This document describes the operation of the VIPERSAT STDMA (Selective Time Division Multiple Access) System. Configured systems provide an IP satellite routed network between a central hub and various remote terminal LANs. It is assumed that readers of this document already have a basic knowledge of the standard Vipersat system. The addition of STDMA capability allows multiple terminals to share the same satellite resources that would be dedicated to a single terminal in a Single Carrier per Channel (SCPC) configuration. This means that more terminals are added to the network with minimal additional cost in either satellite bandwidth or Hub Terminal hardware. STDMA provides a low cost solution for medium to large sized networks with generally moderate bandwidth requirements, while at the same time providing all the features of the existing VIPERSAT systems, including the availability of a Dynamic Bandwidth On Demand.

The network topology consists of from one to several hundred remote terminals, managed from a central hub terminal with the VIPERSAT Management System (VMS). Each upstream channel from the remote terminals to the hub uses a STDMA frame operating at an aggregate data rate from 64Kbps to 2Mbps and can support up to hundreds of remote terminals with multiple burst channel inbounds. To achieve scalability for larger networks, the system allows multiple STDMA channels to operate simultaneously at the hub. The downstream channel from the hub to the remotes uses a TDM scheme, transmitted over either a standard SCPC or DVB channel, typically operating from 512Kbps to 45Mbps. This allows data to be broadcast to all remote LANs simultaneously without the routing issues inherent in a strictly terrestrial network.

Sales Contact:

3089 Skyway Court, Fremont, CA 94539 USA

Tel. (480) 333-2200. Fax (480) 333-2540

Email: sales@ComtechEFData.com

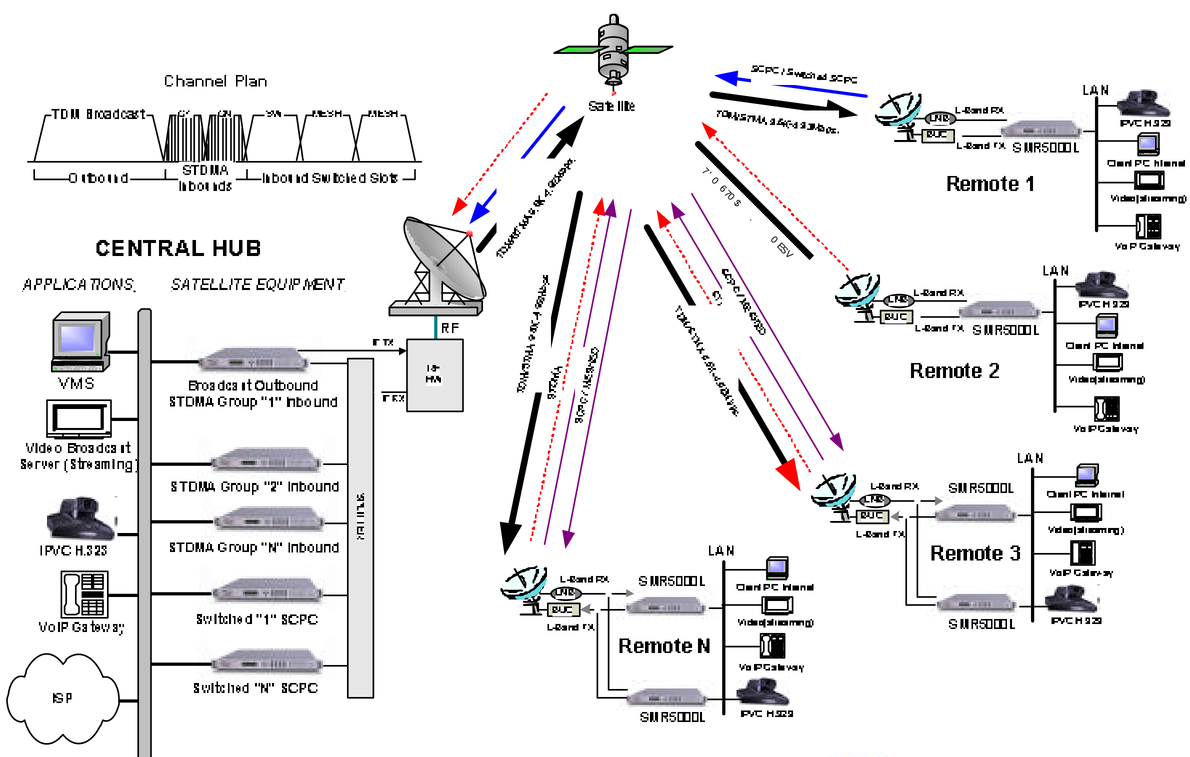
www.ComtechEFData.com

Revision 1.00.04
Printed in the USA

Introduction

STDMA provides shared bandwidth access networks with a low initial hub cost as compared to traditional TDMA networks. This low cost, achieved by using a fast acquisition SCPC demodulator as the burst controller allows users with small to moderately sized networks to take advantage of demand driven space segment usage without a huge capital investment in hub hardware. STDMA is easily scalable to allow for network growth simply by adding burst controllers at the hub to accommodate additional groups of remote terminals.

The basic system is comprised of a Time Division Multiplexed (TDM) outbound which is shared by all remotes in the network. The return channels are Selective Time Division Multiple Access (STDMA). STDMA has two modes of slot allocation operation, fixed or dynamic. In fixed mode all remotes within a group are granted the same amount of transmission time in a cycle. When operated in dynamic mode, to take advantage of the bursty nature of IP traffic, the return channels are dynamically sized (in terms of transmission time in frame) based upon demand. All IP protocols are supported. Since under most circumstances it makes more sense to operate the network in dynamic mode, descriptions in this document address primarily dynamic mode operation. When combined with VIPERSAT MS[3], STDMA provides an extremely flexible platform supporting any type of data and streaming protocols.



Description

STDMA is a low cost approach for bandwidth sharing. It is based on a star network with a controller(s) at the Hub and from two to 20 remotes sharing bandwidth using time slot management. Hardware costs are kept low by using a fast acquisition SCPC modem rather than a dedicated Burst Demodulator at the hub. The cost advantage of STDMA over standard SCPC is that a single SCPC receiver at the hub can service multiple remotes. In addition, bandwidth can be allocated as needed, rather than dedicating bandwidth to a remote that is not using it. The key to maximizing bandwidth utilization is to continually monitor the remotes for bandwidth requirements and adjust the slot sizes of each remote as needed. This is done by having each remote send a short status and statistics message (ACK) as the first packet in each upstream slot. The STDMA controller accumulates these messages for each cycle and assigns slot size for the next cycle based on current need. Note that since STDMA uses SCPC modems, a fairly large preamble is required to allow the demodulator to lock on the carrier. As a result, it is necessary to use rather large data slots in order to maximize bandwidth efficiency. The trade off is that as the slot size grows, the latency between transmission opportunities for each remote also increases. Note that the minimum required preamble size is inversely proportional to the data rate; systems operating at higher data rates are more efficient than systems operating at lower data rates.

Because of the restrictions on slot size discussed in the previous paragraph, it is not practical to allow more than 20 remotes to be managed by a single STDMA controller. Therefore, in order to accommodate larger networks, it is necessary to allow a hub to support multiple STDMA controllers. This is done by assigning a group number to each controller and its associated remotes. This allows multiple STDMA controllers at a hub to transmit their Burst Map (or slot map) on a common outbound and have a way for the remotes to identify which map is intended for them.

Terminology

The following terms are used to describe the elements of STDMA transmission:

1. Preamble: An arbitrary pattern of data which is transmitted to allow the Hub receiver to lock on the SCPC signal from the remote. The pattern is currently repeating words of 0x55AA but can be changed to any pattern that will improve lockup time; i.e., there is no data processing done on the preamble.
2. ACK: This is a proprietary message that allows the remote to provide its identity and queue buffer usage statistics to the hub. If the hub does not receive this message for a specified number of spins, the remote may be removed from the spin cycle.
3. Data Slot: The amount of time allocated to a remote for continuous data transmission. The ACK is part of the Data Slot but the Preamble is not.

4. Guard Band: This is a period of time during which no terminal is supposed to transmit. This time is used to compensate for uncertainties in clock synchronization.
5. Spin: The period of time during which all remotes have one opportunity to transmit. The spin time is equal to the number of remotes in the Burst Map times the sum of: Guard Band + Preamble + Data Slot.
6. Cycle: The number of spins before the Burst Map is re-calculated and transmitted. The system currently limits the number of spins per cycle to the range 2 to 20.
7. Burst Map: A proprietary message sent from the hub to all remotes, at regular intervals, specifying the start time and duration for each terminal to transmit. (In some TDMA systems, the Burst Map is also referred to as the Slot Map.)

Elements of STDMA

STDMA Burst Map (Slot Map)
Allocation of slot size in Dynamic Burst Maps

- Available Bandwidth =
  (Nominal Slot Size – Minimum Slot Size) * Number of Remotes in Burst Map
- Percent Usage =
  Bytes received from this remote / Bytes received from all remotes
- Actual Slot Size =
  Minimum Slot Size + (Available Bandwidth * Percent Usage)

Time Synchronization

Time Synchronization in Vipersat STDMA is done without closed loop timing or even a system wide standard clock. In fact, there is no time of day clock at all. Each terminal simply maintains its own 32-bit free running clock with a resolution of 125 microseconds. All timing is based on relative offsets. The Burst Map message is transmitted over the air to all terminals as an IP multicast message. Since the message is transmitted by satellite rather than Ethernet, the propagation delay (or transmit latency) is relatively constant. (Satellite movement causes some variation over longer periods of time but this manifests itself as a gradual drift rather than jitter.) As a result, all remote stations receive the Burst Map at the same time within the uncertainty due to propagation delay at different geographic locations and processing latency within the modem. However, this uncertainty is small relative to the lock time of the demodulator and can thus be tolerated by adjusting the guard time and/or preamble size. The remotes attempt to minimize latency by time stamping all multicast messages they receive. This timestamp is performed at the "interrupt" level. Once the timestamp is established, all times within the Burst Map are relative to the start of the frame, which begins when the Burst Map is received. Thus, since the remote "knows" when the Burst Map was received (relative to the remote's clock) and the relative offset to the beginning of its slot, it can determine the actual beginning and end of its slot.

Burst Map Generation

The burst controller monitors statistics in the received ACK from each remote. The statistics report the fill status of the STDMA buffers. The burst controller builds a table of the group and calculates the relative buffer fill for each remote. It then calculates the length of the Data Slot for each remote based on the Minimum Slot Size + a percentage of the Available Bandwidth. Idle remotes would receive a Data Slot equal to the Minimum Slot Size.

STDMA Statistics

Figure 2 shows the statistics table for STDMA at the burst controller.

Current Spins = 84	Missed Acks At Hub			Rcvd ACKs	Ave Rx Bytes	Avg Slot Usage	Avg Slot (MSecs)
IP Address		Cont	Total				
1. 192.168.151.1	E	0	0	84	1	22.3%	71
2. 192.168.151.65	E	0	0	84	165	32.3%	103
3. 192.168.151.129	E	0	0	84	1	22.3%	71
4. 192.168.151.193	E	0	0	83	6	23.1%	74

Figure 2

In the table above Remote 2 had activity during the averaging period. It captured 32.3% of the total slot time and had an average slot length of 103 ms. Remotes 1, 3 and 4 dropped to 22.3 and 23.1% respectively. The dynamic range of STDMA is a function of the difference between the nominal Data Slot Size and the Minimum Data Slot Size parameters. These parameters are operator selectable. The speed with which STDMA reacts to changes in dynamic load is a function of the Statistics Accumulation Window parameter and the Cycles per New Burst Map parameter, both of which are also operator selectable.

STDMA Channel Mapping

The STDMA groups share a common TDM outbound. Each group controller generates its own burst map. Additional access channels can be provided, as the network grows larger. The number of channels will be based on the number of terminals and access delay requirements. The channels can be changed or modified by the network operator to meet evolving system requirements. The STDMA design lets the network manager determine the number of channels, the data rate, center frequency and BW of each channel. The frequency channels do not need to be adjacent in the transponder as illustrated in figure 1, but can be assigned anywhere in the satellite transponder.

.

STDMA Analysis Calculator

Figure 3 is an example of an STDMA analysis calculator. This calculator, in spreadsheet form allows the network designer to manipulate STDMA parameters to determine the required burst rates and number of burst controllers for a given network application.

Proprietary Information

Note: All table results are subject to change.

Analysis of STDMA

Required Preamble in Milliseconds	40
GuardBand in Milliseconds	15

Date: 8/15/03

Equipment:SMR5000

Select Slot Size in Milliseconds	100					
	Bytes	5	8	10	15	20
Burst Rate	Per Slot	Effective Bit rate Per Remote Node				
64000	800	8258	5161	4129	2753	2065
128000	1600	16516	10323	8258	5505	4129
252000	3150	32516	20323	16258	10839	8129
512000	6400	66065	41290	33032	22022	16516
1024000	12800	132129	82581	66065	44043	33032
1544000	19300	199226	124516	99613	66409	49806
2048000	25600	264258	165161	132129	88086	66065
Cycles Per Second		1.29	0.81	0.65	0.43	0.32
Seconds Per Cycle		0.78	1.24	1.55	2.33	3.10

SPC=Seconds per Cycle
DSS = DataSlotSize (Nominal)
PRE = Preamble
GB = GuardBand
EBR = Effective Bit Rate
BR = Burst Rate
N = Number of Nodes
ENT = Effective Network Throughput
MIN = Minimum Slot Size
EBR = ((DSS)(/DSS + PRE + GB)*BR/)N
EMAX=Maximum Bit Rate
EMIN=Minimum Bit Rate

Figure 3

The four parameters effecting network performance are the Preamble, Burst Rate, Guardband and Data Slot Size.

The Preamble is inversely proportional to the Burst Rate. This will make the network more efficient at higher rates. In the example shown above, a preamble of 40ms is selected. This is appropriate for a burst rate of 512kbps. Figure 4 shows a plot of Preamble vs various Burst Rates. The values in the chart should be considered starting values when tuning a network for maximum performance.

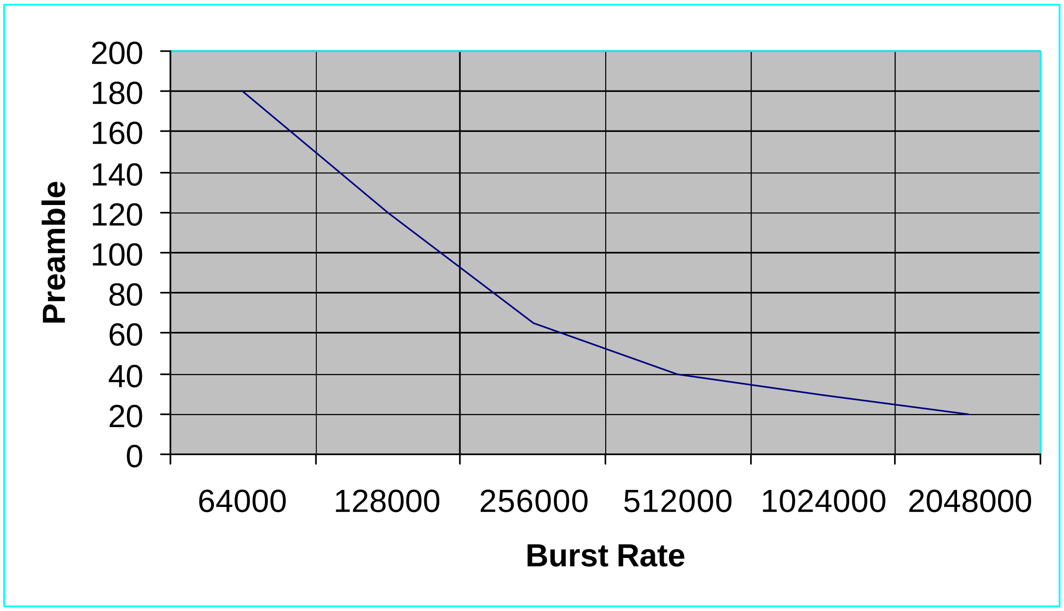


Figure 4

As stated earlier, the purpose of the Guardband is to compensate for uncertainties in clock synchronization. It also compensates for geographical diversity in the satellite footprint. The Guardband will vary in a relatively small range between 13 and 16ms.

The Preamble and Guardband are the primary tuning parameters. Since they represent "dead" time in the cycle in terms of customer data they should be tuned to the lowest value to maximize efficiency without loss of data.

The value of the Data Slot Size parameter is a function of network traffic. Network efficiency can be stated as a function of the formula DSS/(DSS + PRE + GB). Therefore, increasing the Data Slot Size will increase network efficiency. However, it will also increase latency in the network as it will increase the length of the cycle. Therefore, a tradeoff must be made considering the applications running on the network between efficiency and latency.

The Data Slot Size is also a nominal value when running in dynamic mode. There is another parameter setting for the Minimum Slot Size. The greater the difference between the DSS and the MIN, the more dynamic range will be available in STDMA. Refer to Figure 3:

Given a Burst Rate of 512000, 10 nodes in the group, a DSS of 100 and a MIN of 50:

EBR = 33032

The Effective Bit Rate (EBR) represents a value when all remotes are busy and therefore using the DSS (nominal slot size). To calculate EMAX (the maximum possible bit rate) assume that nine of the remotes are idle. Each of the nine remotes will use 50ms (MIN) of the data time within the cycle. Since the total data time within the cycle is equal to the DSS * N, or 100 * 10, the total time is 1000. This leaves the busy remote 550ms to transmit within the cycle (total time – 9 * 50). EMAX will therefore be equal to 550 * BR (512000) / cycle time, or ((.550*512000)/1.55), or 181677.4bps. Conversely, EMIN (the minimum bit rate) would equal ((.050*512000)/1.55) or 16,516bps.

When calculating the MIN, it is important to insure that the MTU of the network will fit into the slot.

Transmission Error Sensitivity

STDMA technology is based on standard SCPC transmissions which alleviates the need for carrier control loops. Traditional TDMA networks require closing carrier control loops to narrow the frequency error offsets and input power levels.

The burst demodulator carrier tracking and acquisition circuits can receive burst-to-burst receptions while using only a small amount of overhead (bits). This small bit decision does not come without a price. Additional hardware, software, and bandwidth are required to facilitate this small bit reception process. The small bit processing narrows the reception window through complex algorithms and feedback control loops. These control loops are very important in maintaining center window targeting of inbound transmission bursts. Every terminal within the network must be provided separate correction control information during each burst transmission. If the loop becomes unstable during environmental, network loading or if the separate control channel is distorted, the terminal reception is lost. If the processing of narrow window control loops is done correctly these types of networks provide stable communications circuits.

STDMA provides a level of simplicity using a large acquisition window. This window without control loops can receive clear burst transmissions with frequency errors of ± 20 KHz and carrier levels as low as 3dB. The exclusion of control loops provides not only simplicity but reliable carrier links.