United States Patent [19]

Wolfe et al.

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[45] **Date of Patent: Aug. 9, 1988**

[54] **DEMAND ASSIGNED REFORMATTING WITH AN OVERFLOW AREA FOR TIME DIVISION MULTIPLE ACCESS COMMUNICATION**

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[73] Assignee: **Comsat Telesystems, Inc.**, Fairfax, Va.

[21] Appl. No.: **772,536**

[22] Filed: **Sep. 4, 1985**

[51] **Int. Cl.**[4] **H04J 3/16**
[52] **U.S. Cl.** **370/104**; 370/95
[58] **Field of Search** 370/99, 104, 79, 95; 455/12

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,204,093	5/1980	Yeh	370/104
4,322,845	3/1982	Fennel, Jr. et al.	370/104
4,504,946	3/1985	Raychaudhuri	370/104
4,513,416	4/1985	Fujiwara	370/104
4,599,720	7/1986	Kunzinger	370/104

Primary Examiner—Douglas W. Olms
Attorney, Agent, or Firm—Sughrue, Mion, Zinn, Macpeak & Seas

[57] **ABSTRACT**

A time division multiple access communication system in which the repetitive frame is divided into fixed portions preallocated to separate stations and an overflow portion. Each station retains control of its own preallocated portion. Whenever one of the stations needs space that is not available in its preallocated portion, it requests a reference station for part of the overflow portion, which is relinquished as soon as the requirement stops.

5 Claims, 3 Drawing Sheets

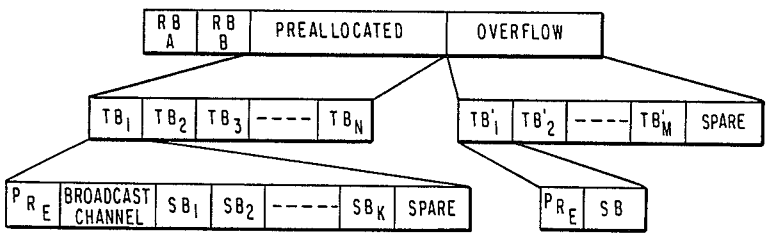


FIG. 1

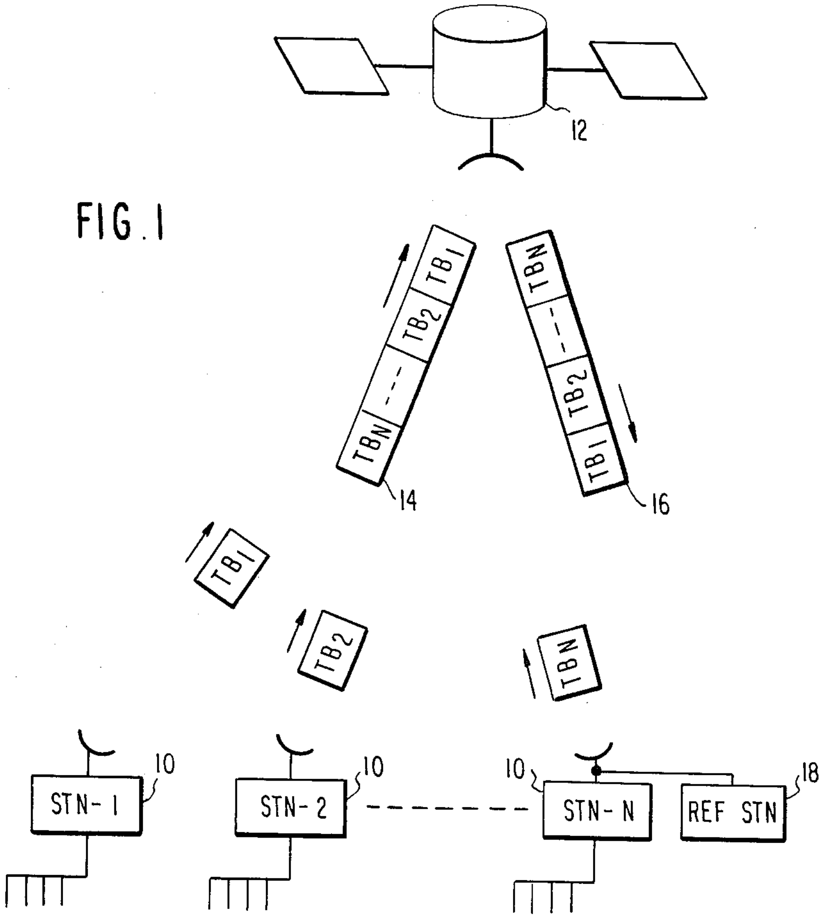
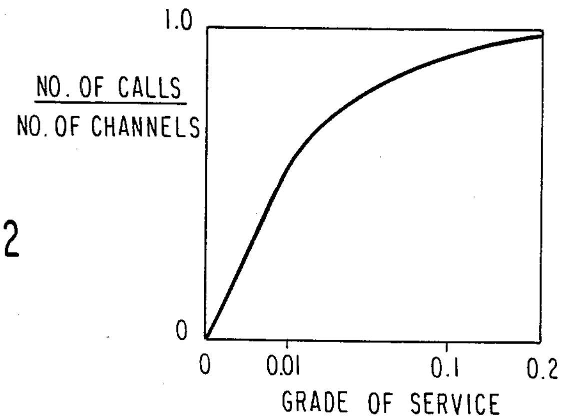

12
TB1
TB2
TBN
14
16
STN-1
STN-2
STN-N
REF STN
10
18
TELEPHONE LINES

FIG. 2


1.0
NO. OF CALLS
NO. OF CHANNELS
0
0
0.01
0.1
0.2
GRADE OF SERVICE

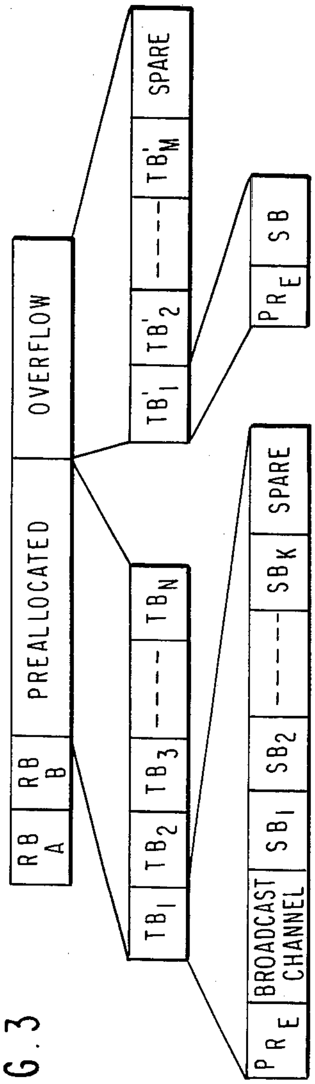

RB A
RB B
PREALLOCATED
OVERFLOW
TB1
TB2
TB3
TBN
TB'1
TB'2
TB'M
SPARE
PRE
BROADCAST CHANNEL
SB1
SB2
SBK
SPARE
PRE
SB

FIG. 3

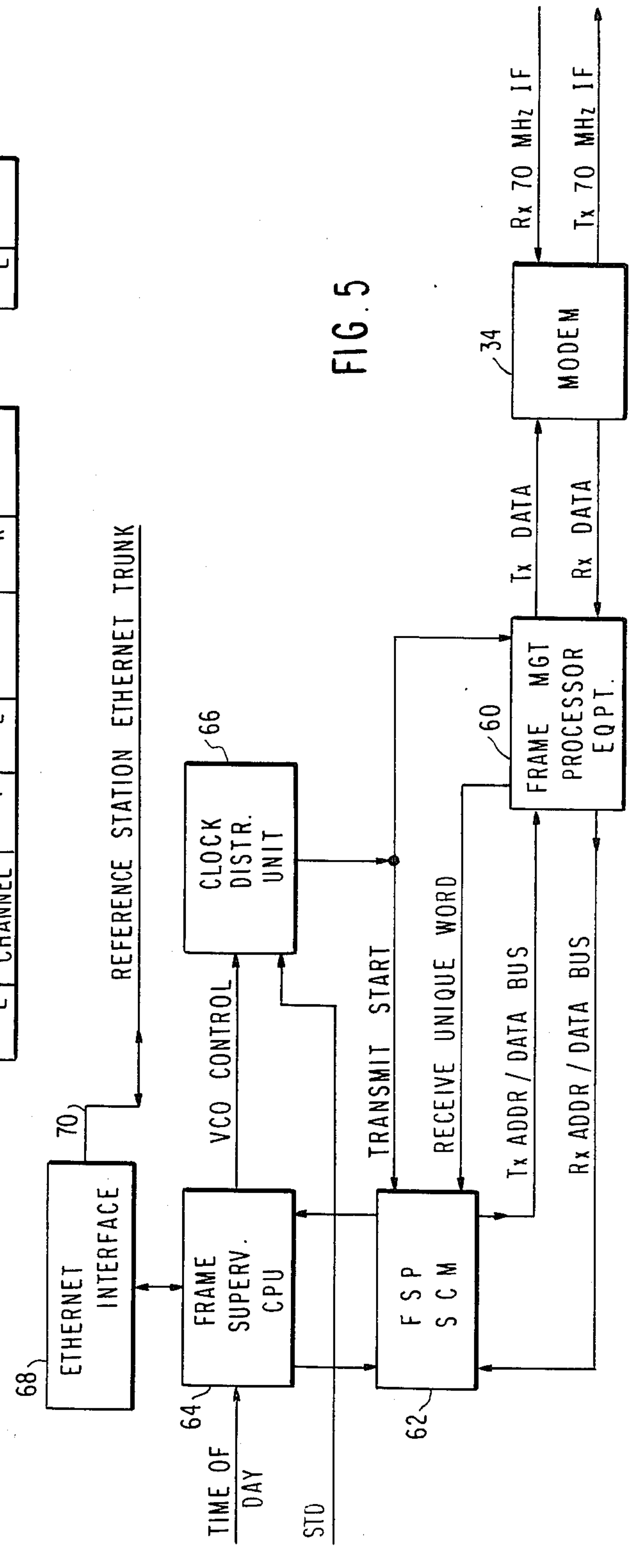
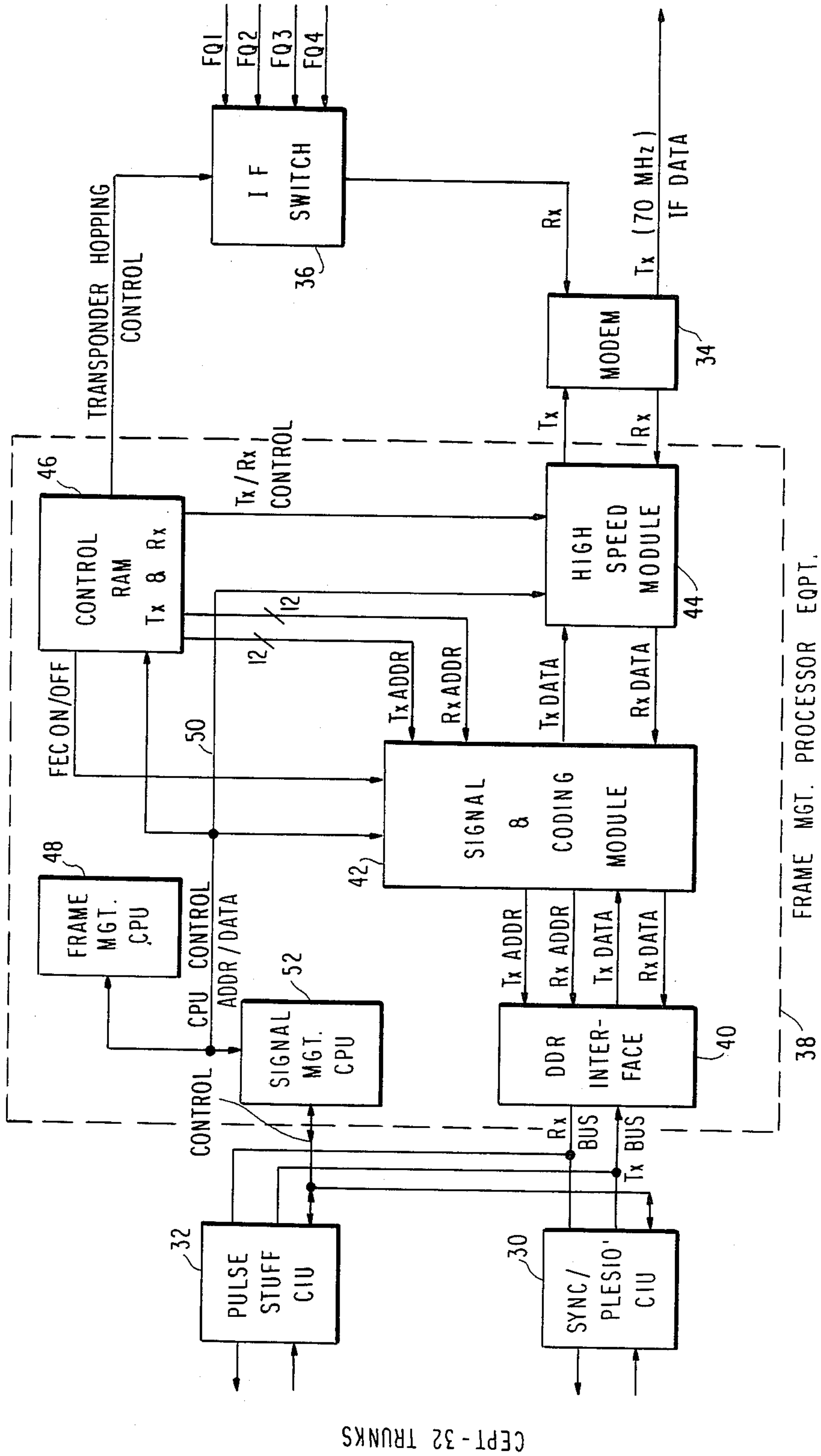

REFERENCE STATION ETHERNET TRUNK
70
68
ETHERNET INTERFACE
64
FRAME SUPERV. CPU
TIME OF DAY
STD
VCO CONTROL
66
CLOCK DISTR. UNIT
62
FSP SCM
TRANSMIT START
RECEIVE UNIQUE WORD
Tx ADDR / DATA BUS
Rx ADDR / DATA BUS
60
FRAME MGT PROCESSOR EQPT.
Tx DATA
Rx DATA
34
MODEM
Rx 70 MHz IF
Tx 70 MHz IF

FIG. 5



FQ1
FQ2
FQ3
FQ4
I F SWITCH
36
TRANSPONDER HOPPING CONTROL
Rx
MODEM
34
Tx (70 MHz) IF DATA
Tx
Rx
46
CONTROL RAM Tx & Rx
Tx/Rx CONTROL
HIGH SPEED MODULE
44
12
12
FEC ON/OFF
50
Tx ADDR
Rx ADDR
Tx DATA
Rx DATA
SIGNAL & CODING MODULE
42
48
FRAME MGT. CPU
CPU CONTROL
ADDR/DATA
52
SIGNAL MGT. CPU
Tx ADDR
Rx ADDR
Tx DATA
Rx DATA
DDR INTER-FACE
40
38
FRAME MGT. PROCESSOR EQPT.
CONTROL
Rx BUS
Tx BUS
32
PULSE STUFF CIU
30
SYNC/PLESIO' CIU
CEPT-32 TRUNKS

FIG. 4

DEMAND ASSIGNED REFORMATTING WITH AN OVERFLOW AREA FOR TIME DIVISION MULTIPLE ACCESS COMMUNICATION

BACKGROUND

The invention relates generally to communication systems. In particular, the invention relates to the dynamic reformatting of a time division multiple access frame dependent upon the demand of the attached stations.

Many modern, large-scale communication systems rely upon geosynchronous satellites acting as transponders between the transmitting and receiving stations. Although originally used for point-to-point communication between two ground stations, more recent satellite communication systems link together a substantial number of ground stations, offering selective communication between any pair of the ground stations. Such a system is schematically illustrated in FIG. **1** for N ground stations **10** linked together by a communication satellite **12** in geosynchronous orbit. The illustrated system is designed for telephone communications with each station **10** being associated with a telephone regional office. Whenever a telephone connection is desired between two telephone lines connected to different regional offices, the call is routed through the associated ground station **10** and is transmitted from there, through the satellite **12**, to the appropriate receiving ground station **10**.

Older satellite communication systems relied upon frequency allocation between the transmitting ground stations **10**. However, more recent multi-point systems, particularly those designed to support telephone/data communications, have adopted a TDMA (time division multiple access) approach. Such a system is disclosed by Maillet in U.S. Pat. No. 3,649,764. In a TDMA system, data is not transmitted continuously but is time multiplexed. The transmission is divided into time frames **14** and **16** with each frame being further subdivided, according to a predetermined format, into traffic bursts TB. Both data and voice signals are transmitted in digital form. The frames repeat often enough that a telephone conversation can be made to appear continuous and instantaneous. In the illustrated example, each ground station **10** is assigned one traffic burst. The transmission of the traffic bursts from the individual ground stations **10** are synchronized so that they arrive at the satellite **12** in the proper time sequence to form the up-link frame **14**. The communication satellite **12** receives the up-link frame **14** and retransmits the frame as the down-link framep **16**. Although the satellite **12** amplifies and frequency shifts the up-link frame **14** into the downlink frame **16** and perhaps uses part of the frame for housekeeping purposes, the satellite **12** can be viewed as a passive transponder with the up-link frame **14** being identical to the down-link frame **16**. It is of course to be appreciated that the frames **14** and **16** illustrated in FIG. **1** are only one pair of a nearly continuous series of up-link frames and down-link frames, the frames in each series being separated by the minimum necessary time.

The entire down-link frame **16** is received by each of the N stations **10** so tht each station **10** is receiving the transmissions of every other station **10**. The individual traffic burst TB must contain additional information indicating for which of the ground stations **10** the transmission is intended.

In a TDMA system, a reference station **18** is usually present to provide some degree of coordination between the ground stations **10**. At a minimum, the reference station **18** must synchronize the ground stations **10** so that the frames **14** and **16** are synchronized between the stations **10** and furthermore it synchronizes the traffic bursts TB within the frame.

One of the difficulties of a telephone-based communication system is the fluctuation in the loads of the various ground stations **10**. These fluctions may be either statistical or predictable. A statistical fluctuation arises because the ground stations **10** has no control on the number of requests for a telephone connection and this number statistically varies with time. A predictable fluctuation would arise from different times of day for ground stations **10** located in different time zones. Nonetheless, for a consumer-based telephone/data system, there must be a high probability that, when a connection is demanded, channel capacity is available. If the frame format is fixed, this requirement for availability means that there must be a large amount of excess capacity within each of the traffic bursts TB. This in turn implies a relatively high bandwidth system.

Bandwidth is both scarce and, in the case of the satellite **12**, expensive to support because of the correspondingly increased power level. Alternatively, for a fixed bandwidth, the excess capacity required for a high availablity with a fixed format implies a decreased number of reliably available channels.

In view of the problems of a fixed allocation between the multiple ground stations **10**, demand assigned multiple access (DAMA) has been developed. By DAMA is meant that the allocation of time or bandwidth between the ground stations **10** is dynamically allocated according to a real-time demand for channel capacity demanded by the individual ground stations **10**. Demand assigned multiple access has been traditionally used in single channel per carrier satellite communication systems, that is, frequency division rather than the time division illustrated in FIG. **1**. Examples of these systems include the SPADE system, which has been implemented in the INTELSAT network. In the SPADE system, each earth station **10** communicates with all other stations **10** via a wide band common signalling channel. All call requests are communicated via this channel among all the stations **10** in the network. The different carrier channels, corresponding to different frequencies, are allocated to the different ground stations **10**, according to these requests. Each station **10** maintains a data base that represents the frequency assignments for all carrier frequencies in the transponder of a satellite **12**. The SPADE system represents a decentralized approach to channel allocation.

Other satellite systems have been designed for centralized control of single channel per carrier satellite communication networks. For example, a master control computer located in a reference station **18** polls each of the earth stations **10** in the network for call requests and thereafter assigns satellite frequencies as required to set up the desired calls. Both of the described DAMA systems have been used with frequency division rather than time division communication. However, demand assignment for a TDMA system is described by Edstrom in U.S. Pat. No. 3,848,093. It is not felt that either the centralized or the decentralized approaches are totally appropriate for a TDMA system.

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