Higher Speed Amateur Packet Radio Using The Apple Macintosh Computer

by
Doug Yuill VE3OCU, Ottawa, Canada
dyuill@ccs.carleton.ca

Abstract

This paper will discuss higher speed amateur packet radio experiments conducted with the Apple Macintosh computer and the WA4DSY radio modem. In particular, the results of using two different hardware/software combinations will be explored. The first combination uses KA9Q's NET/Mac program with a modified Pat-Comm TNC-2; the second combines Intercons TCP/Connect II™ with the Gracillis PackeTen NOS in a box, a stand-alone IP switch.

Introduction

Packeteers in the Canadian National Capital region have enjoyed higher quality networking through the use of a high-speed, wide area, digital repeater and packet switch known as Hydra [1]. This repeater has served as the focal point for experimentation with advanced computer-mediated communications (CMC). Access to the resources of a Unix based university size network has created the need for better end-user software. Phil Kam KA9Q's TCP/IP software NET/Mac provides robust access to a core set of tcp/ip applications [2]. In conjunction with the Gracillis PackeTen [3], the Macintosh becomes a platform, rich in CMC possibilities. Commercial software such as Intercon's TCP/Connect II™ can be connected via a SLIP (serial line internet protocol) interface to the PackeTen. This configuration has the dual advantage of providing an improved quality user interface with support for NNTP (network news transport protocol), SNMP (simple network management protocol) & POP (post office protocol), while still supporting AX25 via KA9Q's more advanced NOS (network operating system), running on the Motorola 68302 in the PackeTen. The PackeTen also serves to filter out unwanted packets which would otherwise reduce the performance of the Mac.

History

In the spring of 1989 four members of the Ottawa Amateur Radio Club's Packet Radio Working Group each decided to purchase WA4DSY radio modem kits [4]. This decision was brought about by dissatisfaction with attempts to utilise "off the shelf' voice grade radios to achieve 9600 baud packet radio operation with Steve Goode K9NG's FSK modem [5]. The narrow bandwidth of such radios makes it difficult to pass data at 9600 baud. Also, pre-emphasis and de-emphasis must be used to minimise the group delay caused by non-linear IF stages present in many voice grade rigs. This has the effect of decreasing the inter-operability between different manufacturers' radios. The WA4DSY was seen as a means to circumvent these problems. The extra cost of the WA4DSY modem and transverter was easily justified by the 6 fold increase in performance (56k baud). Off the shelf transverters were used to convert the 28Mhz I.F. of the WA4DSY modem. to 220Mhz where the Canadian D.O.C. has allocated frequency spectrum for experimenting with wider bandwidth packet radio in the form of two 100Khz wide channels.

While the WA4DSY modem provides a stock solution for higher speed packeteering from the RF end of things, its high data rate required a more creative solution for interfacing it to a host computer. Documentation provided with the modem describes, in step-by-step detail, how to modify a standard TNC-2 for use as a host interface [6]. This includes replacing the TNC's firmware with a special high-speed version of KISS. As the WA4DSY modern is of a synchronous design, the KISS firmware assembles the packets so that they can be passed asynchronously to the host computer for further processing. This type of interface was used for the initial testing of the modems on the air. Unfortunately, 56k baud is too fast a data rate for most computers using interrupt-driven serial I/O, This requires the TNC to buffer the packets and exchange them with the host at a lower data rate, usually 19.2k baud. Of course this reduces the maximum effective speed by a full two thirds. On the Macintosh this had the dubious advantage of hiding some performance bottle-necks which will be described in detail later. After several months of successful testing using half duplex links between home QTHs, it was realised that a repeater could provide continuous coverage to a growing higher speed user community while also providing a mechanism for overcoming the dreaded hidden terminal syndrome [7].
A cross-band digital repeater was designed and built for about $1000 using mostly off the shelf hardware (220.55 Mhz input, 433.55 Mhz output). The bit re-generator circuit designed by Barry McLarnon VE3JF is the only custom part of the design, The repeater has been continuously operational from the Dunton tower at Carleton University since January of 1990.

The First Configuration

I was inspired to finish constructing my modem for testing with my Macintosh, after Marcus Leech (VE3MDL) and Barry McLarnon (VE3JF) made the first successful radio contacts using the WA4DSY modem over a 15 km. path in August of 1989. I installed and configured KA9Q's NET/Mac software for use with a Pat-Comm Tiny-2 TNC running KISS-56k firmware. The host interface was set to run at 19.2k baud.

After noting a lower amount of RF output from the transmit oscillator of the modem than was suggested in the alignment procedure, and being unable to increase it, I decided to try an on-air test over a 20km metro-wide path. With seven-element yagis at each end using lo-watt transverters on 220.55Mhz, I achieved a 100% ping return rate for hours at a time over thousands of packets. During 4 months of testing, the quality varied between a 0% ping return rate for up to 2 days at a time (on several occasions) and the more usual 70%-80% [8]. The wider bandwidth used by the WA4DSY modem probably requires a higher margin for the link budget.

The rtt (round trip time) averaged about 300ms after installing a bandpass filter in front of the receive converter to stop intermittent falsing of the DCD (data carrier detect). Performance in file transfers left much to be desired with only hundreds of bytes per second being moved. In part, this was due to the slow interrupt driven I/O of the PC's at the other end of the connection. As well, smaller then necessary values for tcp mss (maximum segment size) were causing the txd (transmit delay timer) to play a much bigger role in overall efficiency. Also, the 19.2k baud rate between the TNC and computer was creating a longer rtt. Be that as it may, I considered what changes could be made to the TNC to accommodate a higher baud rate. I discovered that by tripling the frequency of the CPU clock to 14.7456 Mhz and then jumpering the CPU for half-speed operation (7.3728 Mhz), I could achieve a 57.6k baud rate on the host port, the maximum asynchronous data rate available on the Macintosh using NET/Mac. The higher clock speed of the Z-80 would help the KISS-56k firmware service the now three times faster host port.

After replacing the CPU and SIO chips in the TNC with parts rated for 6Mhz operation, upgrading the 4.9152 Mhz crystal to 14.7456 Mhz and making the additional Printed Circuit Board trace cuts and jumpers for higher speed operation, I was ready for more testing. The modifications worked fine and I was now the fastest user on our network! It was noted that the channel loading seemed evenly distributed with four regular users and the Mac did not pause to service I/O from the TNC. This condition was not to last much longer.

Without any other higher speed users to test with, I was still unable to measure maximum performance. This did not last long as Dave Perry VE3IFB started testing the driver software for a high speed DMA (Direct Memory Access) interface board he had prototyped for use on the IBM PC [9]. File transfers were now measured at 3k bytes per second during an ftp get using an IBM PC as a server. Rtt's of less then 100ms were now common. It was observed that this transfer rate was still less then 1/2 of the theoretical maximum. I determined that this was the result of the TNC running in "stop & wait mode". In this mode the TNC can only service either the WA4DSY modem port or the: Mac port, but not both simultaneously. The honeymoon created by this ten-fold increase in performance ended abruptly when the second PI board came on-line. The (soon to be infamous) "flatlining" problem now began to occur [10]. This situation was created during ftp sessions between the two PI board users during which almost continuous DCD was observed. This created a band-width bottleneck between the TNC and the Mac in which the Mac (Mac+ with 25Mhz 68030) would stop dead for up to five minutes at a time while it serviced interrupts from the TNC. When this first started happening I thought my machine had crashed! A solution was clearly required.

The Second Configuration

After discovering the flatlining problem, I realised I needed a packet switch to filter out all of the traffic that was not directed to me. It was only logical that with new hardware should come newer software. I evaluated Intercon's TCP/Connect II™ vl .O. 1 & v1.0.7. Version 1.0.1 provides a debug window which proved to be quite useful for monitoring system performance. Unfortunately, it is not present in version 1.0.7. TCP/Connect utilises POP (post-office protocol) for supporting E-mail. After several attempts to test Intercon's POP client with NOS, the results are still inconclusive. It should be noted that the KA9Q SMTP (simple mail transfer protocol) implementation in NET/Mac worked very well. A new graphical mail browser written by R. Taylor KA6NAN provides an excellent user interface. NET/Mac's lack of support for cut, copy and paste between session windows (except for mail) and the absence of standard terminal emulation with cursor positioning has limited its usefulness with Unix. Memory usage by NET/Mac is 600k bytes under Multi-Finder vs. TCP/Connects 1.8 Mbytes. These heap sizes were found to prevent system crashes during continuous operation of days at a time while allowing a complete exercise: of features and facilities. TCP/Connect's support for NNTP is superlative. The client can be customised for font size and type in all three panes of the browser window. It's even possible to cause the subject field of the message text to appear in bold!

Tests were conducted with a server running on a Sun-4 with subscriptions available to over 1200 different groups.
The ftp client is also graphical and provides an intelligent interface to its service. The configuration palette provides a quick and intuitive setup. Telnet support provides a complete set of terminal emulations for DEC, Tektronics and IBM. Finger is supported via a server only. In all cases except **SMTP,** where **TCP/Connect** did not provide support for a service, the **PackeTen** did. The mailbox feature of the **PackeTen** is accessible via telnet with an escape to the NOS console supported for remote administration. The **PackeTen** firmware was found to be of adequate quality. A problem setting the SLIP data rate at any speed other then 9600 baud, is expected to be fixed in the next release of the firmware. During the initial **(mis)configuration** of the **PackeTen's** 2k EERPOM some crashes were experienced. The following configuration information has run the **PackeTen** for weeks with-out a crash:

```
Hostname: switch.ve3ocu.ampr.org
Site Alias Name: OCU-SW
IP address: 44.135.96.13
AX25 mycall: VE3OCU
attach asy 0 slip sl0 2048 1536 57600 [44.135.96.13]
route add [44.135.96.12] sl0
Sysop password: NotReally
Additional Command List:
0: attach sync302 1 hdx ax25 ax0 2048 2048 0 ext ext
[44.135.96.13]
1: route add [134.117]/16 ax0 44.135.96.35
2: route add default ax0
3: ifconfig ax0 mtu 1536
4: param ax0 0 15
5: start telnet
6: attach netrom ; start netrom ; netrom interface ax0
600C 190
7: start tty ; domain addserver 134.117.1.1
8:
[illegible]
[illegible]
11:
```

Cost/benefit

The cost of the DSY Modem is minimal when compared to the increase in performance. By investing more in equipment, real-time, high performance advanced CMC applications will become possible. This might include multi-media E-mail complete with full motion video. Or even more exciting, Virtual Reality experiments. Remember, the WA4DSY modem is already 10 times less expensive then a typical 1200 baud packet station if you factor in performance. About $700 for 3k bytes/second vs. $230 for 100 bytes/second. Of course, the PackeTen and any additional software will increase the cost beyond that of a basic station. Why be "penny wise and pound foolish" when the price/performance ratio of higher speed Packeteering makes the extra cost of upgrading so palatable?

Future Directions

With the addition of an Ethernet interface for the PackeTen, the SLIP interface could be discarded. This would then completely integrate all of the native Macintosh networking resources available through Apple's Communications Tool Box while still supporting AX25 in the PackeTen. Such a configuration could provide distributed file system experimentation. Support is already available through Intercon's NFS/Share™, a Macintosh NFS (Network File System) client. Also, either White Pine Software or Apple's X-window server could be used to gain access to any X clients such as the XRN newsreader or XMH, a graphical version of the Rand Mail Handler. It should also be possible using Multi-Finder to simultaneously run the Macintosh version of KA9Q's NET via a SLIP interface to the PackeTen. This would provide SMTP service albeit, via a separate IP address. This would still leave the second serial port available on the Mac for experimenting with Timbuktu/Remote via the console port of the PackeTen. Timbuktu/Remote is a utility that allows complete remote control of a Macintosh. It is expected that the presently available software will create an acute need for the extra speed afforded by the inexpensive digital microwave transceiver technology now under development [11].

Conclusions

"...everytime you make an amplifier for a deep human need, you have a winner regardless of whether it has ever been done before... " Alan C. Kay [12]

Warren Toomey VK1XWT [13] has suggested that "...papers involving digital radio communications may be useful in swaying the minds of some of the Universities who control Internet access.", noting also that these papers might "place amateur packet activity on a research footing". Based on the results of my experience with both the amateur radio and University communities, fostering such cooperation is a real possibility. The challenge for builders of amateur packet radio networks is to realise a fully connected class A intemet capable of maintaining a minimum quality of service. This should involve an organised effort to interconnect more users of the .44 intemet address space.

I hope I have suggested the scope of creative and cooperative projects that can be undertaken on a network of inter-operatable hosts and clients, distributed between amateur and academic computer networks.

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