

Satellite Internet access

Satellite Internet access is Internet access provided through communications satellites. Modern satellite Internet service is typically provided to users through geostationary satellites that can offer high data speeds,^[2] with newer satellites using Ka band to achieve downstream data speeds up to 50 Mbps.^[3]

1 History of satellite Internet

Following the launch of the first satellite, Sputnik 1, by the Soviet Union in October, 1957, the US successfully launched the Explorer 1 satellite in 1958. The first commercial communications satellite was Telstar 1, built by Bell Labs and launched in July, 1962.

The idea of a Geosynchronous satellite — one that could orbit the Earth above the equator and remain fixed by following the Earth's rotation — was first proposed by Herman Potočnik in 1928 and popularised by the science fiction author Arthur C. Clarke in a paper in *Wireless World* in 1945.^[4] The first satellite to successfully reach geostationary orbit was Syncom3, built by Hughes Aircraft for NASA and launched Aug. 19, 1963. Succeeding generations of communications satellites featuring larger capacities and improved performance characteristics were adopted for use in television delivery, military applications and telecommunications purposes. Following the invention of the Internet and the World Wide Web, geostationary satellites attracted interest as a potential means of providing Internet access.

A significant enabler of satellite-delivered Internet has been the opening up of the Ka band for satellites. In December, 1993, Hughes Aircraft Co. filed with the Federal Communications Commission for a license to launch the first Ka-band satellite, Spaceway. In 1995, the FCC issued a call for more Ka-band satellite applications, attracting applications from 15 companies. Among those were EchoStar, Lockheed Martin, GE-Americom, Motorola and KaStar Satellite, which later became WildBlue.

Among prominent aspirants in the early-stage satellite Internet sector was Teledesic, an ambitious and ultimately failed project funded in part by Microsoft that ended up costing more than \$9 billion. Teledesic's idea was to create a broadband satellite constellation of hundreds of low-orbiting satellites in the Ka-band frequency, providing inexpensive Internet access with download speeds of up to 720 Mbit/s. The project was abandoned in 2003. Teledesic's failure, coupled with the bankruptcy filings of

the satellite communications providers Iridium Communications Inc. and Globalstar, dampened marketplace enthusiasm for satellite Internet development. It wasn't until September 2003 when the first Internet-ready satellite for consumers was launched by Eutelsat.^[5]

In 2004 with the launch of Anik F2, the first high throughput satellite, a class of next-generation satellites providing improved capacity and bandwidth became operational. More recently, high throughput satellites such as ViaSat's ViaSat-1 satellite in 2011 and HughesNet's Jupiter in 2012 have achieved further improvements, elevating downstream data rates from 1-3 Mbit/s up to 12-15Mbit/s and beyond. Internet access services tied to these satellites are targeted largely to rural residents as an alternative to Internet service via dial-up, ADSL or classic FSSes.^[6]



WildBlue satellite Internet dish on the side of a house

2 Function

Satellite Internet generally relies on three primary components: a satellite in geostationary orbit (sometimes referred to as a geosynchronous Earth orbit, or GEO), a number of ground stations known as gateways that relay Internet data to and from the satellite via radio waves (microwave), and a VSAT (very-small-aperture terminal) dish antenna with a transceiver, located at the subscriber's premises. Other components of a satellite Internet system include a modem at the user end which links the user's network with the transceiver, and a centralized network

operations center (NOC) for monitoring the entire system. Working in concert with a broadband gateway, the satellite operates a *Star network* topology where all network communication passes through the network's hub processor, which is at the center of the star. With this configuration, the number of remote VSATs that can be connected to the hub is virtually limitless.

2.1 Satellite

At the center of the new broadband satellite networks are a new generation of high-powered GEO satellites positioned 35,786 kilometres (22,236 mi) above the equator, operating in Ka-band (18.3–30 GHz) mode.^[7] These new purpose-built satellites are designed and optimized for broadband applications, employing many narrow spot beams,^[8] which target a much smaller area than the broad beams used by earlier communication satellites. This spot beam technology allows satellites to reuse assigned bandwidth multiple times, enabling them to achieve much higher capacity than conventional broad beam satellites. The spot beams also increase performance and consequential capacity by focusing more power and increased receiver sensitivity into concentrated areas. Spot beams are designated as one of two types: subscriber spot beams, which transmit to and from the subscriber-side terminal, and gateway spot beams, which transmit to/from a service provider ground station.

In conjunction with the satellite's spot-beam technology, a *bent-pipe* architecture is employed in the network in which the satellite functions as a bridge in space, connecting two communication points on the ground. The term "bent-pipe" is used to describe the shape of the data path between sending and receiving antennas, with the satellite positioned at the point of the bend. Simply put, the satellite's role in this network arrangement is to relay signals from the end user's terminal to the ISP's gateways, and back again. The satellite receives, amplifies, and redirects signals carried on a specific radio frequency through a signal path called a transponder.

The satellite has its own set of antennas to receive communication signals from Earth and to transmit signals to their target location. These antennas and transponders are part of the satellite's "payload", which is designed to receive and transmit signals to and from various places on Earth. What enables this transmission and reception in the payload transponders is a repeater subsystem (RF (radio frequency) equipment) used to change frequencies, filter, separate, amplify and group signals before routing them to their destination address on Earth. The satellite's high-gain receiving antenna passes the transmitted data to the transponder which filters, translates and amplifies them, then redirects them to the transmitting antenna on board. The signal is then routed to a specific ground location through a channel known as a carrier. Beside the payload, the other main component of a communications satellite is called the bus, which comprises all equip-

ment required to move the satellite into position, supply power, regulate equipment temperatures, provide health and tracking information, and perform numerous other operational tasks.^[9]

2.2 Gateways

Along with dramatic advances in satellite technology over the past decade, ground equipment has similarly evolved, benefiting from higher levels of integration and increasing processing power, expanding both capacity and performance boundaries. The *Gateway*—or Gateway Earth Station (its full name)—is also referred to as a ground station, teleport or hub. The term is sometimes used to describe just the antenna dish portion, or it can refer to the complete system with all associated components. In short, the gateway receives radio wave signals from the satellite on the last leg of the return or upstream payload, carrying the request originating from the end-user's site. The satellite modem at the gateway location demodulates the incoming signal from the outdoor antenna into IP packets and sends the packets to the local network. Access server/gateways manage traffic transported to/from the Internet. Once the initial request has been processed by the gateway's servers, sent to and returned from the Internet, the requested information is sent back as a forward or downstream payload to the end-user via the satellite, which directs the signal to the subscriber terminal. Each Gateway provides the connection to the Internet backbone for the gateway spot-beam(s) it serves. The system of gateways comprising the satellite ground system provides all network services for satellite and corresponding terrestrial connectivity. Each gateway provides a multi-service access network for subscriber terminal connections to the Internet. In the continental United States, because it is north of the equator, all gateway and subscriber dish antenna must have an unobstructed view of the southern sky. Because of the satellite's geostationary orbit, the gateway antenna can stay pointed at a fixed position.

2.3 Antenna dish and modem

For the customer-provided equipment (i.e. PC and router) to access the broadband satellite network, the customer must have additional physical components installed:

2.3.1 Outdoor unit (ODU)

At the far end of the outdoor unit is a small (2–3-foot diameter), reflective dish-type radio antenna constructed from and coated with a variety of materials. As indicated earlier, like the antenna used by the gateway, the VSAT antenna must also have an unobstructed view of the sky to allow for proper line-of-sight (L-O-S) to the satellite.

There are four characteristic settings used to ensure that the antenna is configured correctly at the satellite, which are: **azimuth**, **elevation**, **polarization**, and **skew**. The combination of these settings gives the outdoor unit a L-O-S to the chosen satellite and makes data transmission possible. These parameters are generally set at the time the equipment is installed, along with a beam assignment (Ka-band only); these steps must all be taken prior to the actual activation of service. Transmit and receive components are mounted at the focal point of the antenna which receives/sends data from/to the satellite. The main parts are:

- **Feed** – This assembly is part of the VSAT receive and transmit chain, which consists of several components with different functions, including the feed horn at the front of the unit, which resembles a funnel and has the task of focusing the satellite microwave signals across the surface of the dish reflector. The feed horn both receives signals reflected off the dish's surface and transmits outbound signals back to the satellite.
- **Block upconverter (BUC)** – This unit sits behind the feed horn and may be part of the same unit, but a larger (higher wattage) BUC could be a separate piece attached to the base of the antenna. Its job is to convert the signal from the modem to a higher frequency and amplify it before it is reflected off the dish and towards the satellite.
- **Low-noise block downconverter (LNB)** – This is the receiving element of the terminal. The LNB's job is to amplify the received satellite radio signal bouncing off the dish and filter out the noise, which is any signal not carrying valid information. The LNB passes the amplified, filtered signal to the satellite modem at the user's location.

2.3.2 Indoor unit (IDU)

The satellite modem serves as an interface between the outdoor unit and customer-provided equipment (i.e. PC, router) and controls satellite transmission and reception. From the sending device (computer, router, etc.) it receives an input bitstream and converts or modulates it into radio waves, reversing that order for incoming transmissions, which is called **demodulation**. It provides two types of connectivity:

- **Coaxial cable (COAX)** connectivity to the satellite antenna. The cable carrying electromagnetic satellite signals between the modem and the antenna generally is limited to be no more than 150 feet in length.
- **Ethernet** connectivity to the computer, carrying the customer's data packets to and from the Internet content servers.

Satellite modems employ either the DOCSIS (Data Over Cable Service Interface Specification) or WiMAX (World Interoperability for Microwave Access) telecommunication standard to communicate with the assigned gateway.

3 Challenges & limitations

3.1 Signal latency

Latency is the delay between requesting data and the receipt of a response, or in the case of one-way communication, between the actual moment of a signal's broadcast and the time it is received at its destination. The amount of latency depends on the distance travelled and the speed of light. Light including wireless radiation would take about 0.12 seconds to reach a geostationary satellite (at 36,000 km above the equator), so nearly 1/4 second for a round trip. Latency is the main difference between a standard terrestrial based network and a geostationary satellite network. The round trip latency of a geostationary satellite communication's network is almost 20 times that of a terrestrial based network.^[10]

3.1.1 Geostationary unsuitable for low-latency applications

A **geostationary orbit** (or geostationary Earth orbit/GEO) is a geosynchronous orbit directly above the Earth's equator (0° latitude), with a period equal to the Earth's rotational period and an orbital eccentricity of approximately zero (i.e. "circular orbit"). An object in a geostationary orbit appears motionless, at a fixed position in the sky, to ground observers. Communications satellites and weather satellites are often given geostationary orbits, so that the satellite antennas that communicate with them do not have to move to track them, but can be pointed permanently at the position in the sky where they stay. Due to the constant 0° latitude and circularity of geostationary orbits, satellites in GEO differ in location by longitude only.

Compared to ground-based communication, all geostationary satellite communications experience high latency due to the signal having to travel 35,786 km (22,236 mi) to a satellite in geostationary orbit and back to Earth again. Even at the **speed of light** (about 300,000 km/s or 186,000 miles per second), this delay can be significant. If all other signaling delays could be eliminated, it still takes a radio signal about 250 milliseconds (ms), or about a quarter of a second, to travel to the satellite and back to the ground.^[11] The absolute minimum total amount of delay is variable, due to the satellite staying in one place in the sky, while ground based users can be directly below with a roundtrip latency of 239.6 ms, or far to the side of the planet near the horizon with a roundtrip latency of 279.0 ms.^[12]

For an internet packet, that delay is doubled before a reply is received. That is the theoretical minimum. Factoring in other normal delays from network sources gives a typical one-way connection latency of 500–700 ms from the user to the ISP, or about 1,000–1,400 ms latency for the total round-trip time (RTT) back to the user. This is much more than most dial-up users experience at typically 150–200 ms total latency, and two orders of magnitude higher than the typical 15–40 ms latency experienced by users of other high-speed internet services, such as cable or VDSL.^[13]

For geostationary satellites, there is no way to eliminate latency, but the problem can be somewhat mitigated in Internet communications with TCP acceleration features that shorten the round trip time (RTT) per packet by splitting the feedback loop between the sender and the receiver. Such acceleration features are usually present in recent technology developments embedded in new satellite Internet services.

Latency also impacts the initiation of secure Internet connections such as SSL which require the exchange of numerous pieces of data between web server and web client. Although these pieces of data are small, the multiple round trips involved in the handshake produce long delays compared to other forms of Internet connectivity, as documented by Stephen T. Cobb in a 2011 report published by the Rural Mobile and Broadband Alliance.^[14] This annoyance extends to entering and editing data using some Software as a Service or SaaS applications as well as other forms of online work.

The functionality of live interactive access to a distant computer—such as virtual private networks—is working much better with the new generation of satellite Internet service than in the past.

3.1.2 Acceptable latencies, but lower speeds, of lower orbits

Medium Earth orbit (MEO) and low Earth orbit (LEO) satellites do not have such great delays. For example:

- The current LEO constellations of Globalstar and Iridium satellites have delays of less than 40 ms round trip, but their throughput is less than broadband at 64 kbit/s per channel. The Globalstar constellation orbits 1,420 km above the earth and Iridium orbits at 670 km altitude.
- The proposed O3b Networks MEO constellation scheduled for deployment in 2013 would orbit at 8,062 km, with RTT latency of approximately 125 ms. The proposed new network is also designed for much higher throughput with links well in excess of 1 Gbit/s (Gigabits per second).
- The planned COMMStellation, scheduled for launch in 2018, will orbit the earth at 1,000 km

with a latency of approximately 7 ms. This polar orbiting constellation of 78 microsattellites will provide global backhaul with throughput in excess of 1.2 Gbit/s.

Unlike geostationary satellites, low and medium Earth orbit satellites do not stay in a fixed position in the sky. Consequently, ground based antennas cannot be easily locked into communication with any one specific satellite. As with GPS, the small orbits may cause a low Earth orbit satellite to only be in the sky for an hour or less before it goes over the horizon and out of range, so a complex relaying and passing-off needs to be done to hand over the fixed-position terrestrial signal to other satellites passing overhead.

Communications with MEO or LEO satellites that are moving in the sky can be done in two ways:

- More diffuse or completely omnidirectional ground antennas capable of communicating with one or more satellites visible in the sky at the same time, but at significantly higher transmit power than fixed geostationary dish antennas (due to the lower gain), and with much poorer signal to noise ratios for receiving the signal.
- Tracking, high-gain, narrow beam antennas, but the tracking requires more expensive solutions like a motorized antenna mount or a dynamic phased array antenna that can steer the beam electronically, and complex software that can predict the path of each satellite in the constellation.

3.1.3 Ultralight atmospheric aircraft as satellites

A proposed alternative to geostationary relay satellites is a special-purpose solar-powered ultralight aircraft, which would fly along a circular path above a fixed ground location, operating under autonomous computer control at a height of approximately 20,000 meters.

One example of this is the United States Defense Advanced Research Projects Agency Vulture project, an ultralight aircraft capable of station-keeping over a fixed area for a period of up to five years, able to provide both continuous surveillance to ground assets as well as to provide extremely low latency communications networks.^[15]

Onboard batteries would be charged during daylight hours by solar panels covering the wings, and would provide power to the plane during night. Ground-based satellite dishes would relay signals to and from the aircraft, resulting in a greatly reduced round-trip signal latency of only 0.25 milliseconds. The planes could potentially run for long periods without refueling. Several such schemes involving various types of aircraft have been proposed in the past.

3.2 Interference



A foldable Bigpond satellite Internet dish

Satellite communications are affected by moisture and various forms of precipitation (such as rain or snow) in the signal path between end users or ground stations and the satellite being utilized. This interference with the signal is known as *rain fade*. The effects are less pronounced on the lower frequency 'L' and 'C' bands, but can become quite severe on the higher frequency 'Ku' and 'Ka' band. For satellite Internet services in tropical areas with heavy rain, use of the C band (4/6 GHz) with a circular polarisation satellite is popular. Satellite communications on the Ka band (19/29 GHz) can use special techniques such as large *rain margins*, *adaptive uplink power control* and *reduced bit rates* during precipitation.

Rain margins are the extra communication link requirements needed to account for signal degradations due to moisture and precipitation, and are of acute importance on all systems operating at frequencies over 10 GHz.^[16]

The amount of time during which service is lost can be reduced by increasing the size of the **satellite communication dish** so as to gather more of the satellite signal on the downlink and also to provide a stronger signal on the uplink. In other words, increasing antenna gain through the use of a larger parabolic reflector is one way of increasing the overall channel gain and, consequently, the signal-to-noise (S/N) ratio, which allows for greater signal loss due to rain fade without the S/N ratio dropping below its minimum threshold for successful communication.

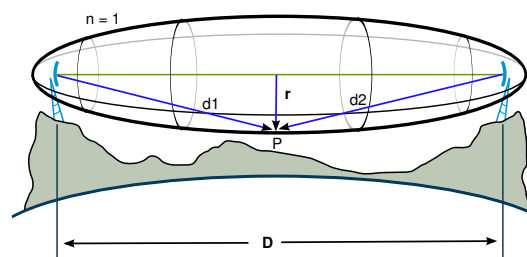
Modern consumer-grade dish antennas tend to be fairly small, which reduces the rain margin or increases the required satellite downlink power and cost. However, it is often more economical to build a more expensive satellite and smaller, less expensive consumer antennas than to increase the consumer antenna size to reduce the satellite cost.

Large commercial dishes of 3.7 m to 13 m diameter are used to achieve large rain margins and also to reduce the cost per bit by requiring far less power from the satellite. Satellites typically use photovoltaic solar power, so there

is no expense for the energy itself, but a more powerful satellite will require larger, more powerful solar panels and electronics, often including a larger transmitting antenna. The larger satellite components not only increase materials costs but also increase the weight of the satellite, and in general, the cost to launch a satellite into an orbit is directly proportional to its weight. (In addition, since satellite launch vehicles [i.e. rockets] have specific payload size limits, making parts of the satellite larger may require either more complex folding mechanisms for parts of the satellite like solar panels and high-gain antennas, or upgrading to a more expensive launch vehicle that can handle a larger payload.)

Modern download DVB-S2 carriers, with RCS feedback, are intended to allow the modulation method to be dynamically altered, in response to rain problems at a receive site. This allows the bit rates to be increased substantially during normal clear sky conditions, thus reducing overall costs per bit.

3.3 Line of sight



Fresnel zone. D is the distance between the transmitter and the receiver, r is the radius of the Fresnel zone.

Typically a completely clear line of sight between the dish and the satellite is required for the system to work. In addition to the signal being susceptible to absorption and scattering by moisture, the signal is similarly impacted by the presence of trees and other vegetation in the path of the signal. As the radio frequency decreases, to below 900 MHz, penetration through vegetation increases, but most satellite communications operate above 2 GHz making them sensitive to even minor obstructions such as tree foliage. A dish installation in the winter must factor in plant foliage growth that will appear in the spring and summer.

3.4 Fresnel Zone

Even if there is a direct line of sight between the transmitting and receiving antenna, reflections from objects near the path of the signal can decrease signal power. Whether and how much signal is lost from a reflection is determined by the location of the object in the Fresnel zone of the antennas.

4 Two-way satellite-only communication



The back panel of a satellite modem, with coaxial connections for both incoming and outgoing signals, and an Ethernet port for connection

Two-way satellite Internet service involves both sending and receiving data from a remote **very-small-aperture terminal (VSAT)** via satellite to a hub **telecommunications port (teleport)**, which then relays data via the terrestrial Internet. The satellite dish at each location must be precisely pointed to avoid interference with other satellites. At each VSAT site the uplink frequency, bit rate and power must be accurately set, under control of the service provider hub.

There are several types of two way satellite Internet services, including **time division multiple access (TDMA)** and **single channel per carrier (SCPC)**. Two-way systems can be simple **VSAT** terminals with a 60–100 cm dish and output power of only a few watts intended for consumers and small business or larger systems which provide more bandwidth. Such systems are frequently marketed as “satellite broadband” and can cost two to three times as much per month as land-based systems such as **ADSL**. The modems required for this service are often proprietary, but some are compatible with several different providers. They are also expensive, costing in the range of **US\$600 to \$2000**.

The two-way “iLNB” used on the **ASTRA2Connect** terminal dish has a transmitter and single-polarity receive LNB, both operating in the **Ku band**. Pricing for Astra2Connect modems range from **€299 to €350**. These types of system are generally unsuitable for use on moving vehicles, although some dishes may be fitted to an automatic pan and tilt mechanism to continuously re-align the dish—but these are more expensive. The technology for **ASTRA2Connect** was delivered by a Belgian company called **Newtec**.



The two-way “iLNB” used on the **ASTRA2Connect**.



The **Tooway** satellite modem

4.1 Bandwidth

Satellite internet customers range from individual home users with one PC to large remote business sites with several hundred PCs.

Home users tend to use shared satellite capacity to reduce the cost, while still allowing high peak bit rates when congestion is absent. There are usually restrictive time-based bandwidth allowances so that each user gets their

fair share, according to their payment. When a user exceeds their allowance, the company may slow down their access, deprioritise their traffic or charge for the excess bandwidth used. For consumer satellite internet, the allowance can typically range from 200 MB per day to 25 GB per month.^{[17][18][19]} A shared download carrier may have a bit rate of 1 to 40 Mbit/s and be shared by up to 100 to 4,000 end users.

The uplink direction for shared user customers is normally **time division multiple access (TDMA)**, which involves transmitting occasional short packet bursts in between other users (similar to how a cellular phone shares a cell tower)

Each remote location may also be equipped with a telephone modem; the connections for this are as with a conventional dial-up ISP. Two-way satellite systems may sometimes use the modem channel in both directions for data where latency is more important than bandwidth, reserving the satellite channel for download data where bandwidth is more important than latency, such as for file transfers.

In 2006, the **European Commission** sponsored the **UNIC** project which aims at developing an end-to-end scientific test bed for the distribution of new broadband interactive TV-centric services delivered over low-cost two-way satellite to actual end-users in the home. The UNIC architecture employs **DVB-S2** standard for downlink and **DVB-RCS** standard for uplink.

Normal VSAT dishes (1.2–2.4 m diameter) are widely used for VoIP phone services. A voice call is sent by means of packets via the satellite and internet. Using coding and compression techniques the bit rate needed per call is only 10.8 kbit/s each way.

4.2 Portable satellite Internet

4.2.1 Portable satellite modem

These usually come in the shape of a self-contained flat rectangular box that needs to be pointed in the general direction of the satellite—unlike VSAT the alignment need not be very precise and the modems have built in signal strength meters to help the user align the device properly. The modems have commonly used connectors such as **Ethernet** or **Universal Serial Bus (USB)**. Some also have an integrated **Bluetooth** transceiver and double as a satellite phone. The modems also tend to have their own batteries so they can be connected to a laptop without draining its battery. The most common such system is **INMARSAT's BGAN**—these terminals are about the size of a briefcase and have near-symmetric connection speeds of around 350–500 kbit/s. Smaller modems exist like those offered by **Thuraya** but only connect at 444 kbit/s in a limited coverage area.

Using such a modem is extremely expensive—bandwidth

costs between \$5 and \$7 per megabyte. The modems themselves are also expensive, usually costing between \$1,000 and \$5,000.^[20]

4.2.2 Internet via satellite phone

For many years **satellite phones** have been able to connect to the internet. Bandwidth varies from about 2400 bit/s for **Iridium network satellites** and **ACeS** based phones to 15 kbit/s upstream and 60 kbit/s downstream for **Thuraya** handsets. **Globalstar** also provides internet access at 9600 bit/s—like **Iridium** and **ACeS** a dial-up connection is required and is billed per minute, however both **Globalstar** and **Iridium** are planning to launch new satellites offering always-on data services at higher rates. With **Thuraya** phones the 9,600 bit/s dial-up connection is also possible, the 60 kbit/s service is always-on and the user is billed for data transferred (about \$5 per megabyte). The phones can be connected to a laptop or other computer using a **USB** or **RS-232** interface. Due to the low bandwidths involved it is extremely slow to browse the web with such a connection, but useful for sending email, **Secure Shell** data and using other low-bandwidth protocols. Since satellite phones tend to have omnidirectional antennas no alignment is required as long as there is a line of sight between the phone and the satellite.

5 One-way receive, with terrestrial transmit

One-way terrestrial return satellite Internet systems are used with conventional dial-up Internet access, with outbound (upstream) data traveling through a telephone modem, but downstream data sent via satellite at a higher rate. In the U.S., an FCC license is required for the uplink station only; no license is required for the users.

Another type of 1-way satellite Internet system uses **General Packet Radio Service (GPRS)** for the back-channel.^[21] Using standard GPRS or **Enhanced Data Rates for GSM Evolution (EDGE)**, costs are reduced for higher effective rates if the upload volume is very low, and also because this service is not per-time charged, but charged by volume uploaded. GPRS as return improves mobility when the service is provided by a satellite that transmits in the field of 50–53 dBW. Using a 33 cm wide satellite dish, a notebook and a normal GPRS equipped **GSM** phone, users can get mobile satellite broadband.

5.1 System components

The transmitting station has two components, consisting of a high speed Internet connection to serve many customers at once, and the satellite uplink to broadcast requested data to the customers. The ISP's routers con-

nect to proxy servers which can enforce quality of service (QoS) bandwidth limits and guarantees for each customer's traffic.

Often, non-standard IP stacks are used to address the latency and asymmetry problems of the satellite connection. As with one-way receive systems, data sent over the satellite link is generally also encrypted, as otherwise it would be accessible to anyone with a satellite receiver.

Many IP-over-satellite implementations use paired proxy servers at both endpoints so that certain communications between clients and servers^[22] need not to accept the latency inherent in a satellite connection. For similar reasons, there exist special Virtual private network (VPN) implementations designed for use over satellite links because standard VPN software cannot handle the long packet travel times.

Upload speeds are limited by the user's dial-up modem, while download speeds can be very fast compared to dial-up, using the modem only as the control channel for packet acknowledgement.

Latency is still high, although lower than full two-way geostationary satellite Internet, since only half of the data path is via satellite, the other half being via the terrestrial channel.

6 One-way broadcast, receive only

One-way broadcast satellite Internet systems are used for Internet Protocol (IP) broadcast-based data, audio and video distribution. In the U.S., a Federal Communications Commission (FCC) license is required only for the uplink station and no license is required for users. Note that most Internet protocols will not work correctly over one-way access, since they require a return channel. However, Internet content such as web pages can still be distributed over a one-way system by "pushing" them out to local storage at end user sites, though full interactivity is not possible. This is much like TV or radio content which offers little user interface.

The broadcast mechanism may include compression and error correction to help ensure the one-way broadcast is properly received. The data may also be rebroadcast periodically, so that receivers that did not previously succeed will have additional chances to try downloading again.

The data may also be encrypted, so that while anyone can receive the data, only certain destinations are able to actually decode and use the broadcast data. Authorized users only need to have possession of either a short decryption key or an automatic rolling code device that uses its own highly accurate independent timing mechanism to decrypt the data.

6.1 System hardware components

Similar to one-way terrestrial return, satellite Internet access may include interfaces to the public switched telephone network for squawk box applications. An Internet connection is not required, but many applications include a File Transfer Protocol (FTP) server to queue data for broadcast.

6.2 System software components

Most one-way broadcast applications require custom programming at the remote sites. The software at the remote site must filter, store, present a selection interface to and display the data. The software at the transmitting station must provide access control, priority queuing, sending, and encapsulating of the data.

6.3 Services

Emerging commercial services in this area include:

- Google's Project Loon - High-altitude balloon broadcast technology
- Outernet - Satellite constellation technology
- Virgin Galactic - Satellite constellation technology^[23]

7 Efficiency increases

7.1 2013 FCC report cites big jump in satellite performance

In its report released in February, 2013, the Federal Communications Commission noted significant advances in satellite Internet performance. The FCC's Measuring Broadband America report also ranked the major ISPs by how close they came to delivering on advertised speeds. In this category, satellite Internet topped the list, with 90% of subscribers seeing speeds at 140% or better than what was advertised.^[24]

7.2 Reducing satellite latency

Much of the slowdown associated with satellite Internet is that for each request, many roundtrips must be completed before any useful data can be received by the requester.^[25] Special IP stacks and proxies can also reduce latency through lessening the number of roundtrips, or simplifying and reducing the length of protocol headers. These types of technologies are generally referred to as TCP acceleration, HTTP pre-fetching and DNS caching.

8 Satellites launched



Launch of ViaSat-1 satellite

ViaSat-1, the highest capacity communications satellite in the world,^[26] was launched Oct. 19, 2011 from Baikonur, Kazakhstan.

With 140 Gbit/s total throughput capacity, the new satellite services the Exede Internet service, with download and upload speeds much faster than anything previously offered in the satellite industry.

In early 2013, the technology is also scheduled to begin delivering this new level of service to airline passengers aboard JetBlue Airways and one other carrier, according to ViaSat.

The EchoStar XVII satellite with JUPITER High-Throughput Technology, built by Space Systems/Loral, was launched July 5, 2012 by Arianespace and was placed in its permanent geosynchronous orbital slot of 107.1° West longitude. The satellite services the HughesNet Gen4 satellite Internet service. Employing a multi-spot beam, bent-pipe architecture, this Ka-band satellite has over 100 Gbit/s of throughput capacity.^[27]

On June 25, 2013, O3b launched the first four of a constellation of 8 satellites into orbit.

A satellite nicknamed Kizuna, means “ties between people”, space internet also known formally as the WINDS satellite was launched on February 23, 2008. The WINDS satellite will be used to provide broadband Internet services to Japan and locations across the Asia-Pacific region. The satellite aims to provide a maximum speed of 155Mbit/s down and 6Mbit/s up to residences with a 45 cm aperture antenna and a 1.2Gbit/s connection to businesses with a 5 meter antenna.^[28]

SkyTerra-1 was launched in mid-November 2010 and will provide service across North America while Hylas-1 was launched at the end of November 2010 and will target Europe.^[29]

On December 26, 2010, Eutelsat’s KA-SAT was successfully launched by an ILS Proton Breeze M vehicle at the Baikonour Cosmodrome Kazakhstan. The last satellite was due in service in mid-2011. It covers the European continent with 80 spot beams—focused signals that cover

an area a few hundred kilometers across Europe and the Mediterranean. Spot beams allow for frequencies to be effectively reused in multiple regions without interference. The result is increased capacity. Each of the spot beams will have an overall capacity of 900 Mbit/s and the entire satellite will have a capacity of 70 Gbit/s.^[29]

9 See also

- ASTRA2Connect (Satellite Internet Access in Europe)
- Back-channel and return channel
- DishNET (Satellite Internet Access in the United States)
- Exede Internet
- HughesNet (formerly DIRECWAY)
- IP over DVB
- ITC Global Career Certifications
- Lamit Company
- List of device bit rates
- StarBand
- Teledesic
- Thaicom 4
- Tooway
- Ts 2
- Very small aperture terminal
- Virtual private network
- Voice over Internet Protocol
- WildBlue
- Wireless Internet Service Provider

10 References

- [1] Brodtkin, Jon (2013-02-15). “Satellite Internet faster than advertised, but latency still awful”. *Ars Technica*. Retrieved 2013-08-29.
- [2] “Satellite Internet: 15 Mbps, no matter where you live in the U.S.”. *Ars Technica*. Retrieved 5 September 2013.
- [3] A new breed of broadband satellites could have you living on a desert island, *Network World*, 23 July 2014, Patrick Nelson

- [4] “Extra-Terrestrial Relays — Can Rocket Stations Give Worldwide Radio Coverage?”. Arthur C. Clark. October 1945. Retrieved 2009-03-04.
- [5] “First Internet Ready Satellite Launched”. Space Daily. 2003-09-29. Retrieved 2013-08-29.
- [6] Fitchard, Kevin (2012-10-01). “With new satellite tech, rural dwellers get access to true broadband”. Gigaom. Retrieved 2013-08-29.
- [7] “Ka-band Permitted Space Station List”. Federal Communications Commission. 2009-01-25. Retrieved 2013-08-29.
- [8] http://www.dbsinstall.com/PDF/WildBlue/Wildblue_Satellite_Basics.pdf
- [9] “How broadband satellite Internet works”. VSAT Systems. Retrieved 2013-08-29.
- [10] Golding, Joshua. “Q: What is the difference between terrestrial (land based) Internet and satellite Internet”. <http://www.NIASAT.com>. Retrieved 8 May 2013.
- [11] Data Communications Protocol Performance on Geostationary Satellite Links (Hans Kruse, Ohio University, 1996)
- [12] Roundtrip latency numbers are from RFC 2488, Section 2: Satellite Characteristics
- [13] See Comparative Latency of Internet Connections in Satellite Internet Connection for Rural Broadband, page 7 (RuMBA White Paper, Stephen Cobb, 2011)
- [14] RuMBA White Paper titled “Satellite Internet Connection for Rural Broadband”
- [15] Press release, *DARPA’s Vulture Program Enters Phase II*, September 15, 2010, <http://www.darpa.mil/WorkArea/DownloadAsset.aspx?id=1800> retrieved 11/03/2012
- [16] Takashi Iida Satellite Communications: System and Its Design Technology, IOS Press, 2000, ISBN 4-274-90379-6, ISBN 978-4-274-90379-3
- [17] HughesNet Fair Access Policy FAQ
- [18] “WildBlue: High Speed Satellite Internet Provider”. *Official web site*. Retrieved July 17, 2011.
- [19] “Exede: High Speed Satellite Internet Provider”. *Official web site*. Retrieved December 11, 2012.
- [20] “Inmarsat BGAN”. GMPCS. Retrieved 2013-08-29.
- [21]
- [22] <ftp://ftp.rfc-editor.org/in-notes/rfc2488.txt>
- [23] Branson, Richard. “Creating the world’s largest ever satellite constellation”. Retrieved 8 February 2015.
- [24] “Measuring Broadband America - February 2013”. Federal Communications Commission. Retrieved 2013-08-29.
- [25] TCP is bound by the low latency of a three-way handshake. See Transmission Control Protocol.
- [26] “Highest-capacity communications satellite”. Guinness World Records. 2011-10-19. Retrieved 2013-08-29.
- [27] <http://www.hughes.com/PRODUCTSANDTECHNOLOGY/JUPITER/Pages/default.aspx>
- [28] http://www.jaxa.jp/projects/sat/winds/index_e.html
- [29] Martyn Williams (December 27, 2010). “European broadband-Internet satellite launched”. *Network World*. Retrieved July 17, 2011.

11 External links

- ViaSat/TIA Satellite Equipment Systems Standardization Efforts

12 Text and image sources, contributors, and licenses

12.1 Text

- **Satellite Internet access** *Source:* <http://en.wikipedia.org/wiki/Satellite%20Internet%20access?oldid=651680298> *Contributors:* Youssef-san, Stevertigo, Pnm, Karada, Ahoerstemeier, Haakon, Mac, Denni, Sarcasticninja, Rfc1394, KellyCoinGuy, Patcat88, Giftlite, DocWatson42, Fleminra, Curps, Leonard G., Rchandra, Bobblewik, Golbez, Wmahan, MacGyverMagic, Jesster79, Bumm13, Mysidia, Raylu, MissIontomars2k4, Kate, Discospinster, Rich Farmbrough, Rhobite, Gpowers, Smyth, Quiensabe, Kbh3rd, Evice, Adambro, Whosyourjudas, Towel401, Idleguy, ClementSeveillac, Liao, Schnell, Pinar, Lightdarkness, Mac Davis, Btornado, JimmycurN, Feydey, Vegaswikian, NeonMerlin, The wub, Elongman, Ian Pitchford, Intgr, Srleffler, Todd Vierling, Charles Gaudette, DMahalko, Expertu, Gaius Cornelius, CambridgeBayWeather, Rsrikanth05, Welsh, CecilWard, Number 57, Deku-shrub, Hosterweis, HopeSeekr of xMule, Igifin, Zzuuzz, LumpyOne, Graemel, ENDelt260, Jeff Silvers, Veinor, KnightRider, SmackBot, Will381796, Cvdr, Gilliam, Ohnoitsjamie, Bidgee, Thumperward, Jeysaba, Delinck, Jerome Charles Potts, Kungming2, Janipewter, A. B., Fotoguzzi, OrphanBot, JonHarder, Smhni, Fitzhugh, Intideas, Poobslag, Winston.PL, JunCTionS, Kuru, Zaphraud, Ksn, Ortho, Breno, Ch3W, Kseferovic, Dicklyon, Atrexx, Nuclearcat, ShakingSpirit, Hu12, Joseph Solis in Australia, Gedinsmore, Linkspamremover, Tawkerbot2, CalebNoble, JForget, Linus M., NickW557, Gogo Dodo, Davekmv, Dmesso, Jbardgett, Kozuch, Talex101, Davidhorman, Grayshi, Uruiamme, Escarbot, Saimhe, Widefox, Keith111, Harryzilber, MER-C, Kipholbeck, Mikef85, Yakushima, Buckshot06, Gintautas, Indon, Hbent, Kiore, Speck-Made, Filksinger, CommonsDelinker, Jmccormac, Dylan anglada, Mange01, RadioGuyTed, Terrek, Kealper, Skier Dude, Zoffoperskof, Mrkmrk, RemoteCar, Philip Trueman, Pichayal, Zybez, Lee o'mara, Rwattage, Billingham, Howard6, Stoj34, Brianga, AlleborgoBot, Thunderbird2, Are2dee2, Kbrose, SieBot, Tiddly Tom, Darth Luxus, GrooveDog, Arda Xi, Lightmouse, Fratrep, Engineerism, OKBot, Gabriele.wiki, Hariva, Jgoid, ImageRemovalBot, Scook2, ClueBot, Mild Bill Hiccup, Bbb2007, Alexbot, Blackhaz, Dcpc0807, Muhandes, Arjayay, Jotterbot, Norandav, Deasington, Stoj71, Ginbot86, XLinkBot, Alex19568, Jvhays, User1u, Acmesat, Addbot, Semper Fi Marine, Satbuff, Knight of Truth, Sp0rk.me.with.a.knife, NJWard, TutterMouse, Fieldday-sunday, Lightbot, C933103, Luckas-bot, Yobot, Bunnyhop11, Neckername, GavMag, Synchronism, Benspun, AnomieBOT, Götz, Dslme, JackieBot, MaterialsScientist, ChristianH, Xqbot, Winniehell, Nasa-verve, Jcmclurg, Mpritza, FrescoBot, Julio hughesnet, W Nowicki, Sapiens scriptor, Louperibot, Chenopodiaceous, AxlSite, Tanis.7x, RedBot, Keri, TobeBot, MikeAllen, Ladies gifts, Lcamposalvarez04, Dych, DASHBot, EmausBot, WikitanvirBot, Dewritech, ZéroBot, Fæ, Bollyjeff, SpaceXplosion, Satwaycommunications, Wingman417, Gsarwa, Carmichael, Ivanpeter50, Cgt, ClueBot NG, Jphil125, Uršul, Visakhmr, Richardq18, Helpful Pixie Bot, HMSSolent, BG19bot, Agrilan, JohnChrysostom, Clyde55, Asaporito91754, Blantond, Voipsatellite, Suleakim, MeanMotherJr, BattyBot, Devzebra, Khazar2, TwoTwoHello, Victorfnp, Joepearce2, Shannon jp, Faizan, Mephistophocles, Harlem Baker Hughes, Catwomantiff, Otisenpdl, WeirickS, Wyn.junior, Ben89129, Corrinagentry, Markeclinger and Anonymous: 304

12.2 Images

- **File:ASTRA2Connect_LNB.jpg** *Source:* http://upload.wikimedia.org/wikipedia/commons/6/66/ASTRA2Connect_LNB.jpg *License:* Public domain *Contributors:* Transferred from en.wikipedia; transfer was stated to be made by User:Closedmouth. *Original artist:* Original uploader was Satbuff at en.wikipedia
- **File:Bigpond_internet_Satellite.jpg** *Source:* http://upload.wikimedia.org/wikipedia/commons/1/18/Bigpond_internet_Satellite.jpg *License:* CC BY 3.0 *Contributors:* Own work *Original artist:* Bidgee
- **File:Commons-logo.svg** *Source:* <http://upload.wikimedia.org/wikipedia/en/4/4a/Commons-logo.svg> *License:* ? *Contributors:* ? *Original artist:* ?
- **File:Folder_Hexagonal_Icon.svg** *Source:* http://upload.wikimedia.org/wikipedia/en/4/48/Folder_Hexagonal_Icon.svg *License:* Cc-by-sa-3.0 *Contributors:* ? *Original artist:* ?
- **File:FresnelSVG.svg** *Source:* <http://upload.wikimedia.org/wikipedia/commons/d/d6/FresnelSVG.svg> *License:* CC-BY-SA-3.0 *Contributors:* Recreated as an SVG based upon GIF by original author *Original artist:* SVG version by Dancraggs based upon original GIF by Averse
- **File:Launch_of_ViaSat-1_satellite.jpg** *Source:* http://upload.wikimedia.org/wikipedia/en/b/b4/Launch_of_ViaSat-1_satellite.jpg *License:* Fair use *Contributors:* viasat.com *Original artist:* ViaSat Inc.
- **File:Portal-puzzle.svg** *Source:* <http://upload.wikimedia.org/wikipedia/en/f/fd/Portal-puzzle.svg> *License:* Public domain *Contributors:* ? *Original artist:* ?
- **File:Telecom-icon.svg** *Source:* <http://upload.wikimedia.org/wikipedia/commons/4/4e/Telecom-icon.svg> *License:* Public domain *Contributors:* ? *Original artist:* ?
- **File:Tooway_satellite_modem.jpg** *Source:* http://upload.wikimedia.org/wikipedia/commons/b/b4/Tooway_satellite_modem.jpg *License:* CC BY-SA 1.0 *Contributors:* Own work *Original artist:* AxlSite
- **File:WildBlueDish.jpg** *Source:* <http://upload.wikimedia.org/wikipedia/commons/5/56/WildBlueDish.jpg> *License:* CC-BY-SA-3.0 *Contributors:* ? *Original artist:* ?
- **File:WildBlueSatelliteModemBack.JPG** *Source:* <http://upload.wikimedia.org/wikipedia/commons/0/07/WildBlueSatelliteModemBack.JPG> *License:* CC-BY-SA-3.0 *Contributors:* ? *Original artist:* ?

12.3 Content license

- Creative Commons Attribution-Share Alike 3.0