Broadband

The West Wight, the western tip of the Isle of Wight, is a pleasant place to live. It features good beaches, rolling downland and picturesque villages with thatched roofs and half-timber frames. It is also blessed with a laid-back pace of life and very low crime, but does share with many rural areas the problems of seasonal unemployment, under-employment generally, and a lack of infrastructure. Freshwater, the largest settlement on West Wight, was once a teeming Victorian resort which Alfred Lord Tennyson chose to make his home, but in modern times it seems to have had little investment, especially since the days when Spain became the preferred destination for English people in search of low-cost holidays.

Laying our own underwater cable to the mainland was judged to be beyond our modest resources

It's safe to say that most islanders are more than happy to do without motorways and hypermarkets, but one contemporary infrastructural deficiency – the lack of decent Internet connections – was enough of a concern for several of us to start work, two years back, on Turboweb, the community-based networking project that's now providing the benefits of permanent network access to local people, on an extremely modest budget.

Having decided, for our various individual reasons, that we had to bring more bandwidth to our remote corner of the island, we looked at the leased line options. NewNet, an ISP based over the water at Fareham in Hampshire, could offer the bandwidth, but delivering it via the BT network was prohibitive if we were to keep end-user cost to an affordable £30 per month. Laying our own underwater cable to the mainland was judged to be beyond our modest resources. We appealed via the local press for any existing leased line users in our community to approach us, with a view to sharing bandwidth costs. This led to the discovery of some highly expensive and often unreliable private circuits in use – typically connecting remote offices – but no-one in our village came forward to say that they already enjoyed a 'fat pipe' connection to the Internet.

A fixed wireless link to the mainland was technically feasible and more affordable than a BT circuit, but we would have needed a relatively high-altitude base station or tower on both sides of the Solent (the few miles of water separating us from the mainland). This might turn out to be the best long-term solution, but for the time being we

In the most isolated part of the Isle of Wight, locals are using Linux to get fast, affordable, continuous network access

Words: Cris Verrinder and Daniel James

on the beach

don't have access to suitable sites. Our other option was a satellite link. One-way satellite systems that use a proxy server and an independent upstream are well established, but rely on ISDN lines or other legacy systems for packet requests and uploads.

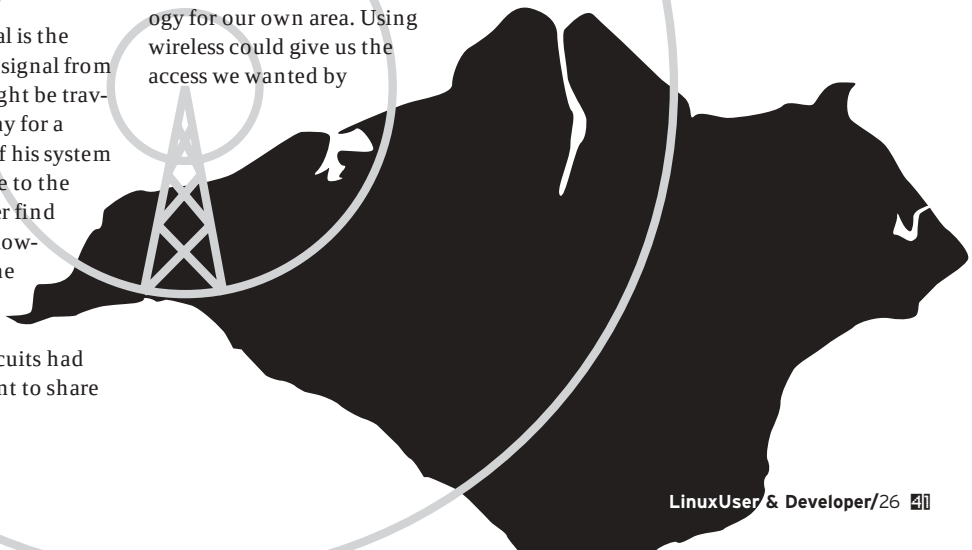
We couldn't find a flat-rate ISDN tariff that didn't impose limitations, and the combination worked out to be nearly as expensive as the new VSAT two-way satellite systems. Although two-way satellite broadband was still in its infancy, it did appear to provide the bandwidth we needed at a fixed price without the use of high buildings or towers. Satellite bandwidth is relatively expensive, but due to contention and the lack of a private circuit, start-up and ongoing costs can be lower than that of a leased line – especially in rural areas.

A key objection to satellite internet in general is the latency caused by the very long journey for the signal from the dish to the satellite and back. The signal might be travelling at the speed of light, but it's still a long way for a round trip. One salesman told us that latency of his system could actually be less than with leased lines, due to the lower number of hops, although we could never find any evidence for this. We decided to eliminate low-latency services such as IP telephony and on-line gaming from our list of supported applications, at least across the Internet. The price of international phone calls on conventional PSTN circuits had dropped to reasonable levels, and we didn't want to share scarce bandwidth with gamers playing Quake.

The last mile

Once we had established a broadband link to the village of Freshwater, the problem of the 'last mile' would remain. A low population density means that a fibre network would never be viable outside of the main towns on the Island – the local cable TV company had gone into receivership before even attempting to lay fibre in our direction. The cable company is now under new ownership, but there are still no plans to provide a fibre network – rather, there was a vague promise to install a wireless system when it became 'technically feasible'.

We had been monitoring the 802.11b wireless LAN communities springing up in the US and became interested in the potential of this technology for our own area. Using wireless could give us the access we wanted by



sharing the cost of the satellite link between several subscribers. Our 'Turboweb' scheme might even become a small business in its own right, and create a couple of jobs, since BT was clearly uninterested in ADSL for rural communities. Besides, many of our local users would be too far from the exchange to use standard ADSL systems. With these assumptions as a starting point we spent two years researching 802.11b WLAN (wireless local area network) technology and the satellite providers available in Europe. We collected a great deal of information, and opened accounts with trade suppliers to enable us to connect local people at a similar price to that offered by ADSL. Mesh designs for the wireless network looked attractive, but were complex and didn't make sense when there would be a single point of failure at the satellite internet connection. A far simpler star topology was decided upon, with a central Ethernet access point serving wireless data to various Ethernet, PCMCIA and PCI client devices.

The main access point was modified from an indoor SMC unit and fitted with a pigtail connector inside a weatherproof housing. It was mounted on a pole with a 12dBi omnidirectional antenna for 360-degree coverage – hills, trees and buildings permitting. Range tests were carried out all over the West Wight using a Linux laptop with SMC and Orinoco cards, running the Mandrake distribution and the wscan utility. Wscan provides a simple bar graph of signal strength, noise and link quality, which is updated once every second. It can be hard to align a large dish aerial by hand in a blowing gale, but we've proved it can be done with the help of a camera tripod!

Originally (in a surge of optimism) we had proposed free wireless internet access, with paying subscribers reserving higher transfer rates. As we developed the system, it became clear that the cost of bandwidth for such a generous project could bankrupt us. There are several thousand people living in West Wight, with a relatively high proportion of Internet users. Anyone in our village or environs could have bought an 802.11b card from Argos, fashioned a simple antenna from a Pringles can, and got free internet access for life for under £100. But without significant sponsorship, it was simply not affordable for our local businesses to provide a free service.

So we enabled all the security features that the access point could offer. These include MAC address filtering, four 128-bit encryption keys and a non-broadcast ESSID.

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Without knowing the ESSID or station name, ad-hoc users passing by will probably find it difficult to connect – even assuming they can both spoof a known user MAC address and break the encryption. The overhead of the security features was not anticipated to constrain available bandwidth, as early tests indicated that the WLAN was good for at least 4Mbits/sec transfers and we were unlikely to be able to afford that much connectivity to the Internet.

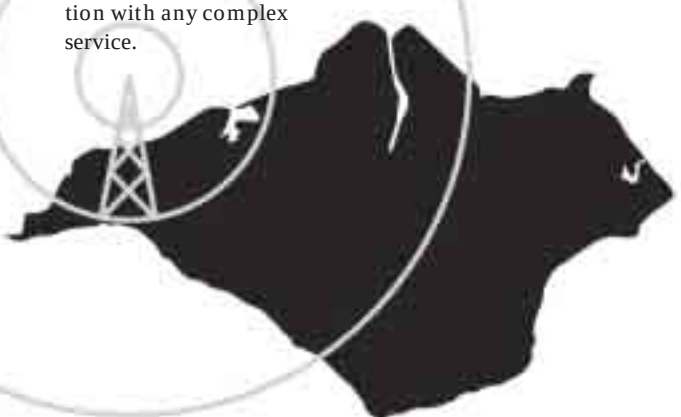
Linux on the radio

Setting up the access point with both the supplied Windows utility and Roman Festchook's programs for Linux, we noticed some anomalies. Using Linux, we had control over low-level functions of the access point that weren't available to the Windows utility. We discovered there was a superuser password for the access point which could overwrite our security settings. The existence of this factory-set default password wasn't even mentioned by the Windows utility or documentation, leaving Windows users with wide open networks.

The more we researched WLAN technology, the more we found that all the interesting developments were being done on Linux systems, with the exception of a few on BSD variants of Unix. Whenever we looked up documentation or specifications for hardware on the Internet, most of it turned out to be Linux-related in one way or another. Linux drivers for our wireless cards were well developed, and installed without a hitch. Jean Tourrilhes maintains an excellent site with all kinds of Linux WLAN information, and this is probably the best place to start looking.

We found the range of our WLAN to be more than adequate for our needs, with line-of-sight users over four kilometres away able to use just a small and cheap 13dBi corner reflector antenna, even with eight metres of low-loss cable between the antennas and the radio device. Corner reflector aerials aren't particularly directional, which means they are very easy to align and the signal is not broken if high winds bend or twist the aerial pole. Within the village we can also get up to 800 metres of non-line-of-sight connectivity, which means you can sit outside the café with a laptop and use the Internet – while the battery lasts, at least.

Fortunately we were able to work with a local aerial installer to get the roof work done. Apart from his many years of experience with aerials, brackets and masts, he had the safety knowledge required to work without danger while hanging on to a chimney. We wanted broadband, but not badly enough to risk our necks. In return, we were able to show him how WLAN aerials work, the special coaxial cable needed for microwave signals and the frequencies at which the 802.11b channels are set. Once he knew the exact frequency in GHz we were using, he was able to use his standard test gear to align WLAN aerials perfectly, without any help from us. Very few problems with the WLAN emerged over six months testing with a 56K modem connection to the Internet, courtesy of a Linux router running the Smoothwall GPL distribution. The satellite system needed far more care in selection, because it proved far from straightforward to get it running smoothly. While a wide variety of firms now offer satellite internet services, there only seem to be about four actual providers, with the rest being resellers. Perhaps this is because the capital investment required in the satellites is so large, like their geographical coverage. These four main companies hardly interact with end users at all, which is a less than ideal situation with any complex service.



Satellite of love?

The consumer satellite providers we discovered were Hughes and Gilat, and the corporate providers were Tachyon and Globecast. Hughes offers the greatest range of packages, including USB and Ethernet systems, and seems to be the most popular with resellers in the UK. So far the only company we found reselling the Gilat product was BT – the service offers a maximum of 512Kbits/sec downstream with 50:1 contention like ADSL, and would therefore not suit our project. On the plus side the Gilat satellite receiver/transmitter does have an Ethernet port hidden by an easily-removed USB daughterboard, although doing this modification voids the warranty. We have also heard that BT has been denying service to satellite customers who have used the Gilat service 'too heavily'.

The Tachyon service offers 2Mbits/sec downstream and 256Kbits/sec upstream with uncontended bandwidth at a price similar to a leased line. This could be useful in locations where a fixed connection is completely out of the question. The service comes with an Ethernet connection and is resold by one company that we know of, called SatWeb. Globecast seems to be aiming its satellite service at corporations, but we don't know of any resellers in the UK.

We chose a Hughes Direcway 4000 system from resellers Isonetric, in part because we told them about our community WLAN plans and they didn't threaten an immediate ban for breaking terms and conditions. Perhaps they just didn't believe us. Another benefit was that we could lease the expensive satellite client hardware instead of paying up front – some resellers wanted over £1000 for the transmitter, receiver and dish before a single packet had been downloaded.

The only drawback was that the financially feasible 'bronze' service at £159 plus VAT per month relied on USB satellite transmit-and-receive units which did not have Linux drivers available. Some Hughes users around the world had reverse-engineered Linux drivers, but not yet for the brand new two-way systems such as the DW4000. So we reluctantly accepted a Windows 98 box into our network design, where it would sit between the satellite hardware and the 802.11b access point.

The satellite dish installers were helpful enough, but weren't trained in networking. The dish was aligned with the satellite, but nothing worked. Eventually we tracked down the problem – each DW4000 system has to be activated from the satellite base station in Germany, which needs to know the exact latitude and longitude of the client dish. The GPS device wielded by the dish installers produced figures that the system would not accept. To our surprise, careful measurement with nothing more complex than an Ordnance Survey map and a ruler produced figures that the DW4000 would accept, and the unit began working.

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The DW4000 offers asymmetrical bandwidth, with our 'bronze' service offering 512Kbits/sec downstream burstable to 4Mbits/sec and 128Kbits/sec upstream. In everyday use, we've achieved downloads of large files from the Internet at up to 1Mbit/sec, although a typical download speed for a user on the WLAN would be around 256Kbits/sec. While this might not seem impressive to the urban broadband user on a fibre network, it represents at least a five-times speed increase for members of our community – with flat-rate permanent access, too.

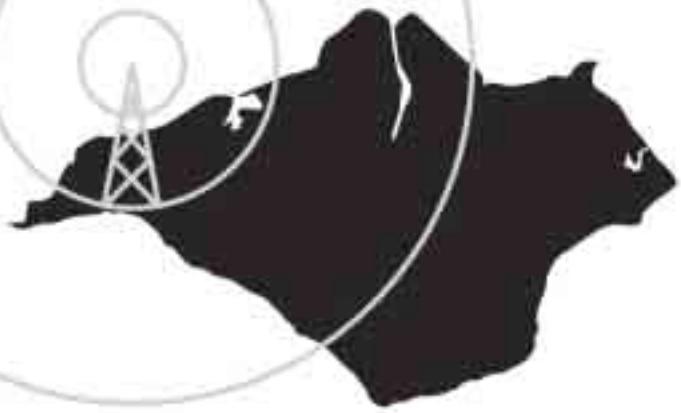
With only 128Kbits/sec upstream to the Internet, our WLAN is most definitely not designed for hosting services. We have the use of a co-located Linux box in a San Francisco datacentre for that purpose, offering the usual webspace and email services to our local users. FTP uploads can be slow when the majority of users are active, but we have tried to balance the number of daytime users with evening and weekend counterparts. Hughes has announced a service upgrade to 512Kbits/sec upstream, to be available in the summer of 2003; we certainly hope to make use of that.

Breaking Windows

Windows 98 supposedly works with the DirecPC service. It works as well as any Windows 9x solution in a network infrastructure role – that's to say not very well at all. Despite trying every software router available, from free downloads to expensive proprietary offerings, the Windows box froze up on a regular basis and performance was poor. We couldn't believe that a Compaq-built Pentium II running at 450MHz with 512MB RAM would not be able to perform the relatively simple task of routing packets. The least bad software router for Windows was Hughes' own Orbitnet program, but we couldn't take it seriously at the price of US$700 for unlimited users, given that it only worked some of the time.

Reports in unofficial Direcway web forums indicated that Windows 2000 performed better, while Windows XP was something of an uncertainty at the time. Buying a copy of Windows 2000 would have been a relatively cheap solution, but our experience with Microsoft products told us it would have only been a partial fix. The issue of 'security by obscurity' would still have been outstanding – as for reliability and performance, just being 'better than Windows 98' was not good enough. We needed a satellite system that was as good as our wireless network, running 24/7 without significant downtime.

So we ordered the Direcway 4020 upgrade for our DW4000 system, which cost a further £500. This is a third box which sits under the transmit and receive units, and acts as a USB to Ethernet router. After paying in advance and waiting for several months, we took delivery of one of the first units to be imported. The DW4020 is an embedded system which appears to run a proprietary operating system



from Wind River. The device isn't doing anything that the Linux equivalent could not – except that it includes proprietary drivers for the satellite hardware.

With the DW4020 fitted the system behaves more like a 512Kbits/sec leased line, with bursts up to around 700Kbits/sec. It would seem that higher maximum speeds have been sacrificed for a more consistent connection, which is just as well given the shared nature of our network. Best-case latency for a ping from the Internet is around 700ms, and worst-case latency is about 2000ms.

Whose router is it anyway?

The Direcway 4020 is typical of the new generation of 'trusted' devices, in that it has a 'root' superuser, but the root password is not given to the person who buys and pays for the device. As with our 802.11b access point, the deepest level of control over configuration is intended to remain with the manufacturer – and any agent that the manufacturer wishes to share the root password with. The unit seems to be remotely controlled by the main Hughes network operations centre. When you power on, or reboot the device, it appears to download fresh firmware or software from the NOC, enabling both stealthy downgrades and the removal of any modified settings. The implications for security, in particular of virtual private networks, are obvious.

In the days of analogue connectivity, service was limited by the nature of the system. By the time the 56K modem had been introduced, there was little that end users could do to squeeze more bandwidth out of a single phone line. However, once the limitations of copper networks have been left behind, the innovative Linux user has scope to tweak his or her network to maximise available bandwidth. This is bound to prove unpopular with ISPs, whose business models often rely on selling bandwidth to people who aren't actually going to use much of it.

Before unpacking the Direcway 4020, we knew that it had been 'pre-configured'. The real IP address had been set up with a 255.255.255.240 network, which only allows 16 IP devices – presumably an attempt to constrain the amount of bandwidth we could use. Sixteen IP addresses aren't likely to be sufficient for a modern business, let alone our entire broadband community.

Checking the web interface of the DW4020 unit, we noted that NAT was described as not activated, but there was nothing to click on to enable it. There was nothing in the user documentation about enabling NAT either. We phoned Isonetric tech support, to be told that although the device we had bought might support NAT, we were not allowed to enable it – and that they would not do it for us either. According to Isonetric, our router was not a router at all, but a £500 USB to Ethernet converter!

Presumably at this point, the typical Windows user is expected to upgrade to a higher tariff which allows more IP devices to be connected to their Direcway 4020 – regardless of the amount of bandwidth used. A more pragmatic solution is to connect the satellite router to a dual Ethernet Linux box, and again we chose the Smoothwall GPL distribution. This also meant we did not have to rely on the uncertain firewalling capabilities of the Direcway unit, which as a 'black box' system is hardly open to scrutiny by the security community. Smoothwall offered improved logging, load balancing and Squid web-caching abilities, so it would have been a worthwhile addition in any case. It improved the end-user feel of the satellite link no end, compensating for the high latency of the satellite system by sending cached files over the WLAN only.

If we had a pure Linux satellite solution available, this extra hardware and complexity might not have been necessary. During our research, we discovered the Helius satellite router, which runs Linux and could have fitted our needs perfectly. But we could not find a single UK two-way satellite internet service which would allow us to specify or source our own hardware. Doubtless this is because the ISPs fear the crafty Linux user, given control over his or her own hardware, would somehow be able to monopolise an entire satellite transponder.

As one of the first customers in the UK for two-way satellite internet, we can't help feeling like beta testers, rather than users of a properly refined service. For example, the satellite hardware seems to block incoming web browser traffic after just a few hours' use, which is very curious. Presumably this is because some sort of log is filling up, although it's hard to tell with the impenetrable nature of proprietary embedded hardware. Power-cycling the transmit unit returns normal functionality, and our temporary solution has been to fit a £9.99 electrical timer from B&Q, which reboots the unit every six hours. It's a crude fix, but it works – and we are pestering Isonetric tech support for a proper solution.

We have achieved our goal of providing broadband to our rural community on a shoestring budget, and are now investigating future options. We can upgrade the satellite bandwidth to 2Mbits/sec downstream if we get enough local users, and the low latency of the WLAN at around 5ms ping time could make all kinds of local services possible – video conferencing and other types of multimedia streaming, for example. A grant of £2000 from SEEDA, our regional government body for economic development, has helped offset initial costs, and we are now helping other rural communities who hope to replicate our broadband solution. It remains to be seen if we are penalised by our satellite service provider for being too creative.

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Key links

Turboweb
www.turboweb.org

Roman Festchook's utilities
http://ap-utils.polesye.net

Jean Tourrilhes' pages
www.hpl.hp.com/personal/Jean_Tourrilhes/Linux/

Isonetric
www.satellite-adsl.co.uk

Helius
www.helius.com

Hughes
www.hns.com

Gilat
www.gilat.com

Tachyon
www.tachyon.net

SatWeb
www.satweb.co.uk

Globecast
www.globecast.com