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Discussion on Very Small Aperture Terminal Networks

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Abstract

Recent advances in technology have given a new thrust to the satellite communication industry by deploying low cost very small aperture terminal (VSAT) network for data, voice, and video communication. VSAT networks are characterized by their low cost per node, integrated network management facilities, and support of multiple applications and integrated communication services. During the last five years, VSATs' evolution has brought a significant change in the satellite communications industry, both in its current product offerings and future development strategies. In this paper, we propose an introduction to VSAT, architecture design of a VSAT network. Future trends in VSAT technology are also discussed

I. INTRODUCTION TO VSAT: -

A VSAT is defined as a small earth station with antenna diameter typically less than **2.4** m and suitable for easy installation on customer premises to provide a wide range of telecommunications services with a large hub station or another VSAT. A VSAT typically consists of a compact 1-3 W RF outdoor unit to receive and transmit signals, and an intelligent indoor unit housing the modem, satellite interface, and terrestrial interface unit.

VSAT networks provide one-way or two-way data communications, video broadcast, and/or voice communication. These networks can be categorized as point-to-point, broadcast, or interactive networks. Due to limited and known network components -i.e.- hub earth station, VSATs and space segment-it is easy to diagnose problems and to maintain the network. The user exercises full control over his network with a centralized network management system.

The overall service cost-effectiveness is playing an increasingly important part in user decisions to invest in satellite networks predictable cost over the life of the network. VSATs provide economical solutions to many of the communications needs of virtually all segments of business and industry. For large networks, VSATs costs dominate; however, one must optimize the life-term cost per node, which also includes the hub, installation, maintenance, and space segment.

As fiber optics becomes more prevalent, satellite technology is less likely to be used for voice and heavy-traffic applications. Voice telephony is more likely to be carried on public switched networks based on terrestrial technologies for both cost and performance reasons. However, VSATs can be used in locations where there is no access to the public switched network. Video distribution via satellites to the head ends of cable systems and direct to homes using TV receive only (TVRO) has been widely used. Analog video broadcast over satellite networks, primarily designed for data communication, is becoming increasingly popular for corporate presentations and training. Digitized video with advanced data compression to data rates as low as 56 kb/s has recently made VSATs cost-effective for videoconferencing applications. The inherent capability of a satellite to broadcast over geographically dispersed areas makes broadcast networks ideally suited for information providers [IO]. Low-cost receive-only terminals can receive news and weather services, and financial information on stock and commodities. Subscribers can get better service and faster response by searching a local database, which is updated in near real time over the satellite link. If required, a return channel can be provided through dial-up or a local access to a public packet network for infrequent trades or inquiries to the central host. The primary applications **of** two-way star networks include point-of-sale, banking/financial, credit verifications, centralized stock control, centralized reservation, and pipeline monitoring and control systems. Contrary to leased lines, which is an inherently symmetric transmission medium, satellite capacity can be allocated independently in each direction, and thus VSAT networks can provide cost savings by taking advantage of non symmetric applications.

II. Architecture of VSAT networks: -

Under architecture of VSAT there is discussion of following topics: -

A. Topologies
B. Architectural Issues

(A). **Topologies**

VSAT networks can be classified into three general categories: broadcast networks, point-to-point networks, and two-way interactive networks.

1) Broadcast Networks: Broadcast points to multipoint networks were the first ones to exploit VSAT technology commercially. Although the first systems introduced were

C-band, technology is now moving towards Ku-band. In a broadcast network, a centralized hub station broadcasts packetized data, program quality audio, broadcast video, or a combination of these to all or groups of remote receive only VSATs. Techniques employed for these networks include single channel per carrier (SCPC), spread spectrum, and FM2 or sub carrier.

2) Point-to-Point Networks: Point-to-point networks provide voice, data, and image transmission between two locations without the requirement of a large hub earth station.

A variation is a star network, where by point-to-point circuits are provided from a centralized location to multiple remote locations. These networks usually use SCPC transmission supporting a variety of applications including remote batch, file transfer, high-volume printing, and digital facsimile.

3) Two-way Interactive Networks: Two-way interactive networks are by far the most popular. These networks offer a wide range of voice, video, and data services from a central hub station to a large number of remote VSATs in a star topology (Fig. **1).** VSAT-to-VSAT communication is possible through the hub station but requires two satellite hops. The outbound transmission from the hub to remote VSATs is broadcast to all VSATs over a high-speed time-division multiplexed channel. By use of addressing, a VSAT accepts only the messages directed to it and rejects all others. Inbound transmissions from VSATs to the hub are carried over one or more shared channels using a multiple access protocol, and many VSATs can share a satellite channel in low-activity applications.

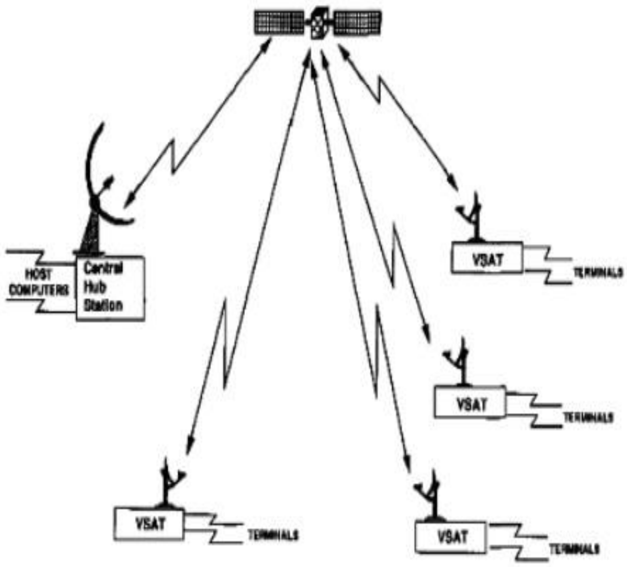


Fig: - 1 Two way interactive networks.

(B). **Architectural Issues**

It is unlikely that a single product can meet the needs of all users. Some trade-offs must be made between cost and performance. This section describes some of the architecture and design optimization and trade-off areas.

1. Network Size: For very small networks, the cost of the hub station and space segment is the most significant portion of the overall network cost. A shared hub or low-cost hub that makes efficient use of the space segment is suitable for these networks. Very large networks will benefit enormously by even small reductions in the cost of the VSAT equipment, even at the expense of hub equipment, space segment, or both. Moderate sized networks benefit from a design that balances the cost of VSATs, hub, and recurring space segment charges.
2. Network Availability: Perhaps the most concern expressed regarding Ku-band satellite networks is about the effect of rain attenuation on the satellite communications links. While link availability is typically specified at antenna sizes or energy-dispersion techniques while still meeting the FCC power-flux density limit of 6 dBW/4 kHz for blanket licensing. While link budgets are clearly important, it is imperative that the network design and architecture ultimately meet the end-user data communications performance requirements. This performance is typically based on the throughput, delay, data channel efficiency/loading, availability (percent time available at some error threshold), data channel error rate, and network connectivity.
3. Redundancy: Since the hub is a single point of failure in a star network, hub equipment is usually configured with 1: 1 or 1: N redundancy. For critical applications, a physically diverse hub may be required to account for both rain fades and catastrophic situations. As a minimum, a disaster recovery plan must be included in the hub architecture. Back-up for the satellite channels i s another desirable feature. This may include both inter- and intra satellite protection. To minimize the cost of remote terminals, redundancy is usually not included in VSAT designs. Dial backup options are available from some vendors. For some critical applications, continuous service may be provided using diversity VSATs.
4. Miscellaneous: The hub design should provide for modular network growth and should impose virtually no hard limits on the size of the network. The network management system should be ”portable” to a variety of machines, from PC/workstations to super minis, to support different network sizes. The VSAT system design should lend itself to easy installation. Aesthetic aspects may be a prime consideration to many potential customers. The difference between the acceptability of a 1.2-m versus a 1.8-m VSAT antenna may be more of a driver

than the difference in installation cost of two options.

1) Hardware Of VSAT Network: -

A VSAT network typically consists of a hub earth station, remote VSATs, and a network management system. The transmission medium is the satellite, which is controlled by the space segment provider.

1. Hub Equipment: The hub earth station consists of RF, IF, and base band equipment (Fig. 2). It handles multiple channels of inbound and outbound data and often one or more channels of broadcast video. In private dedicated networks, the hub is collocated with a user's data-processing facility. In shared hub networks, the hub is connected to the user equipment via terrestrial back-haul circuits. The RF equipment consists of the following subsystems: antenna, low-noise amplifier, down converter, u p-converter, and high-power amplifier. Except for the antenna, the hub RF subsystems are usually configured with 1:l redundancy. The IF and base band equipment consists of the IF combined divider, modulator and demodulators, and the processing equipment for the satellite channel interface and customer equipment interface. The satellite interface unit provides communications control using proprietary multiple access techniques. The customer equipment interface unit provides the interface to the customer host equipment and protocol emulation. The hub base band equipment is designed in a modular fashion to allow ease of network growth and is usually provided in a 1: 1 or 1: N redundant configuration.

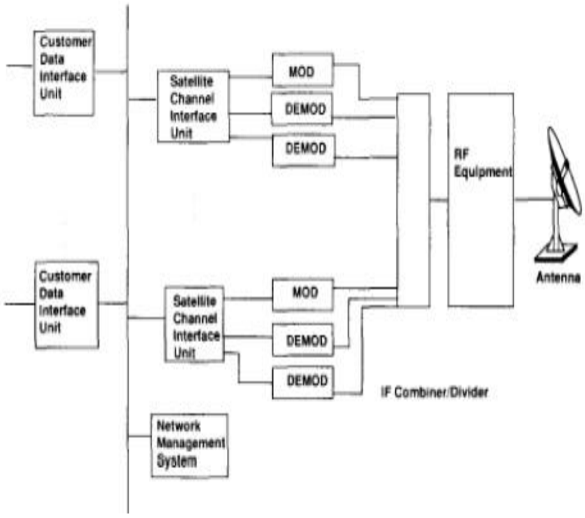
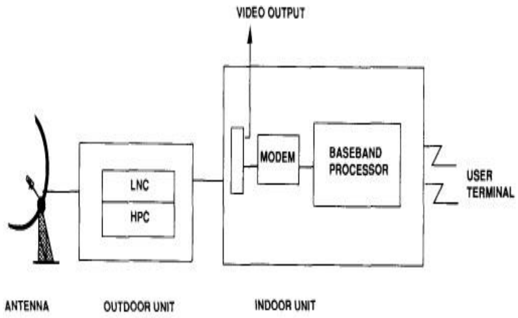


Fig2: Typical block diagram of a hub station

2. Remote VSAT: The VSAT is a stand-alone unit installed at a remote customer site. It provides the user terminal interface and the satellite channel access interface. The VSAT consists of an antenna, an outdoor unit (ODU), and an indoor unit (IDU), as shown in Fig. 3. A single inter facility link (IFL) cable provides communications between the ODU and the IDU. To minimize costs, the VSAT is usually deployed in a non-redundant configuration. Typically, the VSAT uses a 1.2- or 1.8-m offset feed parabolic antenna. The antenna size i s determined by the location of the VSAT with respect to the satellite, the weather conditions, and the need for a video channel.

The ODU is a one-piece compact unit contained in a weatherproof housing. The ODU and antenna transmit and receive radio frequency signals between VSAT and the hub station via the satellite. The ODU typically contains a solid-state power amplifier (SSPA), a low-noise amplifier, up/down converter and an orthomode transducer, and is installed at the antenna focal point to avoid transmission losses between the antenna feed horn and RF equipment. The IDU is located indoors near the user terminal equipment. It consists of a modulator-demodulator subsystem and a base band processing subsystem. Optionally, a video port can be provided with an RF splitter to separate the received video signal from the data signal. The video signal can be connected to a video receiver and a TV monitor. With the use of powerful microprocessors, the base band processing subsystem provides the VSAT with customer inter faces and efficient satellite channel access. It also performs protocol emulation and conversion between a terrestrial protocol and the satellite link protocol.



LNC: - Low noise converter

HPC: - High power converter

Fig 3: - block diagram of VSAT

3. Network Management System

The network management system (NMS) is a critical element of a VSAT network and can often be the determining factor of success or failure of a VSAT network [7]. Through the NMS, the user can have full control of his network, which is usually not possible in the case of terrestrial network facilities. The NMS provides the functionality of network monitoring and control, network configuration control, system performance and statistical information gathering, and can assist in planning functions to optimize the VSAT network according to measured and projected traffic profiles. The NMS provides a centralized management tool through the following major functions:

- Hub and VSAT equipment configuration control including port and satellite channel configuration and address mapping.
- Assignment of inbound and outbound satellite channels.
- Network monitoring and control including health check and switchover to back-up facilities.
- Network congestion monitoring and control.
- Switchover to back-up equipment, transponder, and satellite.
- Network statistics collection including network usage, network performance, and traffic loading.
- Network diagnosis by loop-back tests from the hub to VSAT.
- Down line loading of new software and configuration data to VSAT and hub components.
- Report generation including printouts of alarms, configuration, and periodic statistical reports.

NMS architectures for shared and dedicated hubs are similar with some distinctions. In the shared hub environment, the hub operator controls the allocation of resources among various users and controls the RF transmission facility. However, the user must have the ability to manage his portion of the network transparent to other users. In the case of a dedicated hub, a single management entity can exert full control over the network, including RF transmission facilities. In some cases, the NMS is designed to handle multiple hubs and can be shared by multiple users [22]. Management functions associated with network deployment include installation, maintenance, and equipment sparing, etc. These functions are critical in VSAT networks because of the large number of nodes in such networks [ll]. The nature of VSAT networks typically requires a nationwide system of problem isolation/identification, field-service force, and professional installation services for effective installation and maintenance management.

<u>Future Trends Of Vsat: -</u> Future trends in very small aperture satellite networks, with earth stations located at subscriber sites, will be driven by the following goals:

- Lowering costs of the VSAT terminals, hub (or network master) stations, and installation of these networks.
- Providing a greater range of service, including voice andcompressed video services.
- Providing networks that are more user friendly and flexible in terms of Operations, Administration, and Maintenance (OAM).
- Integration of these networks with a larger variety of Customer Premises Equipment (CPE) and more advanced terrestrial networks including fiber optic networks, newer switching equipment, and Integrated Services Digital Networks (ISDNs).

To achieve these goals, emphasis will be placed on volume manufacturing techniques to lower production costs, as well as using new developments in Microwave Integrated Circuits (MICs), digital integrated circuits, and lower cost antenna designs and mounting methods. In the antenna area, flat panel-phased array antennas offer some promises for less conspicuous, simpler antenna installations. New digital signal processing techniques applied to modem implementation; maintenance and control, “smart” components, and subsystem design hold promise for both lowering cost and providing better performance and a greater range of service. Software development in conjunction with the use of microprocessors is important to meeting all of the above goals and can be done in a way that will permit upgrading of current systems. New software development is especially important in permitting interfacing to a greater variety of customer premise equipment, which includes new data terminals, **PBXs,** host computers, multiplexers, and line and network management controllers.

Voice and video services are provided in current VSAT networks, primarily via the central station. In the future, direct VSAT-to-VSAT connectivity in a mesh network configuration will be provided, using newer signal processing technologies such as low bit rate voice coding (16 kbis or less) and video coding (bit rates around 56 kb/s), combined with improved digital modems and error coding techniques. Centralized network management and administration is likely to be used but multiple access and signaling will be optimized for mesh operation with voice and video signals, as well as data signals. Mesh network configurations will also encourage use of VSAT networks for conferencing applications, using the broadcast capability of satellite systems. Today, Integration of the VSAT networks with the terrestrial common carrier network is via gateways, generally located at the hub station for the network. In the future, the VSAT networks will be interfacing with the ISDN terrestrial network. In the ISDN environment the VSAT network may be viewed as a user (or private) network and interface through an NT2 termination, or may alternatively interface at a hub through an ISDN end office, or be part of the transit network providing complete ISDN services and interfacing to the external ISDN through multiple gateways. Multiple gateway interfaces may become more important in the future with greater use of full mesh VSAT network architecture. It is important that in the selection of the link and network layer protocol standards for ISDN, that satellite networks be considered with respect to unique properties of these networks, such as delay and broadcast capabilities. One of the areas of growth for VSAT networks in the future will be in international VSAT networks, which extend over an ocean basin having terminals on more than one continent. These networks may require integration with terrestrial networks through multiple gateways in different countries, compatible with different terrestrial interfaces in each country. Such networks may also incorporate standard converters, as might be the case for video distribution, as well as more distributed OAM. Such networks may be one of the important future trends in VSAT networks. In addition to future trends in the VSAT ground networks, one can expect new technology to be important in the space segment area. New communication satellites will incorporate the following features, which will have a significant impact on future VSAT networks:

- Higher power HPAs
- Use of spot beams and scanning beams
- On-board processing
- Intersatellite links

These features will permit higher capacity VSAT networks, with lower cost earth stations and greater flexibility. The use of intersatellite links may provide direct connectivity and integration into other networks without requiring terrestrial connections. Direct integration with mobile networks may also be possible by this method. With both the advances in ground network technology, spacecraft technology, and networking technology, we can expect to see significant strides made in achieving the above four identified goals.

B. Conclusion: -

The three things that the current VSAT users are happy with are: cost, performance, and independence. VSATs will have smaller antenna options to reduce equipment and installation costs as well as improve user acceptability of systems The VSAT vendors are pursuing techniques to increase circuit integration and volume production so that the cost of VSATs could be brought down.

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