. Such implementation is widely
10 known by one ordinary skilled in the art. In this example, when the R2 is being sent, channel 113, i.e. supplemental channel S3, appears to have the best quality. Retransmission of data block R2 on channel 113 has statistically a better chance of being received
15 than being retransmitted on, for example, channel 112. In case of R8, and R20, the channel 112 clearly, in this example, has poor quality, thus sending R2 and R8 on channels 111 or 112 would make an inefficient use of the available channels for retransmission.

20 In IS-95B systems, multiple Walsh codes are used for each data call. For each High Speed Data (HSD) call the primary Walsh code is called the fundamental and the other Walsh codes are called the supplemental. The number of supplemental is generally between 0 and 7.

-8-

Only the fundamental channel carries the power control information and the IS-95 system messaging. In cdma2000, three different channels may be used for transmission of radio link protocol (RLP) frames that
5 may include error messages such as NAK messages. Such channels include:

- 1) Fundamental Channel essentially is used for voice, low bit rate data, and signaling at either 9.6Kbps or 14.4Kbps.
- 10 2) Supplemental Channel is mainly used for high bit rate data and multimedia applications.
- 3) Dedicated Control Channel is used for the control and signaling purpose.

In IS-95, CDMA 2000 and CDMA One, data calls use
15 Radio Link Protocol (RLP) to correct errors on the radio link. RLP attempts to correct all radio errors using the following algorithm. Consider a new frame before it is transmitted across the radio link for the first time. If this frame is 'erased' by the radio
20 link, the RLP requests two more copies of it to be retransmitted. If neither of these arrive, then RLP requests 3 more copies. If none of the packets arrive successfully, then RLP gives up and the packet which the frame was a part of is corrupted and must be

-9-

retransmitted by TCP/IP or a higher level protocol. When RLP gives up in this fashion, the action may be 'aborted'. If two or more TCP/IP packets in a row contain at least one frame each which has been aborted,
5 then TCP/IP will 'time-out.' When TCP/IP times-out it takes approximately 2 to 3 seconds for the corrupted packets to be retransmitted. This is a significant delay and thus number of aborts should be minimized. However, as the FER increase, so does the probability
10 of an RLP abort. Generally, system messaging and power control information needs to be transmitted through a radio link with a low FER (e.g. near 1%).

In IS-95B the fundamental channel unlike the supplemental channels is punctured to allow for power
15 control information. This results in the fundamental channel having a higher FER than the supplemental channels for a given set of power control parameters. Thus, it is necessary to use different power control parameters on the fundamental and the supplemental
20 channels in IS-95 independent of the other issues.

The fundamental channel FER target should be similar to that used for voice; between 1% and 3%. This will ensure that the messaging on the fundamental channel will pass through a sufficiently reliable link

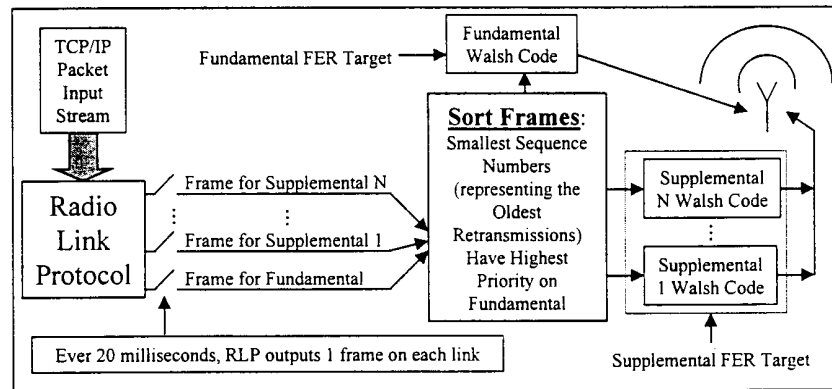
-10-

(when the cell is not overloaded.) The supplemental channel FER target should be higher than what is used for voice; between 3% and 10%. This is because data call use RLP to correct errors on the radio link. By
5 using a higher FER target for the data supplemental, one can drastically reduce the capacity impact of data calls. This is because a call with a higher FER requires less power and thus causes less interference. For example, cell capacity is 40% larger for a system
10 where data calls have 5% FER targets and can tolerate a maximum of 10% FER than the capacity of a cell with voice calls with a 1% target which can tolerate a maximum of 2% FER.

The RLP retransmissions (frames which were in
15 error and must be retransmitted) may be preferentially placed on the fundamental (or Dedicated Control Channel in CDMA 2000) when being transmitted. In other words, when given a choice between sending a retransmission or a new frame on the fundamental (or Dedicated Control
20 Channel in CDMA 2000), the algorithm should send the retransmission. This prioritization is implemented by using a sorting algorithm on the output of the RLP algorithm. The implementation of this sorting algorithm can use the fact that in RLP each frame contains a flag

-11-

that identifies the frame as a retransmission frame or an original frame.



5 The best sorting algorithm choice would not only give the retransmissions higher priority than original transmissions on the fundamental (or Dedicated Control Channel in CDMA 2000), it would also give the oldest retransmissions the highest priority on the fundamental

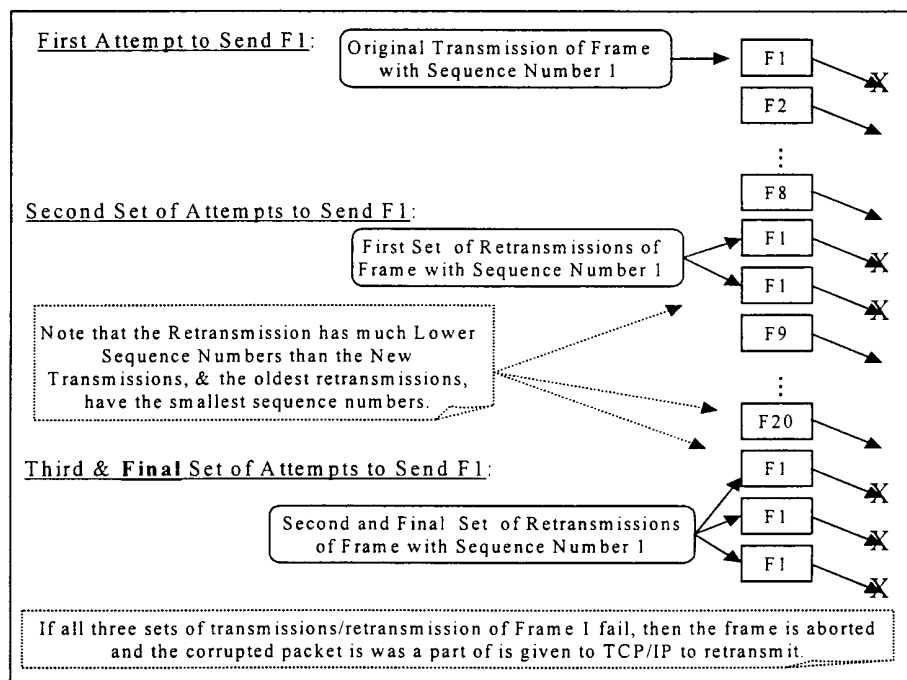
10 (or Dedicated Control Channel in CDMA 2000). The sorting algorithm may be according: Scan through each of the frames, find the frame with the smallest sequence number and place it on the fundamental (or Dedicated Control Channel in CDMA 2000). As a result,

15 each frame in RLP is given a sequence number. While a frame is being retransmitted, the current sequence number of the successful frames continues to increase. When the retransmission is attempted, its sequence number is much smaller than the current sequence

-12-

number. Only 3 sets of attempts are made by RLP to send each frame. For the same reasoning, the retransmission with the smallest sequence number is the oldest, and thus has the smallest number of retransmission attempts left before RLP will 'give up' and abort it.

In short, it is more important to send a third & final round retransmission across the radio link successfully than it is to send a first or second set of attempts successfully because if the third attempt is the final attempt.



The idea of sending three retransmissions on the third and final attempt in RLP is an attempt at achieving the same goal of giving the final transmission attempt a higher probability of success.

-13-

Table 1 shows the use of the algorithm provides a 99.4% decrease in aborts. If RLP aborts, then it gives up and the packet that the frame was a part of is corrupted and must be retransmitted by TCP/IP. When

5 RLP gives up in this fashion, it has 'aborted'. If two or more TCP/IP packets in a row contain at least one frame each which has been aborted, then TCP/IP will 'time-out.' When TCP/IP times-out it takes approximates 2 to 3 seconds for the corrupted packets to be resent.

10 This is a significant delay and thus number of aborts should be minimized. This algorithm does that by reducing the number of and probability of aborts by 99.4%. This corresponds to having an abort every 422 Minutes instead of every 1207 hours, instead of every 7

15 hours.

	FER						Abort Prob- ability	Delay (millisec s)		Thro ugh- put
	Fund- amenta l	Supple - mental	Total	Original Attempts	1st Retran s- missio ns	2nd Retrans- missions		Mean	Var- ianc e	
Random Assignm ent of Retrans mission s	8.88%	8.88%	8.88%	8.88%	8.88%	8.88%	4.6E-09	175.27	352.7	54235
Oldest Retrans mission s on Fundame ntal	1%	10%	8.88%	8.98%	7.19%	1.00%	7.9E-07	174.5	342.8	54170
% Change Incurre d by Using Oldest Retrans mission s on Fundame ntal	-	-	-	-	-	-	-99.4%	-.4%	-3%	- 0.1%

Table 1: Benefits of Prioritizing Oldest Retransmissions

5 The impact of this algorithm on delay is also positive. The delay variance decreases by 3% and the mean delay decrease by 0.4%. This will result in smaller buffer requirements in RLP and mobile. The fact that the delay mean goes down .4% and the

10 throughput goes down 0.1% should result in an overall performance improvement. For example, for a 1500 byte TCP-IP Packet, the delay decrease of 0.4% will reduce the RLP delay by 0.7 milliseconds, and the throughput

-15-

increase of 0.1% will increase the delay by 0.2 milliseconds. Thus, the overall delay change seen by a TCP/IP packet is a decrease of 0.5 milliseconds.

Accordingly, RLP sequence number based sorting
5 algorithm for distinguishing which frames are sent on
the fundamental has substantial benefit in
retransmission efficiency. Moreover, utilizing the
lower FER on fundamental to satisfy signaling and power
control requirements while to significantly improving
10 RLP performance, and utilizing higher FER on
supplemental to obtain significant capacity benefits
data traffic.

-16-

Claims

1. In a communication system, a method comprising the steps of:

5 receiving a negative acknowledgement message from a remote unit indicating reception failure of a packet of data at said remote unit;

comparing a link quality of a plurality of channels available for transmission;

10 selecting at least one of said plurality of channels based on said comparing;

using said selected channel for retransmission of said packet of data.

15 2. The method as recited in claim 1 wherein said comparing comprising:

determining said quality based on at least one of frame erasure ratio, channel noise, cyclic redundancy check information, average energy to interference
20 ratio, signal to noise ratio, and power level of said plurality of channels.

3. The method as recited in claim 1 further comprising:

-17-

sorting a plurality of retransmission packets of data according to a sequence number associated with each of said plurality of retransmission packets of data, and selecting a priority for said sorted
5 plurality of packets of data for retransmission.

4. The method as recited in claim 3 wherein said available channels include a fundamental channel and at least a supplemental channel, further comprising
10 selecting said fundamental channel for retransmission of a highest priority retransmission packet of data according to said priority.

5. In a communication system, an apparatus
15 comprising: means for receiving a negative acknowledgement message from a remote unit indicating reception failure of a packet of data at said remote unit;

means for comparing a link quality of a plurality
20 of channels available for transmission;

means for selecting at least one of said plurality of channels based on said comparing;

means for using said selected channel for retransmission of said packet of data.

-18-

6. The apparatus as recited in claim 5 wherein said means for comparing comprising:

means for determining said quality is based on at least one of frame erasure ratio, channel noise, cyclic redundancy check information, average energy to interference ratio, signal to noise ratio, and power level of said plurality of channels.

7. The apparatus as recited in claim 5 further comprising:

means for sorting a plurality of retransmission packets of data according to a sequence number associated with each of said plurality of retransmission packets of data, and means for selecting a priority for said sorted plurality of packets of data for retransmission.

8. The apparatus as recited in claim 7 wherein said available channels include a fundamental channel and at least a supplemental channel, further comprising means for selecting said fundamental channel for retransmission of a highest priority retransmission packet of data according to said priority.

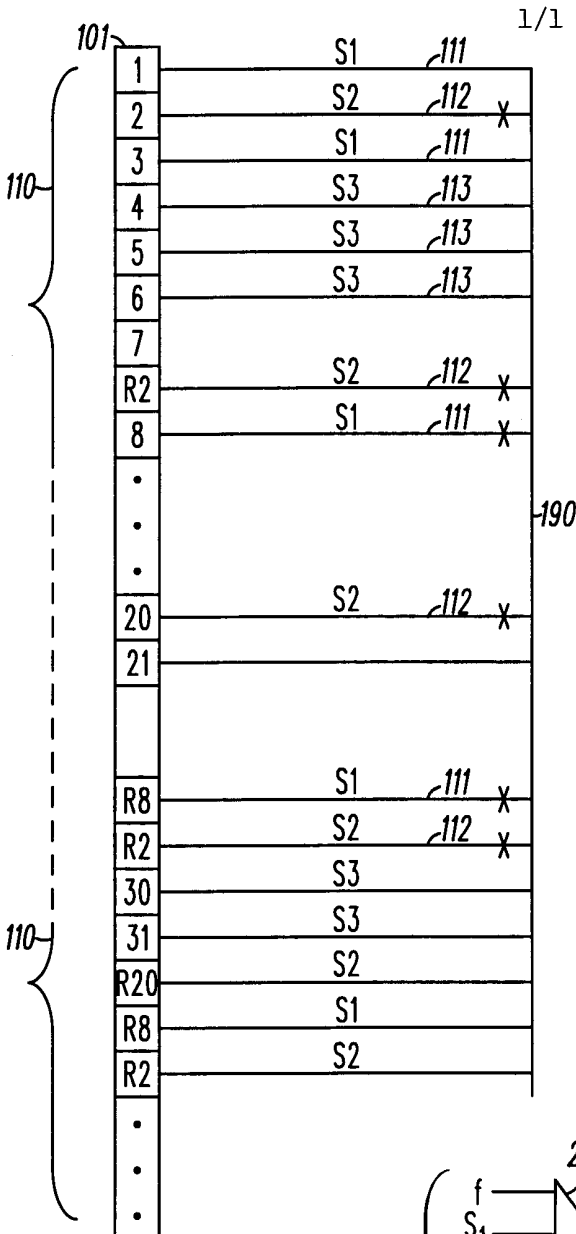


FIG. 1

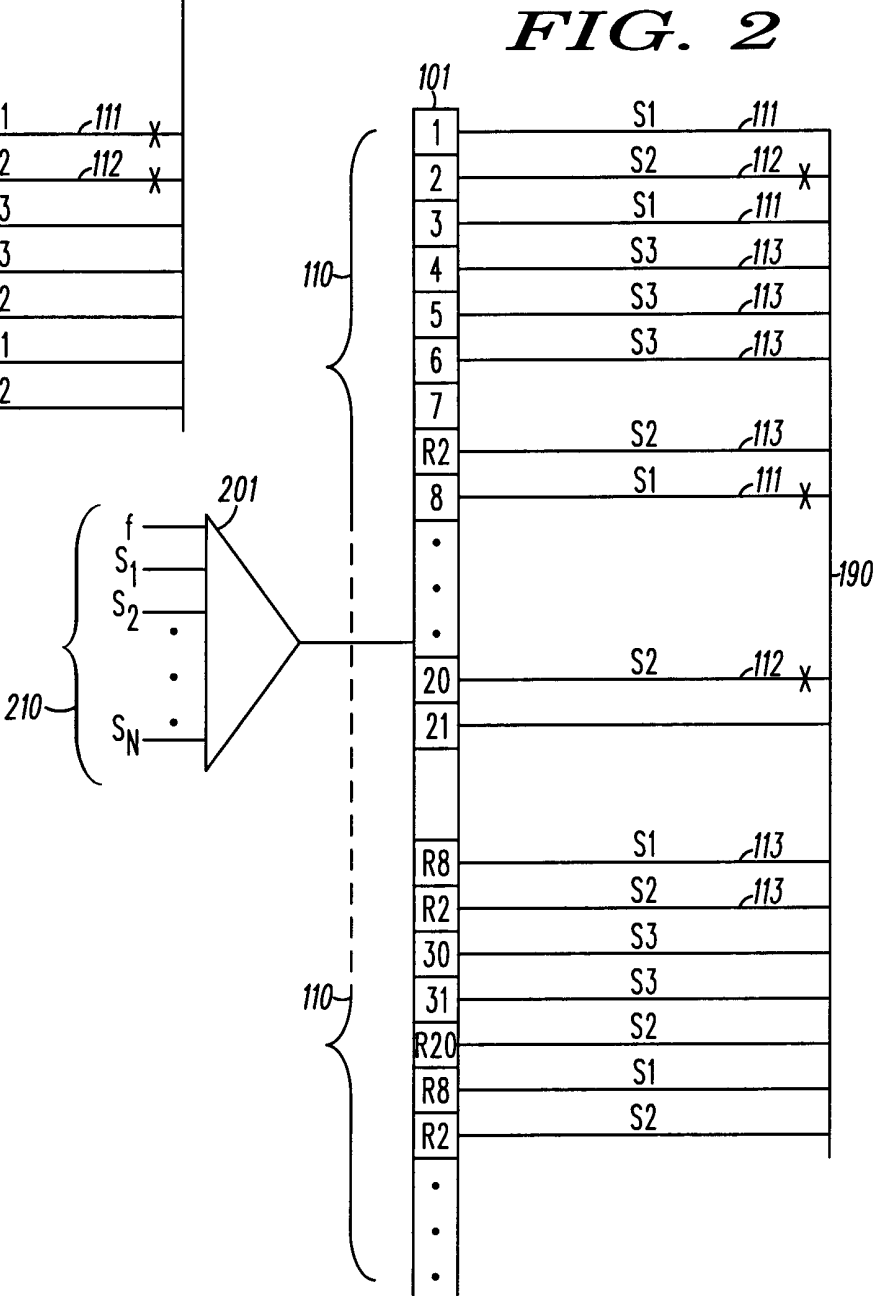
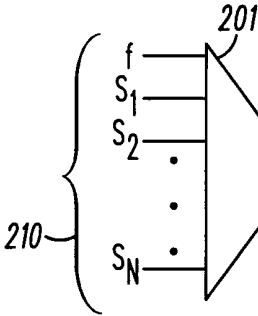


FIG. 2



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/24021

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : H04Q 7/00; H04B 7/216

US CL : 370/329, 322, 348; 714/748; 455/450

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. : 370/329, 322, 348, 320, 313, 336, 396, 345; 714/748, 749; 455/450, 442

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A, P	US 6,088,342 A (CHENG et al.) 11 JULY 2000, column 3, lines 20-50, column 3, lines 55-65, column 7 lines 20-67.	4, 8
A, P	US 6,021,124 A (HAARTSEN) 01 FEBRUARY 2000, Figure 2 and column 10, lines 1-50.	1-8

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

☐ See patent family annex.

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier document published on or after the international filing date	"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
"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
"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	

Date of the actual completion of the international search

19 OCTOBER 2000

Date of mailing of the international search report

16 NOV 2000

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231

Facsimile No. (703) 305-3230

Authorized officer

JOHN PEZZLO

Telephone No. (703) 305-3900