tsat

SELECTING A LOW OPEX SATELLITE SOLUTION

FOR SCADA/TELEMETRY AND LOW DATA RATE APPLICATIONS

Introduction

Satellite systems are often a key part of a power utility SCADA/Telemetry and other low data rate communications network. When selecting your satellite system there are three financial considerations that one usually considers:

1. Equipment costs
2. Installation costs
3. Operational costs

In addition, there are reliability and performance concerns that go into selecting your equipment and network configuration. In this paper, we will focus on operation and installation costs. Fortunately, the techniques used to reduce the operational and installation costs can help with reliability and performance as well.

A Typical Satellite System

The following figure shows a typical satellite system used by utilities, pipeline and seismic network operators when using satellite systems. Such systems are usually referred to as VSAT system (Very Small Aperture Terminals) a reference to the antenna size, which was considered very small when such architectures were first developed.

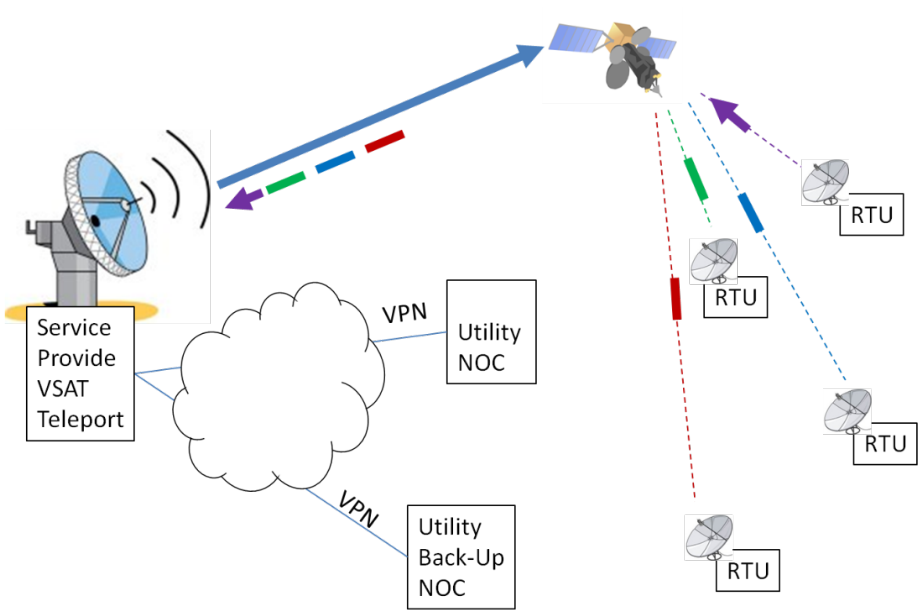

Figure 1 - Typical SCADA and Seismograph network using satellite transport.

Such systems, as shown in Figure 1 commonly share the following characteristics:

1. A star architecture with a large antenna at a hub station and smaller antennas at the Remote Terminal Units (RTU) or digitizers.
2. A terrestrial VPN from the hub to the Network Data Center (NDC).
3. A satellite owner who charges for bandwidth
4. A Teleport owner who charges for services on the system, i.e. a middleman between the satellite operator and the utility customer.
5. The transmitter at the teleport operates at a data rate higher than the inbound transmitter (located at the Remote Terminal)

Reducing Operating Cost

The typical configuration shown in Figure 1 incurs the following operating costs:

1. VPN charges
2. Teleport / Satellite reseller charges
3. Satellite transponder charges

Power consumption and licensing fees from your radio regulatory authority are minor costs, typically under $100 per year.

Eliminating VPN and Teleport Charges
We can eliminate the VPN and reseller/Teleport charges by placing the center of the star (the Hub) on the user's location, usually at the Network Data Centre.

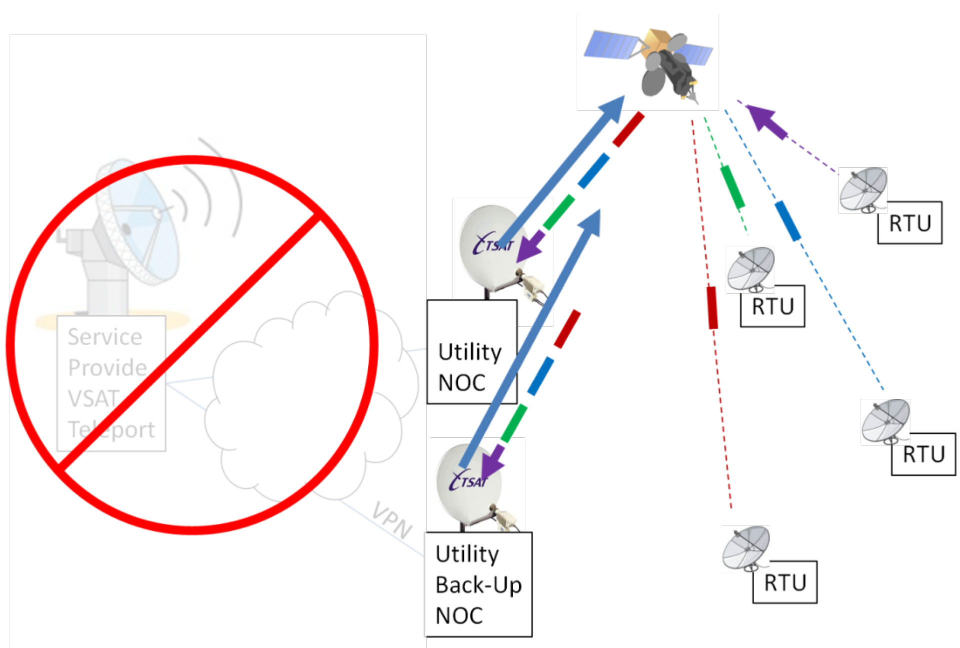

Figure 2 - TSAT System - Hub on User Location

The key to making it practical to have the satellite hub on the user site is to reduce the size of the hub antenna. It is relatively straight forward to mount a 1.8 m antenna on the roof of an office building, but very challenging to mount a 3.5 m antenna in the same location, with the 3.5m antenna weighing in about 8 times heavier than a 1.8 m antenna. We will see below how minimizing the satellite link rate (but not the user data rate) supports small antenna sizes.

Minimizing Transponder Charges

To reduce the satellite transponder charges the system needs to operate at the minimum viable data rate for the target data volumes and delay times. In SCADA and Seismograph systems there is usually an imbalance between the inbound and outbound direction, with the inbound (towards the NDC dominating. With TSAT's variable rate modems and link independence each direction can be optimized individually.

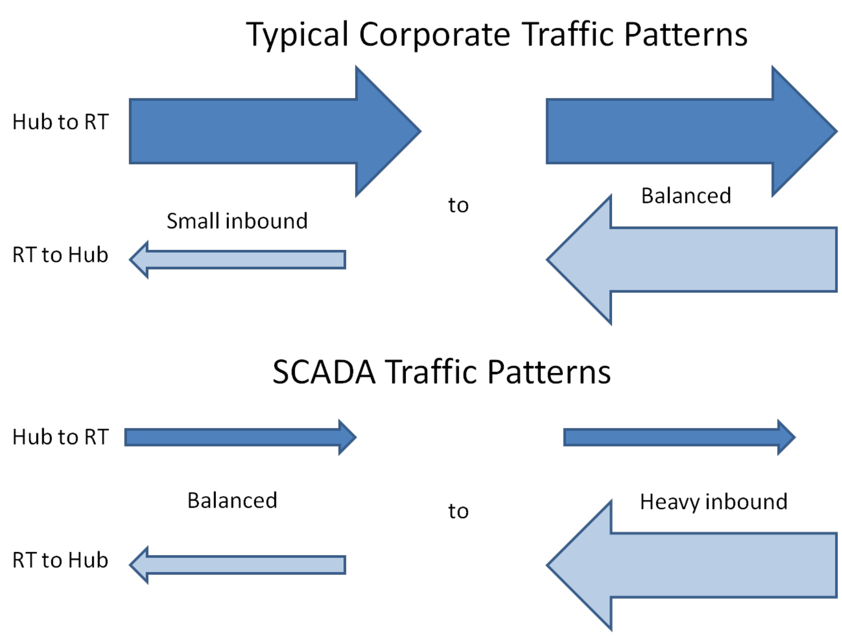

Figure 3 – SCADA/Telemetry and other low data rate traffic such as seismic monitoring is Inbound Heavy and Outbound Light

SCADA/Telemetry and seismograph systems often have significantly more inbound traffic that outbound, which is the opposite of most corporate networks, so traditional TDMA systems can leave some spectrum poorly utilized. Most corporate focused VSAT systems assume symmetric or outbound dominant traffic requirements (see top of Figure 3) such a system leaves a lot of unused capacity in the outbound direction when supporting SCADA/Telemetry and Seismograph systems, but with data charges billed as if traffic was flowing symmetrically. The TSAT system adjusts each direction independently so that the spectrum is optimally used. (See bottom of Figure 3).

> The TSAT satellite data rates are configured independently for each direction so that the satellite spectrum is optimally used.

Typical TSAT 3500 HUB – Size 1U for 19” rack mounting

Reducing Installation Cost

The major costs associated with installing a satellite system are related to:

1. Antenna mounting
2. RF cable installation
3. Electrical and ground wiring

RF cabling and electrical wiring do not vary much between systems, but antenna size does, so we will focus on reducing the antenna size.

At this point it is helpful to know why that big hub antenna is there and why the TSAT hub system can operate with a small antenna. The answer is simple: bit rate. Commercial service offerings use high data rate satellite carriers operating in a TDM/TDMA structure where multiple customers share carriers with each other. Each has a small, contracted data rate, but the overall system runs at a high data rate. When your terminal is transmitting or receiving it is running at the system rate, not the contracted rate.

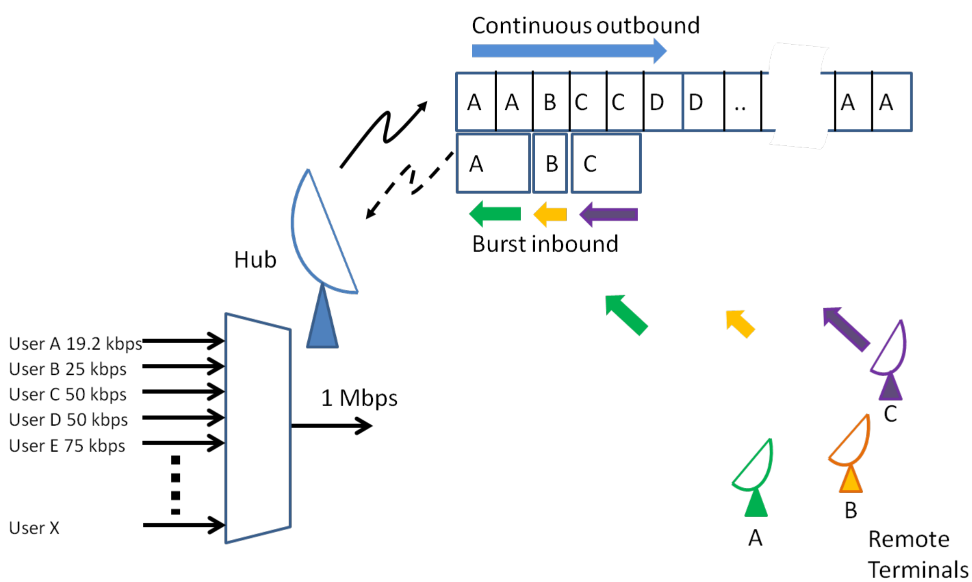

Figure 4 - TDM/TDMA VSAT System

The error performance of a digital data communication system is set by the ratio of the receive energy per bit (E_b) and the noise in the system (N_O) or E_b/N_O. Note that this is energy (joules) per bit, not energy per unit of time (watts). At faster data rates we have less time to transmit the same amount of energy into the radio channel meaning that we need a higher (effective) transmit power. Thus, the power scales directly with the transmitted data rate, not the amount of information sent.

For example, if we consider two satellite systems, one operating at 1 Mbps and one operating at 19.2 kbps (User A in Figure 4), the 1 Mbps will require over 50 times (17 dB) the power for

the same link error performance and availability. The extra receive power can be obtained using one, several, or all of the following techniques:

1. Increasing the transmit antenna size
2. Increasing the transmit power
3. Increasing the receive antenna size
4. Reducing the noise performance of the receiver
5. Adding more error correction overhead

The first two items in the above list increase the effective transmitted power (called EIRP, Effective Isotropic Radiated Power). The latter three items improve the performance of the receiver. In practise VSAT receivers have low noise figures compared to other radio systems and the amount of improvement left to be had is small. Increasing overhead increases the amount of satellite bandwidth consumed with most systems using $\frac{1}{2}, \frac{2}{3}$ or $\frac{3}{4}$ rate codes, we prefer not to consume anymore satellite bandwidth using increased error correction. From a practical perspective we use larger antenna and larger power amplifiers to achieve that 17.2 dB in extra system gain when going from 19.2 kbps to 1 Mbps.

It is the nature of most geostationary satellite system that we can make the antenna sizes asymmetric, that is by having a larger antenna at one end we can reduce the antenna size at the other. To reduce overall system costs the center of the star (Hub) uses the largest antenna size and the remotes the smaller. We can see how making up this system gain difference is typically done by looking at Table 1.

Parameter	TSAT System	1 Mbps VSAT	Note
User Data Rate	19.2 kbps	19.2 kbps	Both systems supporting same SCADA system.
Satellite link Rate	19.2 kbps	1 Mbps	Ignores overhead as all system will add similar amounts of control and FEC.
Hub Antenna	1.8 m	3.5 m	5.7 dB difference
Remote antenna	1.2 m	1.8 m	3.5 dB difference
Transmit power	0.33 W	2.1 W	8.0 dB difference

Table 1 - Making up a 17.2 dB Difference[1]

By operating at a data rate as close as practical to the user data rate we see that the TSAT system, with its variable bit-rate modems, will give us a system with smaller antennas, which lowers the installation costs and allows the hub to be located on the utility's premises close to the NOC.

> With the TSAT 3500 system the entire earth station system is on the utility or research centers property eliminating the delays, expenses and reliability issues associated with teleports and VPNs.

Conclusion

The TSAT system has been designed for use with low data rate SCADA/Telemetry and Seismograph systems. The TSAT system supports SCADA and Seismology over satellite in an optimum manner through use of variable bit-rate modems and asymmetric data flows that match the SCADA and Seismograph data flows, which are usually more towards the NDC than away from it. This architecture results in the following benefits:

1. Smaller and lower cost antennas
2. Minimum satellite bandwidth costs
3. Lower cost installations
4. A simplifies network with no need for a Teleport or VPN delays and charges
5. Fully owned and managed infrastructure

[1] All numbers representative to illustrate the concept that lower data rates use smaller antennas and/or amplifiers. Details vary by location, satellite, actual bit rate, etc.