Satellite Services for Internet Access in Rural Areas[1]

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Executive Summary

This report examines the use of direct satellite services for internet access in rural areas. The broad success of direct to home broadcast service (DirecTV and Dish Network have a combined 17% national market share for cable service) has provided an incentive for service providers to put together satellite internet access packages. At the same time, established VSAT services are being adapted to provide internet access packages in additional to their traditional role in closed corporate networks.

We examine the attributes of rural environments that create a need for unique internet access services, and then describe a number of satellite services available for this purpose. We review several current service offerings including pricing, performance, and availability. Projected future services are outlined briefly.

We conclude that satellite services are a viable option for consumers and businesses in rural areas. However, users must expect to pay a premium price for these services, compared to DSL or CATV based service in metropolitan areas.

This report should be viewed as a snapshot. The satellite internet marketplace is changing rapidly. Schedules for the roll-out of new services are changing constantly. An up-to-date version of this report will be maintained at http://www.csm.ohiou.edu/kruse/SatelliteInternet.

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[1] This report was produced under contract for Communication Network Services at Ohio University

Background

This section will provide some basic information on satellite services, applicable to most service providers. Images of ground stations in this section are not vendor specific, but are drawn from experimental and test projects, courtesy of the NASA Glenn Research Center.

Internet Access Options in Rural Areas

The same internet services available in metropolitan areas can be deployed in rural areas as well; and they usually are. However, the two most effective access services – DSL (Digital Subscriber Line) and Cable Modem service – require that subscribers reside in relative proximity to the switching offices of the service provider. DSL service can only be deployed within 15,000 feet of a telephone company central office. In rural areas this requirement creates service islands around switching offices, with many areas outside large towns not being serviceable.

Cable modem services require that the customer be within the service area of the Cable Television CATV) distribution system. The CATV system structure requires that the areas served have a minimum density of potential subscribers to be cost effective. Therefore, CATV systems are again clustered within larger towns and cities, and are not available outside these areas.

Business internet services, such as T1, are generally available in rural areas, but these services are also generally priced based on the distance between the customer and the switching office. They are therefore more expensive than in metropolitan areas, and they are ususally only available from one provider due to the lack of local telephone service competition in rural areas.

Even basic modem service tends to be less effective in rural areas. Due to the longer average lengths of the local loops serving rural customers, these telephone lines carry more noise than shorter lines. This extra noise is not noticeable in voice conversations, and these telephones lines meet all technical standards and requirements for voice telephone lines. Modern modems, such as the popular 56 kbps modems, rely on the fact that many telephone lines, particularly in metropolitan areas, work much better, with much less noise, than is required by the standards. For that reason, these modems rarely achieve their top performance when used in rural areas.

This document describes the use of direct satellite services to provide high-speed internet access comparable to DSL and Cable Modems. It should be noted that other approaches such as terrestrial wireless services, and airborne radio relays, can be used to provide internet services. These approaches may be inferior, complementary, or superior to the use of satellite services, depending on the terrain in question. However, an analysis of these alternatives is outside the scope of this report.

Satellite Services – "One-Way"

Direct Broadcast Satellite (DBS) services such as DirecTV (which has absorbed PrimeStar) and Dish Network have become very popular in areas without CATV service, or in areas where customers perceive CATV services to be deficient. It is therefore not surprising that an attempt has been made to translate this success into an internet access service based on the same technology. Two companies, Hughes and Gilat, introduced products several years ago which are referred to as one-way, or hybrid systems. Figure 1 shows the basic structure of these services. They are based on a regular modem connection to the internet; in addition to this connection they use a DBS satellite to send data from a central site to the remote system. Since the satellite link is much faster than the modem connection, downloads from the internet to the remote sites are much more efficient. Data from the remote site to the internet uses the modem connection and shows no improvement.

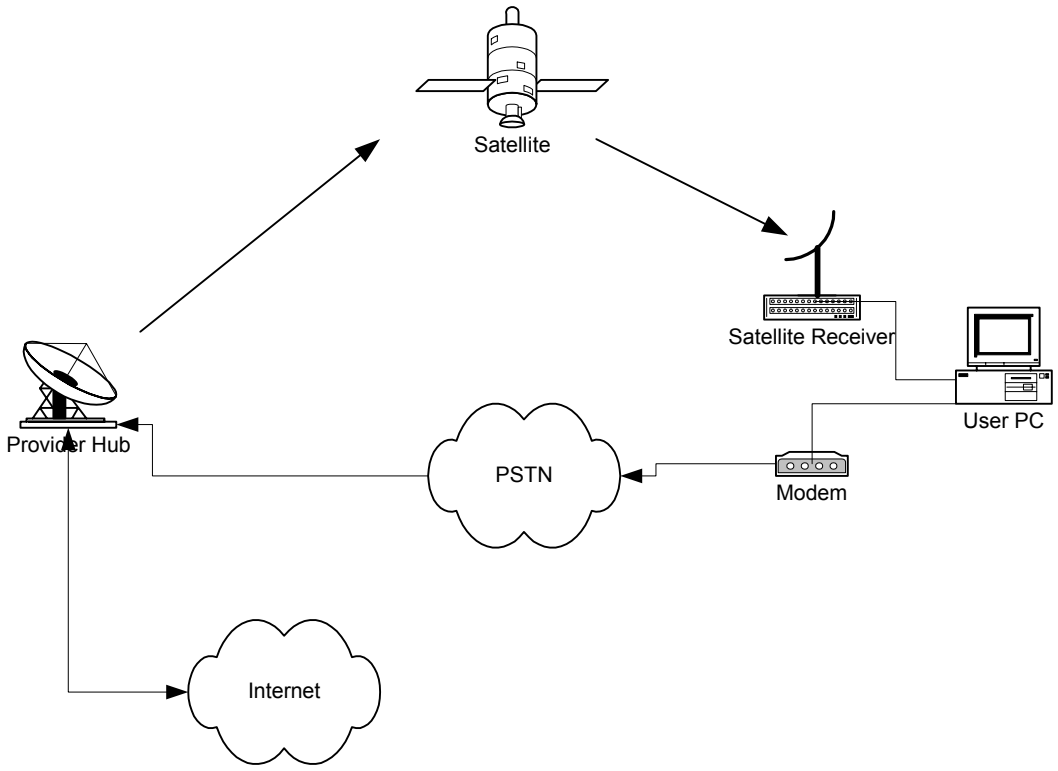

Figure 1

Most computer operating systems and internet components are not normally set up to return data to a remote site along a different path form the one taken by data from the remote site to the internet. Figure 2 shows the hardware and software components of these systems. There is a certain amount of complexity associated with the software changes needed to make these systems work, with an associated increase in the effort needed to support them.

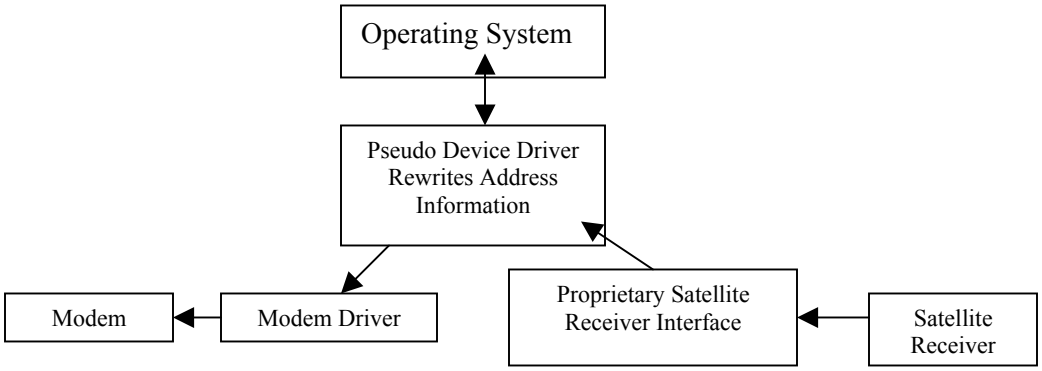

Figure 2

A one-way internet service can be shared on a local area network, but due to the modifications in the networking software of the computer attached to the satellite service, special “router” software is required. Since the link towards the internet travels over the modem, the utility of sharing this type of connection is very limited.

Satellite Services – "Two-Way"

It would appear natural to use the satellite for both directions of the internet access path. VSAT (Very Small Aperture Terminal) services have indeed been used for enterprise networking for many years. Figure 3 shows the parts of a typical VSAT Ground Station. To understand the economics of two-way satellite service, it is necessary to review some of the technical aspects of these systems.

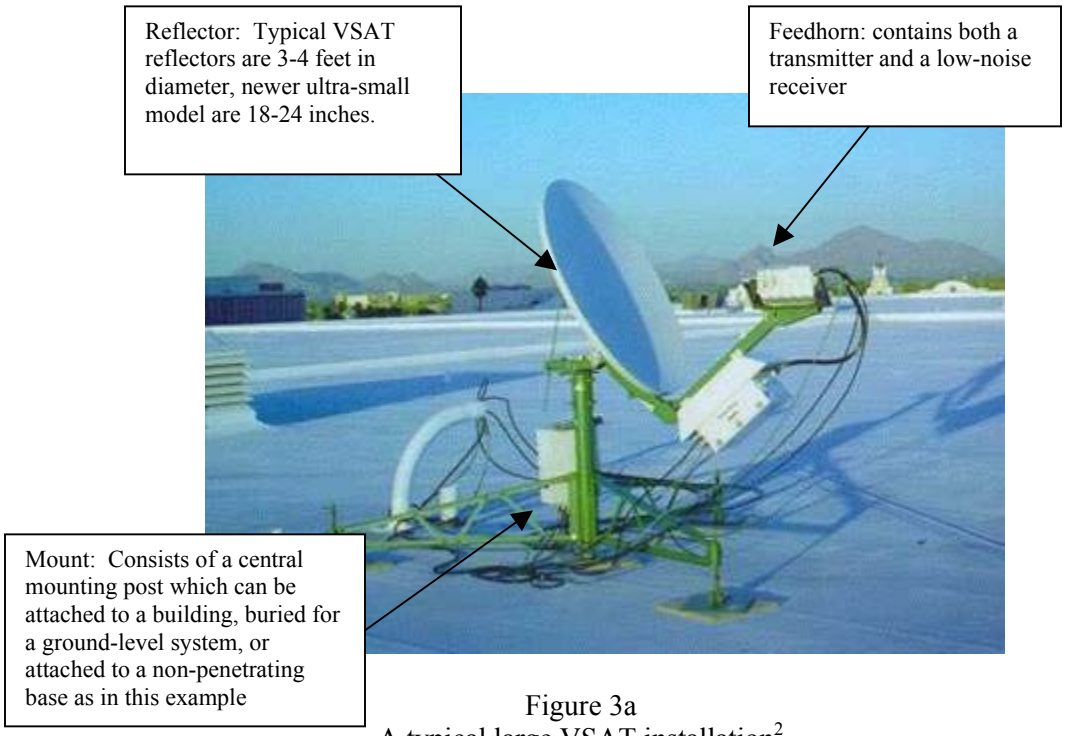

Figure 3a
A typical large VSAT installation[2]

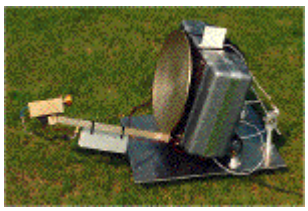

Figure 3b
An ultra-small earth station, in this case a suitcase model[3]

[2] Photo provided by the NASA Glenn Research Center, http://acts.grc.nasa.gov

[3] Photo provided by Air Force Research Lab, Rome/Canadian Research Centre
http://www.crc.ca/earthterm/earth

The satellite modem (at either the hub site or the remote terminal) encodes the data stream into an analog signal. This signal is then modulated onto a high frequency carrier wave. This carrier frequency must fall inside the range of frequencies assigned by the FCC for fixed satellite services; the exact frequency is assigned by the satellite services provider. The modulated signal occupies a range of frequencies around the carrier signal, this is referred to as the bandwidth of the signal. The maximum bandwidth is of course limited by the amount of spectrum assigned by the FCC, and by the need to share this bandwidth among different users. The maximum data rate that can be transmitted over the assigned bandwidth depends on the specifics of the encoding used in the satellite modem. In practical applications, the data rate typically tops out at 1 bit/sec for every Hz of bandwidth.

However, in addition to the encoding, the maximum data rate is also limited by the need to maintain a reasonably error-free signal. The combination of the satellite modems, the transmit and receive electronics, the antennas, and the characteristics of the satellite used, determine the quality of the signal at the receiver. Technical documents will refer to the "E_b/N_o" of the signal, describing the signal energy received in the actual data bits, compared to the background noise. The higher this signal quality figure, the closer one can come to the upper limit of the data rate defined by the bandwidth. To make this value larger, one can increase the power of the transmitter and the size of the antenna. Both of these steps increase cost, and most providers make a tradeoff between data rate and cost. Two-way satellite services are therefore often asymmetric, just like ADSL and cable modems. The small dish and inexpensive transmitter deployed at the user's remote site limit the uplink, or outbound, data rate to a relatively modest number. Services that rely on a large central hub site can use a large antenna and expensive transmitter for the data transmission towards the user, and achieve much higher data rates in this direction compared to the uplink. This is the approach used by most satellite internet access providers.

Aside from the need to manufacture low-cost satellite earth stations, providers of two-way satellite service face another hurdle. Two-way satellite service requires a transmitter at the customer site. In the US, the FCC has jurisdiction over all equipment that transmits radio waves. In some cases, such as cordless phones and wireless local area networks, the FCC provides a blanket authorization for the use of a particular set of frequencies. Satellite services are <u>not</u> handled in this way. Satellite service providers must obtain an FCC license to operate the transmitters at their customers' sites, and the providers are responsible to the FCC for the correct installation and operation of these transmitters (the FCC is mostly concerned with preventing interference between authorized users). Instead of providing self-installation kits as in the case of one-way, receive only, equipment, two-way service providers must use professional installers. Expect the initial installation costs of these services to remain fairly high for this reason. Equipment prices will also remain well above the one-way equipment due to the need for the amplifier and transmitter in the two-way setup.

Special Issues in Satellite Use for Internet Services

VSAT services have been used for data communications for many years. Most corporate VSAT networks have been deployed to extend proprietary data networks to remote locations. Today, interest in satellite networks naturally focuses on the provisioning of Internet access services to remote or mobile locations.

There are many conflicting statements regarding the use of satellite links for Internet services. Competitors to satellite service providers will claim that Internet access over satellite does not work. Satellite service providers attempt to distinguish their offerings from other satellite systems by claiming to have "fixed" these problems. Contrary to many marketing claims, the TCP/IP protocols that form the basis of the Internet <u>will</u> work correctly over a satellite link. However, depending on the intended use of the service, TCP/IP may not work very efficiently unless some modifications are made. This is especially true for single-user applications that involve large file transfers.

Two issues complicate (but do not prevent) the use of TCP/IP over satellite links[4]. First, a transmission over a satellite requires about ¼ of a second to travel from the sender to the receiver, due to the physical distance between the satellite and the earth. TCP/IP relies on a complex system of queries and responses to determine an appropriate rate at which to send data. Too fast, and the transmission overloads one or more links inside the network. Too slow, and the link is not used efficiently. This mechanism needs several query/response cycles between sender and receiver to converge to a proper data rate. The transmission delay over a satellite link slows this convergence process down. In addition, the default values for TCP/IP tunable parameters in many operating systems will prevent this process from converging to the full link speed. Different vendors take somewhat different approaches to deal with this issue. Systems designed to serve a single PC will "tune" the TCP/IP implementation on that PC based on the IETF recommendations. Users who share this type of satellite link among multiple PC have to insure that this tuning step is performed on each PC in the local network. Other vendors, especially those targeting larger sites, provide a protocol gateway which interrupts the normal flow of data and uses proprietary methods to efficiently transmit over the satellite link to a matching gateway at the hub site. This approach does not require retuning of local PCs, and works well for a defined set of applications. However, a gateway approach such as this one can be problematic when the user attempts to deploy a new application; it is likely that the gateway will have to be updated before a new application can be supported.

The second satellite specific issue arises from the fact that any wireless link will suffer from occasional transmission errors. These errors will usually occur at a higher rate than the typical error rate on a wired connection. TCP/IP interprets any packet loss as an indication of congestion, and reacts by reducing its data transfer rate. If the packet was really lost due to a transmission error, this reduction in data rate will not only harm overall throughput, but also slow down the recovery from the transmission error. Fortunately, most modern satellite modems employ very sophisticated error correction software, so transmission errors should be as rare on a satellite link as they are on a wired link, at least during normal operating conditions. Wireless links are effected by weather, so error rates can go up during heavy rain storms and at times when ice or snow accumulates on the satellite dish. There is little that can be done to prevent these effects, but users need to be aware that they can occur.

Currently Available Options

The list below is not intended to be comprehensive. The providers below are currently offering service, and are making an effort to serve the rural and underserved areas we are interested in. New services and service providers appear frequently. Please check our web site for updates.

In reviewing these and other services, it is useful to remember that the satellite service industry consists of two separate parts. A relatively small number of companies actually build, launch, and operate satellites. These include Hughes, Gilat, INMARSAT, PanAmSat, and others. Many more companies manufacture, sell, install, and support ground equipment. Many of these service providers set up one or more central hub locations with large antennas and transmitters. Their customer traffic flows through one of these hubs to and from the terrestrial network.

Traditionally, customers have purchased ground equipment from one or more manufacturers, and contracted with a VSAT service provider for installation, hub, and transmission service. More recently, system integration companies have begun to offer turn-key solutions, especially in the home or small business market.

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[4] A technical description of these issues along with recommended mitigation strategies has been adopted by the Internet Engineering task Force (IETF) as a "Best Current Practice" document. This document is known as BCP 28 and RFC 2488 and may be retrieved from the web at http://www.ietf.org/rfc/rfc2488.txt.

Residential and SOHO Service

Two companies have set up the infrastructure to support home and small office users: Hughes and Gilat. Hughes offers both a one way and a two way service. This service was originally marketed under the DirecPC brand name, and the two-way service is now know as DirecWay. Gilat has focused on their two-way offering known as Starband.

Hughes and Echo Star Communications have announced a merger of the DirecTV and Dish Network units. This merger is awaiting regulatory approval. If allowed to proceed, it will have a number of repercussions for the satellite internet services.

Starband (Gilat)

Gilat markets the Starband offering in the US through the StarBand Corporation headquartered in Virginia[5]. The service is sold through the Dish Network[6] dealerships, with or without direct to home satellite TV service. At this time, StarBand suggests the up-front equipment cost to be about $500, installation at $200, and the service starting at $70 per month. Dish Network dealers have pricing discretion.

Pegasus, Earthlink, Optistreams (Hughes DirectWay)

Hughes appeared for some time to focus on their one-way product[7]. However, more recently several companies have begun to provide two-way DirecWay[8] service as well. Pegasus[9], which is also a major DirecTV reseller, and Earthlink[10], which provides nationwide ISP services, both offer DirecWay services. Both charge about $400-$500 for the equipment, $200 for installation, and $70 per month. Both companies use local/regional installation providers; not all areas of the US are covered.

Optistreams markets services both under the OptiStreams[11] name and through their RuralNetworks[12] division. Optistreams offers the same Hughes DirecWay equipment as the other providers, but uses a national subcontractor for installations. Optistreams aims at the SOHO, rather than the purely residential market. Their up-front and per-month charges are somewhat higher than those charged by Pegasus and Earthlink. Optistreams also supplies higher-end options, which are described below.

Small Business Service

The hardware described above can, and has been, adapted to the use by small businesses. The main difference lies in the support services provided, the data rates supported (in some cases, business services promise higher data rates than the residential version, at a higher cost), and additional services provided such as static IP addresses, encryption and VPN, and integrated web hosting.

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[5] http://www.starband.com

[6] Dish Network is operated by Echo Star Communications; see http://www.dishnetwork.com.

[7] See http://www.direcpc.com

[8] See http://www.direcway.com

[9] Pegasus Express offers the internet service, see http://www.pgtv.net/ContentExpress.htm and the parent site at http://www.pgtv.net.

[10] See http://www.earthlink.net/home/broadband/satellite/

[11] http://www.optistreams.com

[12] http://www.ruralnetworks.com

OptiStreams

Optistreams manufactures a (windows-based) hardware gateway for use in a small network. Combined with the standard Hughes DirecWay equipment, this setup can serve a small number of PCs without using any one of them to perform packet forwarding services. The gateway provides router, Network Address Translation, and packet filtering services. Static IP addresses are available, as are Virtual Private Network services for telecommuting applications which require secure access to internal corporate networks. Equipment costs are about $1,700, with service charges starting at about $105 per month. Service charges increase with the number of users, and with the use of static IP addresses.

SkyCasters

Skycasters[13] is a system integrator providing turn-key installations. There service uses the DirecWay hardware, and SkyCasters gateway equipment. Skycasters sells to business users only, and provides different downlink speeds at different prices. The equipment cost is about $2,900, with service starting at $99 for 128kbps uplink and 384kbps downlink, and currently go to about $500 per month for 128kbps uplink and 1Mbps downlink.

"Enterprise" Services

Enterprise-wide satellite services have traditionally been used only by very large corporations with many domestic sites or very significant foreign operations. There are some signs that the same basic technology used for these services is being re-packaged for the mid-sized businesses market looking for turn-key solutions.

Tachyon

Tachyon uses traditional VSAT equipment combined with a hardware gateway manufactured by Tachyon. Contrary to Skycasters and Optistreams, Tachyon does not use DirecWay equipment, and runs its own satellite hub facility and network management center (Skycasters and Optistreams use the Hughes facilities). Their gateway, in addition to routing and firewall functions, does perform protocol translation to overcome some of the satellite issues mentioned earlier. Tachyon markets its services as a corporate or distance education network solution. Standard pricing information is not available, but the company claims to be competitive with T1 access service and pricing in most areas.

Hughes, Gilat VSAT Service

Traditional VSAT services are beyond the scope of this report. They typically require that the client company or a system integrator working for the company develop a network plan in conjunction with the VSAT provider. While these network can be very effective, they are typically aimed at very large corporations. More information on VSAT service worldwide can be found at http://www.gvf.org.

Future Services

No major changes in the satellite internet industry are likely until more spectrum and data communication specific satellite technology become available. The FCC has licensed 500MHz of spectrum in the Ka band (20/30 GHz) for fixed satellite service use. A large number of satellite operators have filed for and received licenses to launch Ka band satellites. Almost all of them will carry spot beam technology, which is designed to reuse the available spectrum many times over, analogous to the cellular telephony approach. These systems hold the promise of providing both

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[13] http://www.skycasters.com

higher speed service and lower cost equipment compared to current offerings. Based on currently available information, it appears unlikely that any of these satellites will be launched before 2003.

For a time, Low Earth Orbit Satellites (LEOS) like those used by Iridium and GlobalStar were thought to be the best approach for providing wireless data communications services to small and inexpensive devices. Since LEOS are close to the earth, much less power is needed to communicate through them. Iridium and GlobalStar designed their systems for voice communications, with data services promised later. Both systems are in operation and are for the most part technically sound. However, neither company has been able to become profitable; Iridium filed for bankruptcy and GlobalStar is suspending debt payments. The Teledesic LEOS system, which is still on the drawing board, is designed to provide mobile and fixed-site data communication services. However, given the LEOS failures up to this point, financing for the Teledesic system appears to be in doubt.

Conclusions

Satellite Internet services have matured to the point where they can be used to fill in gaps in the internet access infrastructure. Users in rural areas will, however, continue to pay a premium for these services. Lower cost hardware and higher capacity services are likely to become available in the 3-5 year horizon, but it is not clear what the cost and price structures of these future services will look like.