Demand Assigned Multiple Access Subsystem

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Abstract

Demand Assigned Multiple Access (DAMA) is a name for a central allocation of network resources. DAMA is one of the two main techniques for allocating channels to users. In fixed-assigned multiple access, each user is allocated a channel permanently, whether they use it or not. The most multiple-access systems use DAMA in which the available channels are allocated on an as required basis to users. When the user is finished with the channel it is relinquished and made available for another user. DAMA is a technique used to assign satellite channels to on an as request basis. It increases the amount of users in a pool of satellite channels that are available for use by any station in a network. It is assumed that not all users will need simultaneous access to the same communication channels. So that a call can be established, DAMA assigns a pair of available channels based on requests issued from a user. Once the call is completed, the channels are returned to the pool for an assignment to another call. Since the resources of the satellite are being used only in proportion to the occupied channels for the time in which they are being held, it is a perfect environment for voice traffic and data traffic in batch mode.

Keywords: Asynchronous Transfer Mode, Baud rate, Frame, Multiplexer, Satellite communication

I. INTRODUCTION

Demand Assigned Multiple Access (DAMA) is a name for a central allocation of network resources. In practice, it is an operation process that lies above multiple access processes, because it is an administrative, not a technical function. DAMA system can be characterized according to the switching technique (circuit, packet or cell) or control scheme (central, distributed or hybrid) employed. For a dynamic demand assignment technique many choices are available, ranging from highly controlled, constrained access techniques to essentially uncontrolled random access techniques. DAMA is one of the two main techniques for allocating channels to users. In fixed-assigned multiple access (FAMA), each user is allocated a channel permanently, whether they use it or not. This is inefficient and most multiple-access systems use DAMA in which the available channels are allocated on an as-required basis to users. When the user is finished with the channel it is relinquished and made available for another user.

II. ANALYTICAL MODEL

We assume a TDMA frame structure consisting of a number of slots. Each user terminal requests time slots on the uplink channel to utilize bandwidth through the payload on DAMA basis [1]. We propose that slots assigned to a user need not be contiguous since a contiguous slot requirement means that some requests could be denied even though sufficient bandwidth exists (just not in a contiguous segment). We propose an analytical model to quantify the gain in uplink utilization due to the non-contiguous allocation. We assume that when the requested number of slots is not available, the entire request is rejected. This assumption will hold for CBR requests and for variable-bit-rate (VBR) requests of one slot.

III. FRAME STRUCTURE

Consider a super frame structure of $N$ frames per super frame with each frame consisting of $n$ slots as shown in Figure 1. A 16 kbps call would require one slot per frame. The UHF DAMA subsystem [2] was developed to multiplex several baseband systems or users on one 25-kHz satellite channel. This had the effect of adding more satellite circuits per channel to the UHF satellite communications system. Without UHF DAMA, each satellite communications subsystem requires a separate satellite channel. DAMA equipment accepts encrypted data streams from independent baseband sources and combines them into one continuous serial output data stream. DAMA interfaces the Navy UHF satellite communication subsystems DAMA compatible transceivers [3]. The baseband equipment input or output (I/O) data rate with DAMA equipment can be 75, 300, 600, 1200, 2400, 4800, 16,000 bps. The DAMA transmission rate on the satellite link (burst rate) can be 2400, 9600, 19,200, or 32,000
symbols per second. Secure voice currently use 2400 bps. The DAMA multiplexed data stream is divided into frames, with each frame being 1,386 seconds long. Each frame is subdivided into time slots. Most of the DAMA frame formats are derived from this basic format. In the following paragraphs, we will name and describe the purpose of each slot.

<table>
<thead>
<tr>
<th>Channel Control Order Wire</th>
<th>Data Time Slots A</th>
<th>Ranging</th>
<th>Link Test</th>
<th>RCCOW</th>
<th>Data Time Slots B</th>
<th>Data Time Slots C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 5 Users</td>
<td></td>
<td></td>
<td></td>
<td>Return CCOW</td>
<td>1 to 11 Users</td>
<td>1 to 5 Users</td>
</tr>
</tbody>
</table>

A. Channel Control Order Wire (CCOW) Slot:

This slot is used to transmit system timing and control information from the channel controller to subscriber units only. It provides subscriber units with system timing, configuration, and satellite RF control information. It occurs at the beginning of each frame.

B. Return Channel Control Order Wire (RCCOW) Slot:

This time slot provides limited order wire capability for DAMA related subscriber to channel controller communications. It is used for transmission from the subscriber to the channel controller.

C. Ranging Time Slot:

This is the time slot during which the user’s determines the range between the user terminal and the satellite to set the transmitter synchronization required for timing. All DAMA multiplexer [4] transmit times are referenced to the satellite.

D. Link Test Slot:

The link test slot is used to evaluate the performance of the satellite link. Each subscriber is able to transmit a fixed data stream through the satellite, receive that bit stream, and then perform error analysis automatically.

E. Data Time Slots:

These are the time slots during which users transmit or receive data. There are three segments of time slots in each frame, designated A, B, and C. Segment A may contain from one to five circuits; B may contain from one to eleven circuits; and C may contain from one to six circuits. The number of circuits in each group depends on the baseband data rate, the forward correction rate, and the transmission burst rate, as influenced by the radio frequency interference (RFI) environment.

IV. EMERGING TRENDS

Recent trends in military and commercial satellite communication systems [9] to use Demand Assignment Multiple Access (DAMA) dictate DAMA development to improve system utilization, efficiency and resource sharing by a large population of users with diverse traffic. Asynchronous Transfer Mode (ATM) [8] is emerging as the universal transport mechanism for the next generation broadband communication networks in both the military and commercial environments. To meet the future evolving system requirements, e.g., connectivity, interoperability, flexibility, access and control, etc., new SATCOM must be developed including efficient resource allocation and demand assignment algorithms [10]. Several Demand Assignment Multiple Access (DAMA) techniques for circuit switched satellite communication networks are available. To meet future multimedia service requirements, Military Satellite Communications architectures must include new efficient resource allocation and demand assignment algorithms. Asynchronous Transfer Mode is emerging as the universal transport mechanism for the next generation broadband communication network.

Ships at sea could maintain connectivity using a combination of broadband satellite and inter-ship terrestrial communication links. In defense, one of the widely used satellite channel access protocol [9] is DAMA. This technique matches user demands to available satellite capacity. Satellite channels are grouped together as a bulk asset, and DAMA assigns users variable time slots matching user information transmission requirements. While user notices no change in channel quality, the result is a dramatic increase of up to 4 times in communications capacity, number of supported users and networks. DAMA is most effective where there are multiple users operating at low to moderate duty cycles, which is the typical military usage pattern. The network can assign different priorities or serve users on a "first come first served" basis. Prioritization technique is suitable for command type nets, while the minimum percentage operation is suitable for support/logistic nets.

V. CURRENT OPERATIONS

For communications on the eastern Pacific satellite, a master control station is installed at Naval Computer and Telecommunications Area Master Station Pacific (NCTAMS EASTPAC) [12]. Each master control station has multiple multiplexer installed, and each multiplexer can accommodate up to four circuits. The number of multiplexer installed aboard each ship varies according to platform requirements. Any DAMA-equipped platform with full-duplex capability can be
designated a channel controller. This capability provides an emergency backup for the shore based master controller terminals. A DAMA subscriber who is designated a channel controller will provide all the required CCOW functions for DAMA system control of a particular RF channel. Operationally, the user terminal will have its baseband port automatically connected to a data time slot when the proper slot number is keyed into the multiplexer front panel keyboard. Each SATCOM subsystem that uses DAMA will have a specific slot number.

A. Transition:
Transition to DAMA is taking place in a manner that allows subscribers converted to DAMA to communicate with those who have not been converted. During the transition period, equipment installed at shore based master stations will form gateways between DAMA and non-DAMA circuits. In the following paragraphs, we will discuss subsystems that are either currently undergoing conversion to DAMA or are planned for conversion, so you will know what to expect in the future.

B. Secure Voice:
DAMA is now being phased into the secure voice subsystem.

C. Teletypewriter:
Teletypewriter capability via DAMA becomes available as DAMA is installed on each platform. To provide maximum flexibility during the transition, capability is provided at the shore based master control stations to interface non-DAMA and DAMA users.

VI. DIFFERENT SATELLITE ASSIGNMENT TECHNIQUES

Difference of satellite resource sharing or assignment techniques [6], this describes various multiple access techniques to make use of common satellite resources by multiple VSATs/Earth Stations [7].

<table>
<thead>
<tr>
<th>PAMA</th>
<th>DAMA</th>
<th>RMA</th>
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<tbody>
<tr>
<td>PAMA stands for Pre Assigned Multiple Access</td>
<td>DAMA stands for Demand Assigned Multiple Access</td>
<td>RMA stands for Random Multiple Access</td>
</tr>
<tr>
<td>Resource assignment is initially planned and carried</td>
<td>Resource assignment is done at the time of request from subscribers/users via NOC</td>
<td>Not needed</td>
</tr>
<tr>
<td>Assignment can be hold for long duration usually months/years</td>
<td>Assignment can be up to the duration of the call (conversation) or data burst</td>
<td>Connectivity exists during the burst/packet</td>
</tr>
<tr>
<td>Long term exclusive assignment of resource usually in time / frequency / code</td>
<td>Temporary exclusive assignment of resource usually in time / frequency / code</td>
<td>Resource assignment is on shared basis (contention basis)</td>
</tr>
<tr>
<td>Similar to leased line used in a terrestrial telephone network</td>
<td>Similar to dialup line used in a terrestrial telephone network</td>
<td>Similar to private communication exchange network used for telephone application</td>
</tr>
<tr>
<td>Example: INSAT FDMA for TV / Radio Network</td>
<td>Example: INMARSAT space system</td>
<td>Example: ALOHA based data collection terminal systems</td>
</tr>
<tr>
<td>PAMA concept is used in AM / FM / TV application</td>
<td>DAMA concept is used in mobile telephone applications in GSM / CDMA networks</td>
<td>RMA concept is used in private communication / amateur radio</td>
</tr>
<tr>
<td>Merits: low earth station costs and control over back off, wastage of resources if not occupied by users, not economical as need to pay even if service is not utilized</td>
<td>Merits: efficient use of resources as they are allocated till the duration of call, economical as need to pay based on usage</td>
<td>Merits: earth station equipments is very small in RMA based network</td>
</tr>
<tr>
<td>Demerit: it is not flexible to actual traffic conditions and hence it is not resource efficient</td>
<td>Demerit: more complex system is used at earth station side as entire network operation is carried by control station</td>
<td>Demerit: no control over users, Interference / collision / blocking may occur in RMA network</td>
</tr>
</tbody>
</table>

VII. MERITS AND DEMERITS

A. Merits:
In a DAMA system, terminals send requests to a control station, which responds by assigning specified time slots or frequencies. Accordingly, there is no risk of collisions between the signals of different terminals and bandwidth [5] is used efficiently. However, processing and responding to requests takes time. So the challenge in DAMA implementations is to minimize time delays and maximize the use of network resources. This technology provides reliable digital telecommunication connectivity while controlling satellite bandwidth use and cost. A DAMA network uses a pool of bandwidth, which is made available to any station in the network. Upon demand, a pair of available channels is allocated and assigned to a call. When the call is completed, the channels are returned to the pool for another assignment. Since the DAMA networks uses satellite channels on an as-needed
basis, instead of having them permanently assigned, there is no dedicated station-to-station links as in SCPC (Single-Channel-Per-Carrier) PAMA. This lowers the amount of satellite bandwidth needed to service the entire network.

B. Demerits:
DAMA has limitations, particularly in transaction networks, in which a large terminal population sends short transaction messages to a Hub station. The probability of a request from a single Terminal usually is low. Consequently, slotted Aloha, is the only practical access method, as it results in a use of network resources of the order of 20%, which means that 80% of the allocated time slots allocated are wasted. This can be enhanced by the DAMA system.

VIII. CONCLUSION
To improve system responsiveness and flexibility, many DAMA schemes have been proposed; some of them are being developed and also resulting in DAMA standards. However, most of these DAMA systems are for circuit-switched networks. To meet the projected four-to-five fold traffic growth and multimedia services the future SATCOM architectures [9] must include ATM transport technologies.

REFERENCES