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Wireless Networking

The Wireless Jungle

Wireless data communication comes in all shapes and sizes – some of the technologies are over a hundred years old. Read on to learn all about the protocols and technologies involved. BY HOLGER LUBITZ

Wireless data transmission is certainly nothing new. The first morse code was exchanged between two stations at the end of the 18th century, and morse code is generally regarded as the oldest known data encoding technique. Although at the time usage was restricted by fragile technology and immense running costs, which meant that the technological potential was exploited mainly for military purposes, today's inexpensive equipment makes wireless communications a real prospect for home use.

Although a few years have passed since wireless LANs were introduced to the consumer market, the race for an exclusive standard is still on, with various technologies competing for custom and bandwidth. While Bluetooth has more or less established its position as a kind of wireless USB, with low transmitting power, range, and bandwidth, with some careful planning "real" WLAN solutions can be used to cover greater distances and are approaching the bandwidths normally expected in wired environments.

Wireless – but how?

The advantages of wireless solutions are self-evident – no need to install wiring, laptops can access the network directly, wherever they are..The disadvantages are not quite as obvious: Wiring allows exclusive communication between the nodes on a network, but wireless solutions need to take other users of the same frequency into consideration. That means not only unintentional WLAN disruptions due to other users in the same waveband, but also intentional misuse of the WLAN by outsiders. The current encryption services are easily exploited, and if you do not enable encryption at all, the network is available to anyone within range.

License-free radio transmissions are only possible within the so-called ISM wavebands (Industrial, Scientific, Medical). The ISM frequencies 900 MHz, 2.4 GHz and 5 GHz are relevant to our discussion. The 900 MHz waveband would provide the best range due to its comparitively low frequency, however, it is not commonly available for use, having already been assigned to mobile radio communications in Europe. There are very few products available, as mobile telephones dominate this frequency range in the USA.

The higher the frequency, the worse the propagation characteristices of an electromagnetic wave. Although you do not explicitly need visibility between two nodes at WLAN frequencies, even thin internal walls can subject the GHz frequencies to noticable attenuation. Theoretical ranges of several hundred meters thus tend to drop to 20 or 30 meters if walls or other obstacles are in the way. However, distances of up to 50 km can be bridged using directive antennas and avoiding obstructions.

You will need to pay attention to the physical environment when positioning your access points – an access point in the cellar will not be much use to you if you are on the second or third floor, especially if reinforced concrete was used for flooring. Instead, you might prefer to look for a position in the center of your house or appartment, even if this means some additional wiring to reach this point. If you intend to use the wireless LAN in the open, you should position your access point on the roof or in a window to provide maximum range. Access points are normally configured to be omnidirectional – that is they transmit in every direction. However, you can use special antennas to provide a directive element, although you might prefer to have this work done by a specialist who has access to the measuring equipment required to achieve maximum performance. If you are the do-it-yourself type, you should at least make sure that the cable used to attach the antenna is as short as possible.

Standards

The 802.11 protocol family has been standardized by the IEEE, the Institute of Electrical and Electronics Engineers (say: "i triple e"). The original 802.11 standard that dates back to 1997 can be regarded as a predecessor to today's WLANs. It envisaged data transfer rates of 1 or 2 Mbit/s in the 2.4 GHz frequency range, and replaced many of the older proprietary technologies.

However, as wired networks were still a lot quicker, the market demanded higher data transfer rates and got them – although this meant a return to proprietory solutions. To avoid uncontrolled developments, two new standards, 802.11a and 802.11b, were introduced in September 1999.

Products based on 802.11b work in the same waveband as 802.11, but use a different modulation technique to achieve data transfer rates between 5.5 and 11 Mbit/s. But where the USA allows a maximum transmitter power of 1 watt, a restriction of 100 milliwatts applies in Europe – that is enough for LANs, but fairly ineffective if you need to bridge greater distances.

There was some delay before the first products for 802.11a were introduced. This standard means an excursion to the 5 GHz frequency range (5.15-5.35 and 5.725-5.825 Ghz). But again, only the USA allowed the use of this range for wireless LANs. ETSI, the standards body responsible for Europe, had instead reserved this range for the HiperLan and HiperLan/2 (High Performance LAN) technologies. These frequencies had already been assigned in many national frequency usage plans and had to be reassigned. Market restrictions and low demand meant that the first 802.11a products did not have any noticable impact on the market until this year.

Bandwidth for the Masses

Some European countries have started to liberalize the market for 802.11a products. In Germany, the Regulating Authority for Telecommunications and Post (RegTP – similar to the RA in the UK) now permits use of the 5150-5350 and 5470-5725 MHz frequency ranges, without explicitly restricting these wavebands to a specific technical standard. However, transmitter power is restricted to 200 milliwatts at the lower end of the scale (indoors) and to 1 watt at the higher end of the scale (including outdoor use). Although HiperLan/2 does offer lower latency as a wireless ATM, and has superior facilities for guaranteed bandwidth, the protocol overheads are too high for use in pure IP environments. Also, it is cheaper to produce hardware for 802.11a than for HiperLan/2.

The bandwidth available in the 5 GHz waveband allows for a larger number of independent channels, and OFDM modulation permits higher data transfer rates. 802.11a provides eight different data rates between 6 and 54 MBit/s depending on reception quality. The disadvantage is that the higher frequency means a shorter range and consequently a higher concentration of access points. This concentration increases if you intend to use all the available channels, as you will need to resort to lower powered antennae in this case. However, research indicates an approximately 300 % improvement in bandwidth for 802.11a installations compared to 802.11b.

The 802.11g standard is new and has not yet been ratified. It envisages a combination of the old 2.4 GHz waveband with OFDM (which was not permissible in the original standard), and is thus capable of achieving up to 54 MBit/s, although the restriction to three independent channels still applies. If multiple users require improved data transfer rates, 802.11a still seems to be the better solution. But 802.11g comes to its own when existing indivdual nodes in an existing 802.11b installation require increased performance. It might make sense to combine both technologies – look out for dual band access points that support both standards.

One further advantage of 802.11a is the fact that the 5 GHz waveband has not noticably been occupied by other products, so far. 2.4 GHz standards can expect interference from Bluetooth, and even microwave ovens, that transmissions in the 5 GHz waveband are not currently subject to.

The proprietory protocols of the early days continue to lose ground. One notable example is OpenAir by Proxim that goes back to pre-802.11 days. OpenAir uses a frequency hopping protocol and simple modulation techniques to achieve data tranfer rates between 0.8 and 1.6 MBit/s. Cheap to implement, but the performance could hardly be described as earth shattering.

HomeRF by Diamond is also aimed at providing low-cost hardware, but has lost out to 802.11b with far inferior performance at only slightly lower prices in the States with virtually no impact on the European market.

Interference

As previously mentioned, the frequency ranges are available for public use, and interference due to microwaves is commonplace in the 2.4 GHz waveband. WLAN cards thus implement various error avoidance and correction techniques to guarantee error free transmission despite interference.

A WLAN card does not transmit at a fixed frequency, instead using multiple wavelengths or continually changing frequency within a waveband. This technique, referred to as spread spectrum, allows the transmitter to avoid frequency ranges suffering from interference, or at least mitigate the effect. There are two variants: Direct sequence modulates the data with a high frequency code. This requires more bandwidth but makes it easier to filter out interference in individual ranges when the same code is used to demodulate the transmission. Frequency hopping divides a waveband into multiple narrow channels and switches channels continually. If there is interference on one channel, you would not normally expect similar interference when hopping to the next channel.

Error correction takes care of any remaining mistakes. Although there are numerous error correcting encoding procedures, they are inefficient within the context of wireless transmissions. Instead error recognition is the key, and defective packets are simply re-transmitted. Of course this will have a noticable effect on the available bandwidth if a large number of errors occurs. The bandwidths quoted for WLAN products should thus be understood as referring to the maximum gross bandwidth in perfect conditions – practical experience shows that these values are almost impossible to achieve.

The Future

IEEE 802.11b is the de facto standard for today's wireless networks, although the next few years may see it being replaced by 802.11a at 54 MBit/s – the equipment is already on the manufacturers' shelves. However, the introduction of 802.11x should prove to be a more significant innovation for home users. This means devices that adhere to the 11 MBit/s 802.11b standard but provide far superior encryption than WEP-128. Expect the first generation of equipment at the end of this year. ■