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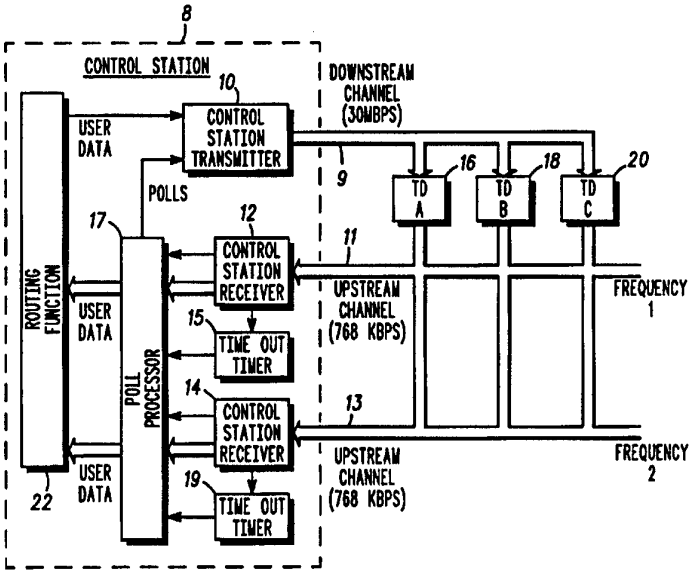
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(54) Title: METHOD, DEVICE AND DATA COMMUNICATION SYSTEM FOR MULTILINK POLLING



(57) Abstract

A control station (8) is coupled to a plurality of tributary devices (16, 18, 20) by way of at least one high speed broadcast downstream data channel (9) and more than one shared lower speed upstream data channels (11, 13). The control station (8) broadcasts data to all the tributary devices (10, 16, 18) and selects a channel for a specific tributary device (16, 18, 20) to respond to a poll. After polling, the tributary device (10, 16, 18) changes the tributary device transmitter (42) to the frequency of the selected channel. The tributary device (16, 18, 20) either sends data to send to the control station (8) or sends a negative acknowledge to the control station (8). If a negative acknowledgment was transmitted, the control station (8) notifies the control station transmitter (10) that the channel is idle.

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METHOD, DEVICE AND DATA COMMUNICATION SYSTEM FOR MULTILINK POLLING

Field of the Invention

This invention relates generally to data communication systems, and more particularly to a multilink polling device and method in data communication systems.

Cross reference to Related Applications

This application is related to the following United States Patent Applications, all assigned to the assignee of this application, incorporated by reference herein, as follows:

CXO95004	METHOD AND APPARATUS FOR A HYBRID CONTENTION AND POLLING PROTOCOL
CXO95005	METHOD AND SYSTEM FOR PROVIDING ACCESS BY SECONDARY STATIONS TO A SHARED TRANSMISSION MEDIUM
CXO95008	METHOD AND SYSTEM FOR MANAGEMENT OF FREQUENCY SPECTRUM AMONG MULTIPLE APPLICATIONS ON A SHARED MEDIUM
CXO95009	METHOD AND APPARATUS FOR A HYBRID LIMITED CONTENTION AND POLLING PROTOCOL
CXO95011	SYSTEM AND METHOD FOR HYBRID CONTENTION/POLLING PROTOCOL COLLISION RESOLUTION USING A COLLISION RESOLUTION USING A DEPTH FIRST SEARCH TECHNIQUE

CXO95012 METHOD AND SYSTEM FOR MANAGEMENT OF FREQUENCY SPECTRUM AMONG MULTIPLE APPLICATIONS ON A SHARED MEDIUM

Background of the Invention

In some high speed data applications, a number of low speed links are combined to achieve high speed data transfer. In simple point to point applications, inverse multiplexing techniques allow a plurality of slow speed channels to be used as a single high speed channel. Inverse multiplexing can be done at physical, link, or network layers with various advantages, disadvantages, and complexities at each layer.

In point to multipoint applications, another layer of complexity is added. Point to multipoint applications are those where a control station has a broadcast, or downstream, channel that reaches a plurality of tributary stations. The plurality of tributary stations share access to an upstream channel or channels which reach the control station. As an added complexity, access to the upstream channel(s) must be controlled.

In such an application, the problems associated with controlling access to the upstream and downstream channels is typically dealt with separately from the problem of accomplishing high speed data transfer through the system over multiple lower speed channels.

The channel access problem may be dealt with through polling, contention access, or hybrid combinations of the two. The multilink problem is typically dealt with through inverse multiplexing, or through static

assignment of subsets of tributary devices to specific upstream channels.

Inverse multiplexing is typically accomplished with complicated and expensive hardware or software solutions. Inverse multiplexing typically requires a start-up synchronization time each time a device begins transmitting. And inverse multiplexing requires the transmitting device to pass data at a speed equal to the sum of all of the low speed channels.

Static assignment of tributary devices to upstream channels does not allow the bandwidth to be utilized efficiently. If a number of users assigned to a channel all have their bandwidth requirements peak concurrently, then their data becomes congested, even if their are other channels in the system which are idle.

A more efficient method of controlling access to the upstream channel while providing efficient utilization of the upstream channel is therefore needed.

Brief Description of the Drawings

FIG. 1 is a block diagram of a data communication system.
FIG. 2 is a block diagram of the tributary station.
FIG. 3 is a flow chart of a tributary station.
FIG. 4 is a flow chart of a control station.

Detailed Description of the Drawings

A method of combining polling type channel access with dynamic assignment of upstream channels provides efficient utilization of the plurality of upstream channels across a population of tributary stations.

When the control station generates polls for a tributary, the control station includes a channel identifier (CID) in the poll message indicating which upstream channel the tributary can respond on. The tributary must use the specified upstream channel

This method allows an individual tributary to fully utilize one link. It also allows multiple tributaries to be balanced across the multiple links, maximizing bandwidth efficiency and minimizing congestion. As long as the bandwidth provided by one link is sufficient for one tributary, this approach allows the use of simpler, less expensive tributaries.

This protocol also avoids the problems associated with allowing multiple links to be used by a tributary simultaneously, such as the need to re-sequence out-of-sequence frames and delay problems that arise due to different links having different characteristics (e.g., link speed, propagation delay, error rate, etc.) and allows the tributaries to require no intelligence related to choosing a link to transmit on. Since the quality of links may vary from tributary to tributary in some environments, the control station can direct a specific tributary to use links that are considered high quality for the specific tributary.

FIG. 1 shows a data communication system 6. Control station (which could be a cable router) 8 broadcasts on downstream channel 9 to a plurality of tributary stations 10, 16, 18. Tributary stations 10, 16, 18 send data to control station 8 by way of a plurality of upstream channels 11, 13.

Control station 8 has two primary components for communication with tributary stations 10, 16, 18. Transmitter 10 sends data and control information from the control station 8 to the tributary stations 10, 16, 18. Receiver 12 is connected to upstream channel 11, and receiver 14 is connected to upstream channel 13. One receiver is needed for each

independent channel carrying data and control information from the tributary stations 10, 16, 18 to the control station 8.

In the downstream direction, control station 8 transmits data packets and control packets which are received by tributary stations 10, 16, 18. Each packet is given a packet identifier which specifies which of the tributary stations 10, 16, 18 should accept the data. For purposes of this invention, downstream packets can be classified as 'data packets' or 'polls'. Polls are used to grant a particular tributary station access to a specified upstream channel.

Upon receipt of a downstream packet, each tributary station 10,1 6, 18 checks the packet identifier to determine if the downstream packet is for the particular tributary station. If the packet is for the tributary station, then it is checked to see if the downstream packet is a 'data packet' or a 'poll'. Data packets are forwarded to an end user interface.

Upon receipt of a poll, a tributary station will tune its transmitter 42 (see Fig. 2) to the specified channel. Then, the tributary station transmits user data in the upstream direction. If there is no data for the tributary to send, then it sends a negative acknowledgment (NAK) to indicate this to the control station.

Receivers 12, 14 wait for upstream packets. When received, the receivers 12, 14 sends a message to the poll processor 17 that the upstream channel 11, 13 can now be used for polling another tributary station 10, 16, 18. The receiver also sends a message to restart the time out timer 15, 19. The poll processor 17 chooses the next tributary station 10, 16, 18 to be polled and sends the poll to the control station transmitter 1 0. The control station transmitter 10 sends the next poll out on the downstream channel 9.

If a downstream poll has a transmission error, or if a tributary station 10, 16, 18 is powered off then some polls will

not generate a response. If a response to a poll is not received then the time out timer 15,19 will expire. At this point the time out timer 15, 19 will generate a message to the poll processor 17 that the upstream channel 11, 13 is idle and can be polled again. The poll processor 17 can correlate messages from time out timers 15, 19 with particular tributary stations 10, 16, 18 and stop polling them (or poll them less frequently) if they are not responding.

FIG. 2 is a block diagram of a tributary station. A tributary station receiver 30 is tuned to the downstream channel 9. Receive data filter 32 differentiates between packets for this tributary station and other tributary stations . Packets destined for other stations are discarded. Receive data filter 32 also differentiates between data packets and polls. Data packets are forwarded to user data interface 36, while polls are forwarded to poll processor 34. User data interface 36 could be coupled to a data terminal equipment.

Poll processor 34 decodes the poll, and tunes the transmitter to the appropriate frequency through frequency selector 40. Upstream user data is stored in transmit data buffer 41 until a poll is received. Poll processor 34 signals the transmit data buffer to send the upstream data to the tributary station transmitter 42. If there is no data in the data buffer, then a NAK is sent instead.

FIG. 3 shows the normal processing flow through a tributary station. Each packet that is broadcast from the control station is received and checked (100). If it is for some other tributary device, then it is discarded. If it is for this device, it is checked to determine if it is a data packet or a poll (1 02). If it is a data packet, then the data is forwarded to the end user. If it is a poll, then the tributary's transmitter is tuned to the channel specified in the poll (104). The transmit data buffer 41 is checked to see if there is any data (106). If so, the data is transmitted (108). Otherwise, a NAK is transmitted (110).

FIG. 4 shows the normal poll processing flow through control station 8. The process begins with an indication from a control station receiver 12, 14 to the control station transmitter 1 0 that an upstream channel 12, 14 is idle (200). The control station receiver 12 also starts time out timer 15 when the idle notification is sent to the control station transmitter 1 0 (200). The control station transmitter 1 0 selects the next tributary device from its list of devices to be polled (202). The transmitter must make sure that the device to be polled is not already being polled on another upstream channel. A poll packet is created which contains the tributary identification (ID) and the idle channel (204). This packet is transmitted on the broadcast channel to all of the tributary devices (206).

At the tributary station, the packet is received and interrogated to determine if the packet is a data packet or an NAK (208). Additionally, the time out timer 15 may expire due to no response to the poll.

If a data packet is received, the data is forwarded to the end user (21 0).

If a NAK is received, a notification is sent to a poll processor 34. (212) The poll processor could cause more or less frequent polling of specific tributary devices based upon how often the tributary device has real data in response to polls.

If a time out occurs, a notification is sent to the poll processor 34. A time out might occur for several reasons. A broadcast poll may have had a transmission error, resulting in no tributary station responding. Or the addressed tributary station for a poll may have been shut down or failed. Algorithms in the poll processor 34 could correlate time out events and take appropriate action regarding continued polling of any specific devices.

After any of the three potential response types, the receive channel is considered idle, and the transmitter is notified so

that the next tributary device can be polled (200) The time out timer 15 is reset.

The method described herein allows a system to attain the performance characteristics of a high speed shared channel upstream by using multiple lower speed channels. By using lower speed channels, a more cost effective tributary device can be used. Further, dynamic allocation of upstream channels through polling automatically accomplishes load balancing across the channels. Static assignment models need a higher level algorithm to re-assign statistically mapped channels in response to congestion.

CLAIMS

We claim:

1. In a data communication system where a control station is coupled to a plurality of tributary devices by way of at least one high speed broadcast downstream data channel and more than one shared lower speed upstream data channels, each of the shared lower speed upstream channel having a channel frequency, a method for controlling access to the shared lower speed upstream transmission data channels by the plurality of tributary devices comprising:

Broadcasting control station data from the control station to the plurality of tributary devices on the at least one high speed broadcast downstream data channel;

selecting a select shared lower speed upstream data channel

sending a poll to a select tributary device; and sending from the select tributary device to the control station on the select shared lower speed upstream data channel a response to the poll.

2. The method of claim 1 further including:

receiving, by the select tributary device, the control station data from the control station;

determining, by the select tributary device, if the control station data contains a poll; and

changing, by the select tributary device, a tributary device transmitter to the channel frequency of the select shared lower speed upstream channel.

3. The method of claim w further including the step of:

if the select tributary device has tributary device data to send to the control station, sending the tributary device data to the control station on the select shared lower speed upstream channel.

4. The method of claim 3 further including the step of:

if the select tributary device does not have tributary device data to send, sending a negative acknowledge to the control station.

5. The method of claim 4 further including the step of:

if the select tributary device sent tributary device data, forwarding the tributary device data for further processing.

6. The method of claim 5 further including the step of:

if the select tributary device sent a negative acknowledgment, notifying a control station transmitter that the select shared lower speed upstream channel is idle.

7. In a data communication system where a control station is coupled to a plurality of tributary device by way of at least one high speed broadcast downstream data channel and more than one shared lower speed upstream data channels, a method for controlling access to the shared lower upstream transmission data channels by the plurality of tributary devices comprising:

AT THE CONTROL STATION:

(a) broadcasting data to the plurality of tributary devices

(b) Selecting a shared lower speed upstream data channel for a select tributary device to respond to a poll;

(c) sending a poll to the select tributary device;

(d) waiting to receive a response to the poll;

AT THE SELECT TRIBUTARY DEVICE:

(e) receiving the data from the control station;

(f) determining if the data contains a poll;
(g) changing a tributary device transmitter of the select tributary device to the select channel;
(h) if the select tributary device has tributary device data to send to the control station, sending the tributary device data to the control station on the selected channel; and
(i) if the select tributary device does not have tributary device data to send, sending a negative acknowledge to the control station.

8. The method of claim 7 further comprising, at the control station, the step of:

(j) if the select tributary device sent tributary device data, forwarding the tributary device data for further processing.

9. The method of claim 8 further comprising, at the control station, the step of:

(k) if the select tributary device sent a negative acknowledgment, notifying the transmitter that a shared lower speed upstream data channel is idle.

10. A tributary device coupled to a control station by way of at least one high speed broadcast downstream data channel for sending control station data from the control station to the tributary device and more that one shared lower speed upstream data channel for sending tributary device data to the control station comprising: a tributary device receiver for receiving the control station data from a control station on the at least one high speed broadcast downstream data channel;
a tributary device transmitter for transmitting the tributary device data to the control station on a select shared lower sped upstream data channel, (the tributary device transmitter coupled to a plurality of upstream channels);

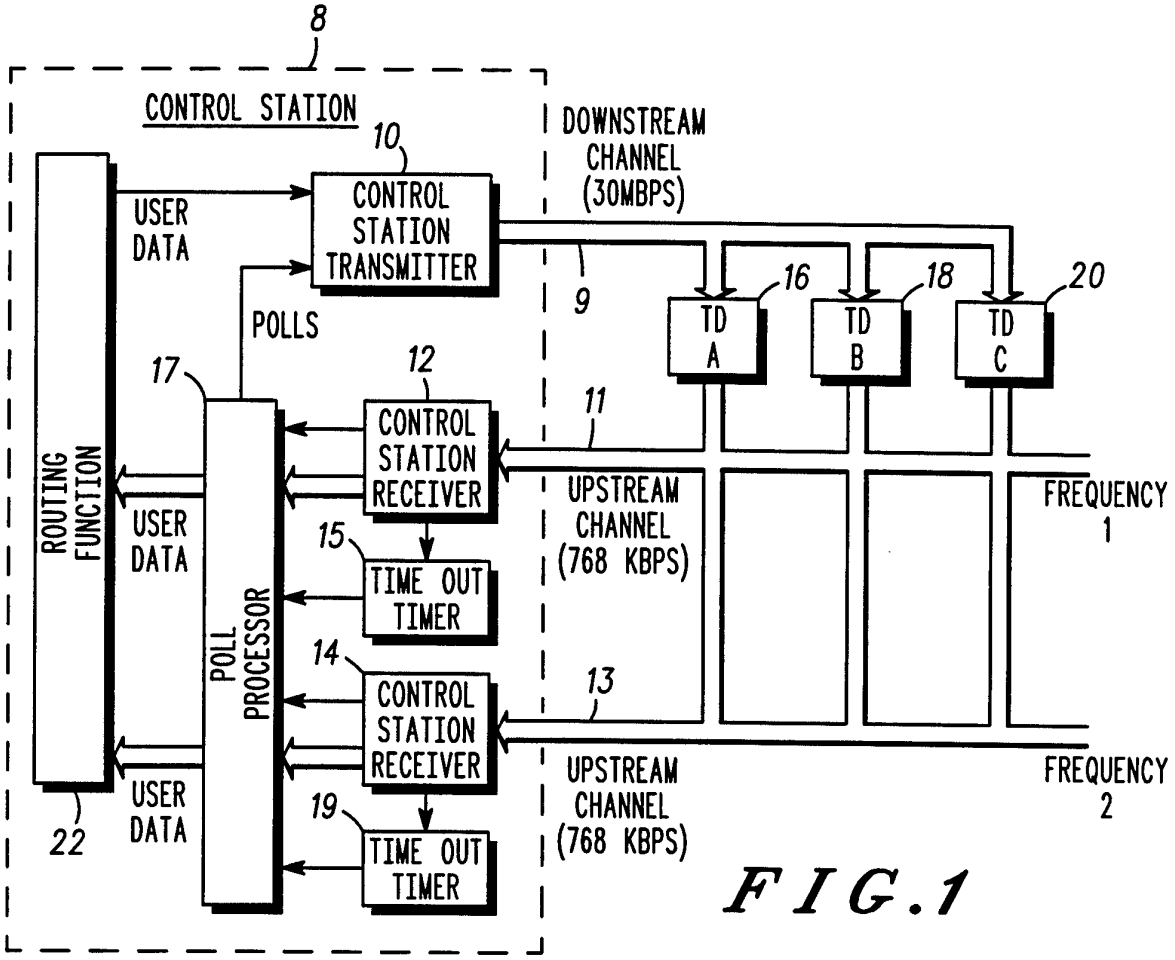
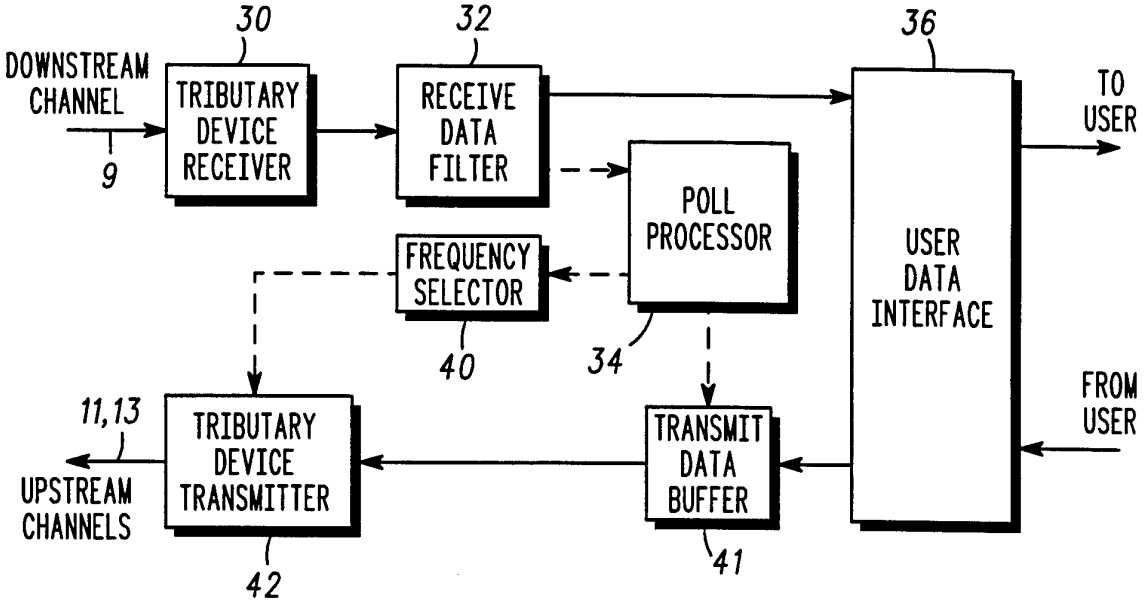

8
CONTROL STATION
10
CONTROL STATION TRANSMITTER
USER DATA
POLLS
DOWNSTREAM CHANNEL (30MBPS)
9
16
18
20
TD A
TD B
TD C
17
12
CONTROL STATION RECEIVER
11
ROUTING FUNCTION
USER DATA
POLL PROCESSOR
15
TIME OUT TIMER
UPSTREAM CHANNEL (768 KBPS)
FREQUENCY 1
14
CONTROL STATION RECEIVER
13
USER DATA
19
TIME OUT TIMER
UPSTREAM CHANNEL (768 KBPS)
FREQUENCY 2
22

FIG. 1

FIG. 2


30
32
36
DOWNSTREAM CHANNEL
9
TRIBUTARY DEVICE RECEIVER
RECEIVE DATA FILTER
TO USER
POLL PROCESSOR
FREQUENCY SELECTOR
40
34
USER DATA INTERFACE
FROM USER
11,13
TRIBUTARY DEVICE TRANSMITTER
TRANSMIT DATA BUFFER
UPSTREAM CHANNELS
42
41

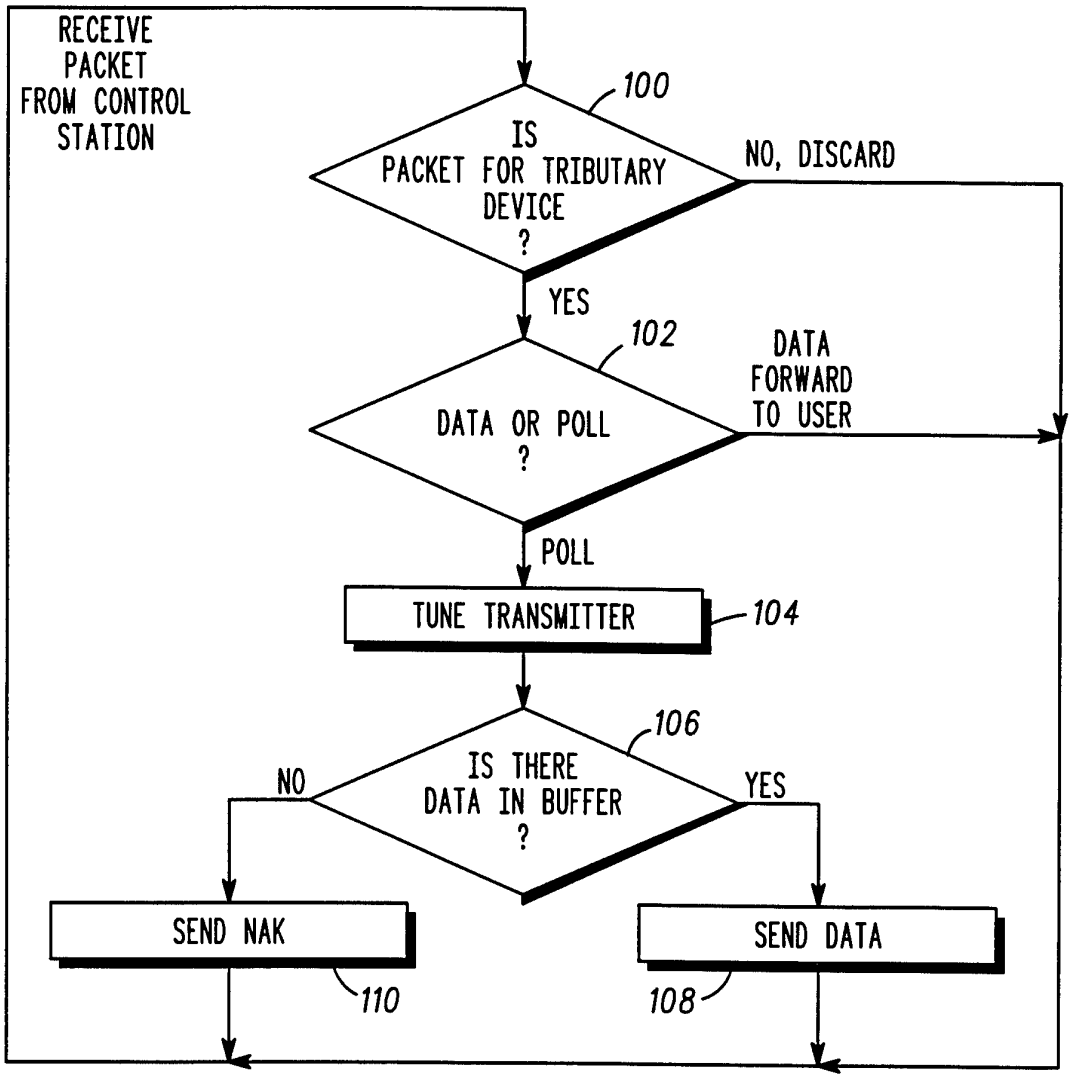

RECEIVE PACKET FROM CONTROL STATION
100
IS PACKET FOR TRIBUTARY DEVICE ?
NO, DISCARD
YES
102
DATA OR POLL ?
DATA FORWARD TO USER
POLL
TUNE TRANSMITTER
104
106
IS THERE DATA IN BUFFER ?
NO
YES
SEND NAK
110
SEND DATA
108

FIG. 3

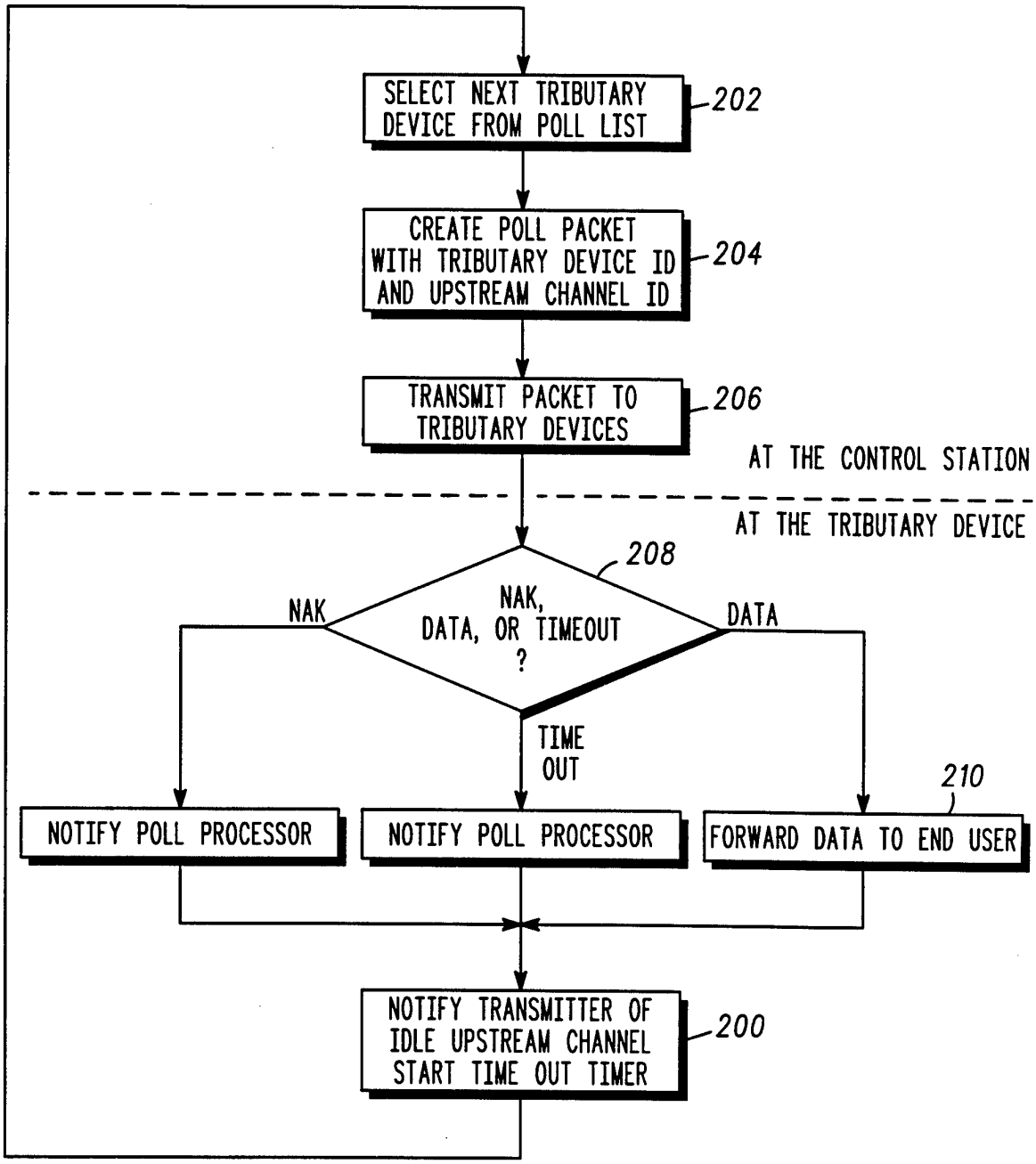

SELECT NEXT TRIBUTARY DEVICE FROM POLL LIST
202
CREATE POLL PACKET WITH TRIBUTARY DEVICE ID AND UPSTREAM CHANNEL ID
204
TRANSMIT PACKET TO TRIBUTARY DEVICES
206
AT THE CONTROL STATION
AT THE TRIBUTARY DEVICE
208
NAK, DATA, OR TIMEOUT ?
NAK
DATA
TIME OUT
210
NOTIFY POLL PROCESSOR
NOTIFY POLL PROCESSOR
FORWARD DATA TO END USER
NOTIFY TRANSMITTER OF IDLE UPSTREAM CHANNEL START TIME OUT TIMER
200

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/05999

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :HO4Q 11/00
US CL :370/85.8, 95.2; 340/825.08
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. : 370/29, 30, 85.7, 85.8, 95.1, 95.2, 85.1, 94.1, 94.3, 93, 95.3, 104.1; 340/825.07, 825.08, 825.54; 455/53.1, 54.1, 54.2

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)

APS

search items: transmitter, receivers, control?, poll?

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4,872,003 (YOSHIDA) 03 October 1989, see entire document.	1-10
A	US, A, 4,742,335 (VOGT) 03 May 1988, see entire document.	1-10
A	US, A, 5,347,515 (MARINO) 13 September 1994, Figure 2.	1-10
A	US, A, 5,132,680 (TEZUKA ET AL.) 21 July 1992, Fig. 3, Fig. 5, and Fig. 6.	1-10

☐ 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
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