802.11 and Ham Radio

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Introduction

The price of 802.11b equipment is continuing to fall. Once retailing for hundreds of dollars, PCMCIA 802.11b cards are now retailing for under $50. These cards contain sophisticated hardware and software that rivals most of the digital technology used in the Ham Radio world today.

A hobby has grown out of this technology in computing circles – building antennas and whole networks, operating at high speeds, with little knowledge of sound engineering principles. Antennas that do not resonate and N Connectors crimped with a pair of pliers are just a couple of the examples of the state of the hobby outside the ham radio world.

If Ham Radio is to survive in the coming years, it is areas such as 802.11b that can be used not only to attract those interested in digital communications, but also as a building block for our own networks.

In this paper I will describe some of the technology, and some of the areas that Ham Radio operators can investigate in order to extend the state of the art.

Frequency of Operation

802.11b is based on Direct Sequence Spread Spectrum utilizing 22 MHz channels centered from 2.412 GHz to 2.462 GHz. There are only three channels orthogonal channels available. Another two channels can be used, subject to acceptance of some interference . These devices are licensed under FCC Part 15.

Contrast this to the Ham Radio allocation in the USA contains an allocation from 2.390 to 2.450 MHz, allowing channels centered on 2.412 to 2.437 (Channels 1-6) to be used under FCC Part 97 (Ham Radio) rules.

Whilst Part 15 allows commercial use, it does this with limitations on the effective transmitted power. The power limit is increased under Part 97, but with the requirement for power control under certain circumstances, and for non-commercial use.

In essence, existing 802.11b hardware can be used either under the Part 15 rules, or under Part 97 rules, allowing this technology to be used as a building block for commercial and non-commercial applications.

Experimentation

802.11b equipment lends itself to experimentation. Several avenues for experimentation exist

- Antennas
- Protocols/Routing
- Hardware Modifications (Frequency/Power)
- Ethernet/USB up the antenna
- Applications (Digital Voice)

Antennas

One of the great areas of experimentation with 802.11 technology is the design and manufacture of antennas to increase the range of the units whilst still operating within the license conditions. Three types of antennas are popular in the 802.11 experimenters world.

- Pringles Can
- MDS Antennas
- Vertical Antennas

Some of the antennas being used have distinct problems, such as not being able to resonate efficiently. When combined with the use of 30 feet of RG-213 in excess of what is needed, poor results are experienced. However due to the error controls and link margins in the system, the link might actually work.

Pringles Cans

Probably the best example of experimentation with 802.11b is the Pringles can antenna, where a Pringles can is fed with a short stub, and a number of washers are placed on a piece of steel inside the can. Simple analysis shows that this antenna will not resonate correctly at the low end of the band. This is partially offset by the use of washers inside the can creating an antenna that could be best described as an inverse cavity antenna.

MDS Antennas

MDS, or Microwave Distribution System antennas are popular in areas where the cable for Cable TV is not present. It reduces the economic investment for an operator wanting to get into Cable TV significantly.

In Australia the major MDS company went bankrupt a few years ago, leading to a large number of the Conifer antennas turning up on the 2nd hand market.

Operating at about 18 dBi, these antennas are actually quite effective, and there is little that can be done to cause these antennas not to cause them not to work.

Vertical Antennas

Several collinear antenna designs are available on the internet, although many of them have problems which lead to less than desirable results. With some effort these designs could be optimized to allow construction to broader tolerances.

Protocols and Routing

One area that hams should be able to work well on is designing intelligent protocols for 802.11 networks and systems. Routing protocols exist for fully or mostly wireless 802.11 networks, but none have a large following in the field.

Combining some of the ideas contained in the Radio Shortest Path First protocol with traditional wired protocols could yield some promising results. The dynamics of mesh networks do not tend to be as well understood as wired networks.

Hardware Modifications

One of the problems when attempting to build high speed radio-communications equipment is the RF side. Using 802.11b units as a building block simplifies building equipment.

Several options exist for modifying 802.11b units, provided that they are to be used under Part 97. As discussed earlier Part 97 allows higher power outputs, alternate frequencies and higher antenna gains.

Increased Power Output

When operating under Part 97, 802.11b equipment can operate at higher powers. Amplifying the signal is a challenge, since half duplex communications are used on a single frequency. Due to the symmetrical nature of the system it is also no use just amplifying one end of a link. Both ends will need to be amplified.

The question is how do we increase power? There are a few options which I will now discuss.

The first is to find a unit that can be programmed in software to use a higher power, such as the LinkSys WAP-11, which can transmit up to 100 mWatts.

Another option is to place an amplifier external to the 802.11b unit. In order for the amplifier to work, it needs to sense transmit power on the input to the amplifier, and only amplify the signal when power is present, and bypassing the amplifier in receive mode.

Whilst this sounds easy, the amplifier must have VERY fast switching times, which may be difficult to realize in practice. One group has reportedly produced a design for this.

One more option involves more research. Many 802.11b units have circuit diagrams available on the FCC web site. Examining these circuit diagrams will show where the power amplifier is inside the unit, allowing a larger device to be installed.

Alternately the transmit/receive switch line could be identified from the circuit diagram, and use to drive an external amplifier.

Frequency Change

Many 802.11b devices use chipsets that use a couple of frequencies internally. The chipset used on one device from D-LINK uses a reference oscillator, and a separate local oscillator. Changing the frequency of operation is almost as simple as changing the frequency of the local oscillator.

Of course that will only move the frequency within a relatively small range. In order to change the frequency more than that, more drastic changes are needed. The same unit from D-Link has a separate mixer device – combined for transmit and receive.

With some effort the mixer can be changed for an external unit operating at almost any frequency.

Another option is to use a transverter, operating in a similar manner to the carrier sense amplifier mentioned about. In this case 2.4 GHz is used as an intermediate frequency. Since a transverter contains a power amplifier, problems inherent in power amplifiers added to 802.11 also exist in transverters.

Ethernet up the Antenna

Ethernet up the Antenna is the Holy Grail of almost every computer literate ham. Cat-5 Ethernet cable is much cheaper than Belden 9913, with significantly less loss.

Putting active devices up the antenna allow the distance between the 802.11b device and the antenna to be so small that even RG-58 could be used without serious losses.

The main point to watch is surge protectors for lightning on the incoming Ethernet cable. To a certain extent 802.11b equipment is disposable, but that does not apply to computer systems.

Unfortunately the cheap devices tend to be not Ethernet, but USB. This is not a problem, since USB cables can be connected up to 25m from the computer. In order to get this far away, Hubs or extension cables are needed.

Applications

We have now seen how 802.11b can used, or modified for use by hams to give us bandwidth. The question then becomes 'How can we use this bandwidth?'.

Some answers to this could be

- Digital Video (ATV)
- Digital Audio for repeater linking
- Digital Audio

Digital ATV

Most parts of the world are using high definition signals with complex modulation schemes for Digital TV. These are far too expensive at the moment except for those working in the television industry to experiment with most receivers being quite rare.

This does not lend itself to experimentation. What does lend itself to experimentation is an MPEG encoded video stream transmitted on an 802.11 transmitter. The cost of equipment is small, particularly compared to the average ATV setup.

All that would be required for this type of setup is a cheap WebCam, computer and 802.11 unit with a good antenna. The 802.11 unit could be removed from the equation if the repeater site has a high speed data connection.

Some work would be required to implement this since multi-cast protocols would need to be used, but this is an area that could see some experimentation.

Digital Voice

802.11 is appearing in consumer handheld equipment such as Palm Pilots. A cute application would be to turn one of these units into a HT. Voice signals connect to the local access point, and get forwarded to an IRLP repeater.

Proximity APRS

In association with Digital Voice is another mode, which I am calling Proximity APRS. This is almost identical to normal APRS, but it based on the access point that is being used by the equipment, rather than GPS position. As a person moves, so does the access point being used, allowing interesting applications. Combining this data with the APRS data stream would not be too difficult.

Digital Audio Repeater Linking

Many parts of the world have complex repeater linking systems. New Zealand has a repeater system that spans the whole country. With IRLP, a world wide repeater system is becoming a possibility.

Many repeater sites do not have Internet access, or the owners have decided not to join IRLP, but want to connect their repeaters together anyway.

802.11 provides a possible solution. The bandwidth available makes it possible for many channels of high quality audio and signaling information to be transmitted on the same frequency.

Imagine a repeater voting system that contains a multitude of receivers and transmitters along a highway. A system could be designed where the received signals from all the sites are combined in a DSP chip to obtain the best signal, regardless of fading. The DSP would have access to all the audio signals so could cut and paste' at will.

Conclusion

What I have shown in this paper is that there are non-traditional sources for equipment that the modern Ham Radio operator can use as part of their hobby. I have outlined some areas for experimentation, and some of the applications that used with the technology.