An Update on TexNet and the Texas Packet Radio Society

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Abstract

This article shows the current status and updates the progress and accomplishments since the last published article in 1990 [l], of Texas Packet Radio Society, TexNet network, and other projects. The topics for this update cover the growth of the organization, the expansion of the network, the reliability aspects of the network, the latest firmware, and continuing projects.

Texas Packet Radio Society

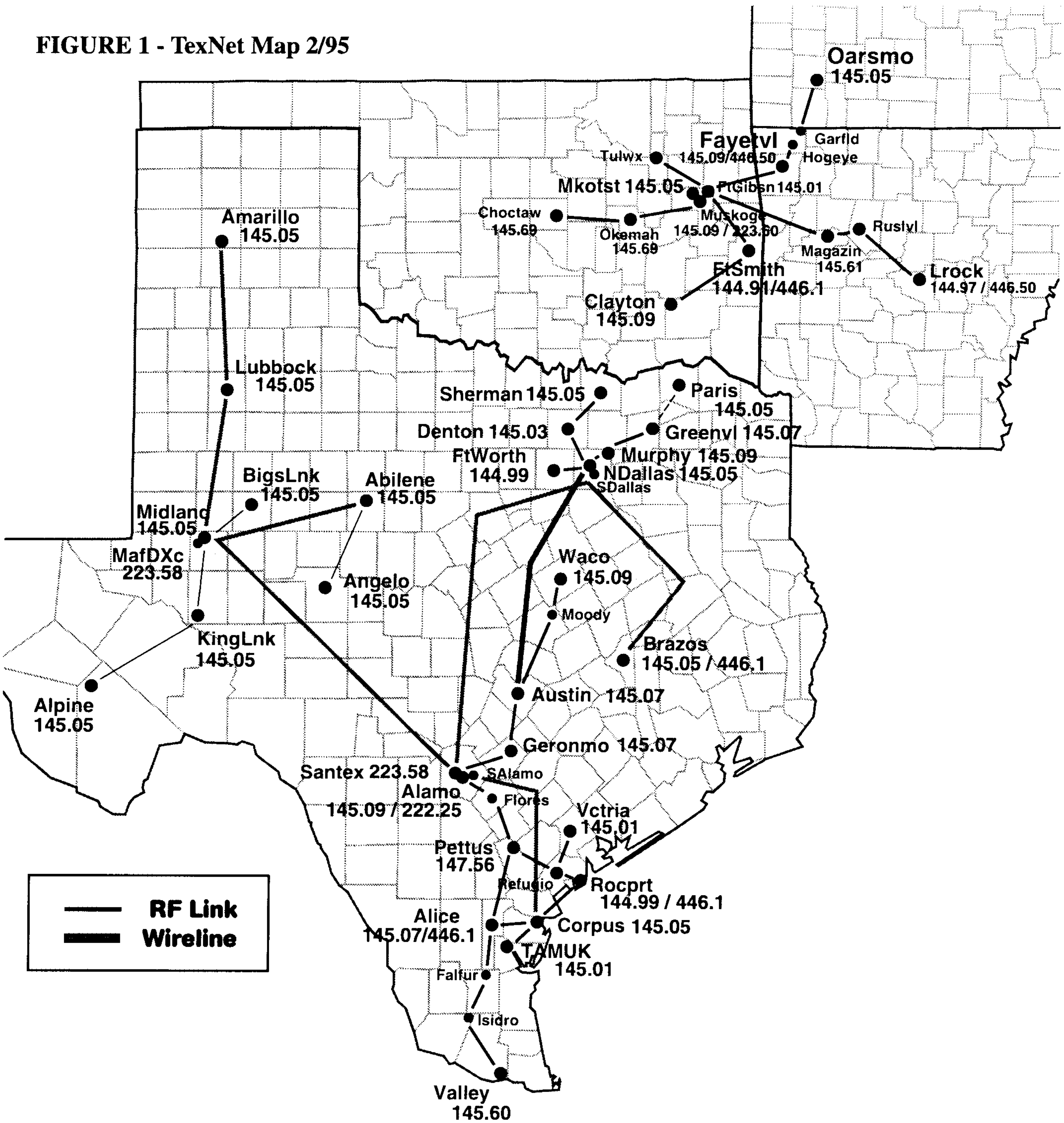
TPRS was founded in 1985, and incorporated in 1986 as an educational, public service, and scientific research non-profit corporation. The Texas Packet Radio Society's goals are: 1) design and research amateur radio packet networks, 2) provide education in the area of general packet usage, and 3) provide an emergency communication service network. The organization has members throughout Texas, many states, and several foreign countries and has had good growth since 1990. Membership in TPRS is now above 500 members.

TPRS itself does not support individual nodes per se, except for a few exceptions, like NWS, which serve the whole network. Individual nodes are the responsibility of local support. TPRS does arrange for support of certain projects (such as donated wire line or facilities) which are used to tie critical parts of the network together. This approach has been very successful in network management. In addition, the level of expertise required to build, install, and keep a network node running has provided a level of selection that has proved beneficial.

TexNet Network Expansion

Figure 1 shows the TexNet network map, which has now grown to include four states. The northern part of the network reaches into Missouri, in the vicinity of Aurora in the southwest part of the state. The network has also pushed all the way northeast to Little Rock, Arkansas, and northwest to the metro outskirts of Oklahoma City, at Choctaw. The southern boundary of the network is the Rio Grande River in the Texas lower valley. Cooperating organizations in adjoining states supporting this network include HogNet in Arkansas, OARS in Missouri, and WopNet in the Valley of Texas. Individual nodes are supported locally by individuals and organizations, and TPRS performs network administration, coordination, and management. Nodes continue to be added from time to time, and further expansions are being planned or are under construction. Approximately fifty full time service nodes are on the air at present, with a few more used for development, testing or construction.

FIGURE 1 - TexNet Map 2/95



Mileage spanned by the network trunks is phenomenal for an amateur packet network and breaks down as follows:

UHF RF amateur radio 9600b fsk	1559 miles	53%
VHF RF amateur radio 1200b afsk	147 miles	5%
Donated carrier wire line	1253 miles	42%
Network total trunk mileage	2959 miles	

The above mileages are point to point from site to site statute miles for active operating sites, as of 1995. In the case of the donated wire line circuits, city center highway mileages were used, and the various carriers deviate from these paths considerably, making the actual circuit mileages higher by some uncalculated amount. The network includes metropolitan coverage into three state capital cities - Austin, Texas, Little Rock, Arkansas, and Oklahoma City, Oklahoma.

End-to-end turnaround time from opposite ends of the network (800 miles), during times of relative network inactivity and smooth operation, are on the order of 15 to 30 seconds. Anything in excess of about 90 seconds indicates a problem in network operations. The network is not immune toproblems of various kinds. Tom McDermott, N5EG, has gone into detail about the reliability of hop-by-hop networking with networks of smaller size and fewer nodes [2].

The user base of TexNet is composed of BBS forwarding, DX Cluster interconnections, real user-to-user keyboard contacts (some of which may use a network conference bridge), message servers for network users, Skywarn spotters and local EOCs, and network experimenters. The higher speed trunking (9600 baud) allows actual keyboard user contacts over wide distances. One of the reasons for the long standing decline and disuse of packet for keyboard contacts are the long response times typically observed on packet across the nation. I have personally participated in keyboard contacts spanning 500 miles or more on TexNet which were conversational and not painfully slow.

Network Challenges and Reliability

The usual challenges and setbacks in operating a network are the month-to-month repair of occasional failures of nodes due to catastrophic events such as lightning damage, or moving of nodes from one site to another in search of more amiable "landlords." TexNet has had problems keeping a site active in order to extend the network between Oklahoma and Texas across the Red River. For over the last year, the north and south parts of the network have had to operate independently until a new network site can be located and brought on-line. Sometimes, we lose a site here and there, and have to regroup and look elsewhere. Meanwhile, the network is broken in the middle. So has been our luck over the vears at the small minoritv of sites where we have had these problems.'Overall, we have enjoyed a good-record of keeping all of the sites intact, and some lesser degree of luck at keeping lightning and surges out of the equipment.

A major disturbance to network operations that occurs from time to time in South Texas (San Antonio, Texas south) is the operations of airborne radar. The 70cm amateur band is a secondarv allocation for amateurs with the prim&y allocation assigned to government radiolocation. In this case, this takes the form of the airborne radar being used in the last few years to intercept drug smuggling in the Gulf of Mexico. From time-to-time on an intermittent basis, this portion of the network is interrupted by radar interference. Most of the time the network stays intact, and only a minority of the time is the network affected.

Another factor in network performance is maintaining the trunk radios on frequency. Network operators have done a good job of putting 9600 baud FSK into the field and making it work well, which it has most of the time, since 1984. The one detractor from that, which has earned the network a "fragile" reputation, is keeping the UHF radios inside a very tight frequency tolerance. Network node owners have to keep their radios on frequency with a lot of sites and few site visits to spare each year. Thus we expect the network to hold up through both summer heat and winter cold at some sites.

We deal with a signal that is almost too tight for the I.F. filters in the radios to pass. It does fit just fine if the radio stays within a few hundred cycles of where it is supposed to be, but this is a tall order at UHF and requires tighter tolerance than the equipment was specified for when it was designed for two-way voice service. Throughout all of our design and construction we have resisted the urge to remove I.F. filters, as some 9600baud conversions have done, because of the introduction noise. We know from experience that the network runs very well if the frequency is kept under control.

Yes, we DC couple, all the way from the modulator, through the transmitter and the channel and the receiver, through the modem to the slicer, for a better error rate. This does place more stress on the frequency control. As long as the node can hold frequency, the result is a better error rate at the slicer. Note, that in contrast to some other 9600baud packet methods in use today, TexNet uses pseudorandom scrambled NRZ, as opposed to NRZI, for tighter bandwidth, which does allow the network to achieve excellent performance with existing narrow filters with the commercial 5 KHz voice deviation two-way commercial land-mobile radio equipment being used. Deviation for data is set to approximately 3 KHz.

We have found it necessary to "age" brand new crystals which we receive from reputable suppliers. This was never much of a concern with the same equipment and suppliers in voice service. There has been some debate concerning whether the manufacturing practices of the crystal industry have changed in the past few years, possibly due to such things as solvents being discontinued and the like. New crystals are operated at elevated temperatures for a few days or weeks prior to installing them, and even then we see drift in the first year of operation, usually requiring readjustment at varying intervals.

In an effort to find a better solution to frequency control over the winter season change, it was found a one component temperature regulator (the positive coefficient thermistor) would work when attached to the crystal can or the channel element. When fed with 12 volts DC the thermistor holds the element within a few degrees of approximately 30 Deg. C. Most of the main trunk radios in Oklahoma now have them and have shown good results.

Network Radios and Modems

Over the past few years, our technical developers have experimented with various surplus two-way radio makes and models to see which are most suited for use in 9600b FSK service in the remote site environment we frequently encounter. The original surplus radio of choice was the RCA model 706. Since then, we have tried several Motorola, GE, and Johnson models. As a general rule, we have found a true discriminator to be superior to anything using a quadrature detector, and we have found some quadrature detectors to be better than others. The radio of choice in the Oklahoma environment has become the Motorola Micor. The Motorola Mocom-70 has seen some use also. The Johnson 6060 has seen some use in Texas. We have had some reliability problems with the venerable RCA-700, due to the failure of some PA components for which replacements are not available. Some of the newer model radios we have tested have a coupling capacitor downstream of the detector, and we find these models to be problematic with end-to-end DC coupled network.

We use one, and only one, RC time constant in the entire FSK signal path, and it is in the slicer of the modem receiver, and its time constant is optimized for the time required to acquire the received packet's DC center. Any other unintended series RC circuit along the way contributes to baseline "wander," and ultimately to receive errors. Any RC network which is part of an original voice radio design is almost certainly NOT optimized for the proper time constant anyway. Very recently, Tom McDermott, N5EG, has developed and is testing a newer improved slicer, which is a lot faster and more accurate than the one we now have. It seems to be a promising development. If successful, it will take the form of a daughterboard for the existing TPRS modem. It locates both extremes of the received signal eye pattern, and sets itself midway a lot faster than the older, simpler RC averaging comparator. It might allow the network to operate with a shorter TxDelay timer.

Network Code Continuing Development and Revisions

Version 1.6x was just coming into use at the last CNC report in 1990 [11. This version was our standard firmware on the network from 1990 through 1993, and was a pretty well behaved product. This version of the code showed excellent performance and reliability. Previous versions were subject to dropping into a state of disconnection when the network was idle. Currently things stay connected as long as the path is there. Unfortunately, it works too well at times. During times of abnormally long range UHF propagation (up to 500 miles in one hop), the network forms rogue routes which do the network no good, and of course, don't last. They certainly disrupt the shortest path algorithm and leave the routing tables in disarray. This phenomenon continues to the present, but we are on the verge of solving most of this problem with the next version (v1.72), currently in distribution.

Version 1.70 was introduced in 1993. Primarily it is version 1.6x, with the routing tables expanded from 50 nodes to 90, and a few cosmetic changes. Version 1.71 was almost the same, but had a minor bug fixed with the DWAIT timer, and allowed for improved performance on shared channels, such as a multidropped wire line circuit we use in West Texas. It has all of the characteristics of the 1.6x versions when it comes to adaptive routing and the corruption of its tables when the band opens. Another change is that the NCP and TNC-2 versions of the code are now handled as a pair of similar products, and are updated together. This overcame a time lag we had prior to that in distributing the TexLink (TNC-2) revision when revisions were made to the NCP version.

Version 1.72 has just now left the testing stage and is being installed throughout the network. It is one of the biggest revisions to TexNet in years. It will soon be in distribution through TPRS and TAPR libraries. Here is an overview of what this software does.

1. TexNode. There is a brand new TexNode service. This is a local node, which is a connected alternative to digipeating. It fills in a gap in TexNet which allows stations which can both hear and work TexNet on the same node (not necessarily on the same physical port or frequency) to work each other without digipeating through the node. The TexNode is accessed by connecting to the node's -1 SSID, which is new. The TexNode is still new and experimental. It may have some problems with flow control. Experience and use will show what its shortcomings are and how to solve them. It will probably need to be fixed at the next opportunity for a revision.

The TexNode provides three pairs of connects for locals to use to connect to each other, without the drawbacks of digipeating. Please note that digipeating was originally invented in the early days of AX.25 as a temporary stopgap to produce some extended range connectivity while waiting for layer 3 networks to appear, which of course, they have now. Digipeating has drawbacks which have been discussed many times, and has been discouraged or locked out in some places [3].

There are a few nodes on TexNet which do not support digipeating for local QSOs, and as this local node service is expanded (and any bugs fixed) there will probably be more digipeating discouraged or locked out.

2. **Weather Alert.** There is a weather alerting service which is allied to the Weather PMS. A PMS, or packet message server, is a message server integrated within TexNet, and will be explained later. The Tulsa PMS is now generating a UI broadcast on most of the NE Oklahoma TexNet ports every time a type “S” or severe weather message is saved to disk from the National Weather Service (NWS) input.

The UI that is sent on all ports of the network includes a bell, and includes the heading, and the first few lines of the message - enough to determine the counties of interest. It is sent from an alias callsign of “ARES”, and anyone wanting to monitor these can put ARES into their Budlis t.

These broadcasts can also be initiated manually by a station with sysop privileges, such as a net controller to announce a net activation. The network can be internally partitioned to limit the geographical distribution of these broadcasts. Presently the only partition is at the Red River into Oklahoma.

There has been some addition to the Weather PMS input handling, and it is now feasible with standard code to upload the raw weather source from one site to another, where a PMS can be located remotely from the source, or to relay input data from one PMS to another. When we consider sites for weather PMS input, this feature needs to be considered. It is possible now to use a TexLink node (the TNC-2 with a TexNet EPROM) to act as the uploading input node, whether or not it has a disk drive. Of course, the standard NCP or possibly the NCP-PC may be used. Presently, there is some fairly widespread investigation behind the scenes to acquire more weather input sources, using the highly successful TULWX Tulsa, Oklahoma site as a model [4]. The Texas network went through spring storm season without a Texas weather PMS, as we lost that site at a critical time.

3. **New Internal Datagrams.** There are a few new internal datagrams to support new functions within the network, and one new network information code, NIC-22, which users may encounter from time to time during routing errors.

This particular error comes about as a result of a datagram propagating through the network and encountering a node which has no knowledge of the return routing for that datagram. It now generates an error which returns on the same channel it was received on, directed back at the source, while the return channel is still known. Previously, there was no check, and a deadlocked condition existed when the response could go no farther on the return trip. In addition to the error completing the “response,” the receipt of the error automatically issues a routing correction to the node finding the error to begin with, so that subsequent uses of that route will be successful.

This release adds some major internal modifications and tuning to the basic routing. The routing methods themselves are unchanged, but it is much easier for the routing manager (i.e. Harry) to maintain the system. He now has the capability to edit any route table, whereas he used to either use a sledgehammer approach, or execute cumbersome memory changes. The release also addresses the root cause of many of the routing corruptions, the unwanted trunk paths during band openings, by limiting the formation of such paths in the first place. When 1.72 is fully installed over the network, expect that there will be fewer corruptions.-The ones that do occur will be mucheasier for Harry to fix, so the network should run better more of the time with less of his attention. This software also implements a remote function needed by the automated NetMgr (a Cardnal function) to perform automated routing management in the future.

4. **Remote User Listing.** There is now a Remote Users listing command. It displays the stations connected to a remote node (presently it does not support the local ncp), and displays some numeric information which can be decoded to reveal which L3 service the user, or trunk, is on, what the L2 state is, and some allied information. It displays both users and other connected trunks. It is useful to both users in general to find out who is on any node and to network sysops to determine the status of trunks.

5. **Improved Local Console.** For those node operators who have terminals installed on the local port of the node, the terminal port has changed from 7El to 8N1, and some bad behaviors of the Console program have been fixed. The input line will no longer force back to command mode if too long a line is typed. PTRACE has been extendevd a little bit to include hex dumps of some of the datagrams, recognition of NetMgr datagrams, and a bad bug fixed which locked up the works from time to time. For those operators who have their node implemented on an NCP-PC card, the console port may be operated over the bus instead of through the serial port, via a supplied INT14 TSR.

6. **New Stats Display.** Information has been added to the node statistics display and the format is completely different, and does allow for it to fit on a screen. However, an unfortunate result occurred and the date now appears in an insane format. Due to code space problems, I'll apologize beforehand for the unfortunate result. With the exception of the screwy looking time/date, it is a lot easier to read. Added information includes TX frames aborted, the revision level of the software of the node, the CPU effective speed raw data, a ROM checksum and the dates/times of initial powerup and subsequent firecode and warm boot restarts of the node. One good result is that no longer does one have to multiply some numbers by 10; they are displayed with a trailing zero so you only have to read the number. Another good result is that the amount of program memory occupied by the statistics routine was cut in half and left room for some of the new features of this release.

7. **Network Path Locking.** The algorithm implemented in ~1.72 follows a general trend that has been seen in other packet networks of route locking, or more accurately called PATH locking. The routing tables in each node are available at all times for updates by the shortest path algorithm. What is locked out is the formation of temporary shorter paths at layer 2. This would seem to be at odds with a system developed over the years for automatic addition of new nodes to the network. To allow for the addition of new nodes (or old nodes out of service for an extended time), there is a way around it - the 15 minute timer. Since v1.6x, all nodes broadcast their existence to the world every 8 minutes, inviting any TexNet node hearing the broadcast to connect, new nodes or old nodes, close or distant. An exclusion list of up to 5 nodes is sent along with the invite. If the two nodes are not on the exclusion list, ~1.6~ allowed the connect to be made, whether it was 500 feet or 500 miles. Whether the nodes were intended neighbors who had briefly lost connection, or distant and unrelated to each other, was irrelevant. This scheme has done a good job of maintaining the integrity of the connections

we wanted, but also opened up a lot of transient rogue paths during band openings, often short-circuiting the distance counts in the tables by 5 or 10 hops, which destroyed the intended stable routing. Version 1.72 now excludes new paths which are not shown as direct neighbors in existing routing. The exclusion is inactive for 15 minutes after a node is reset and started UD. The 15 minute timer may also be started and stopped remotely by an existing manual remote control command. This is one of the means by which a new node can be added to the network. The other means is to manually insert the required entry in the table.

Network Code Testing and Future Directions

This software was extensively tested in ALAMO, one of the highest traffic nodes on the system, for a couple of months prior to releasing it. Thanks to Harry Ridenour, NOCCW, and Clarke Diekmann, K3WGF, and all of the local and remote users of ALAMO who got bumped off in the process of debugging, for seeing the process through. ALAMO was chosen because it is easily accessible to swap eproms, in addition to being a high traffic node, and also to give Harry the earliest access to the new route editing functions. It was also tested on TULWX and neighboring nodes in NE Oklahoma. As of July 8, it was installed in ALAMO, SANTEX, SALAMO, FLORES, ALICE, WACO, TULWX, LROCK, MAGAZIN, FTSMITH, CLAYTON, FTGIESN, MUSKOGE, MKO'IST, DENTON, SHERMAN,MURI'HY,GREENVL,AUSTIN, AUSDXC, and GERONMO, and is ready for a few more. I have e-mailed a copy of it to Jay Nugent for GL-NET to start using.

This software is available in both NCP and TNC-2 versions, as were 1.70 and 1.71. In addition, it is easily adaptable to creating a specialized weather PMS, such as TULWX, without many changes other than preparing the weather product database. Previously, a weather PMS became almost a separate programming task, and this is less true now. As in 1.70 and 1.71, the software supports 90 nodes per network. I estimate that I spent 300 to 400 manhours on this release and it was a major undertaking. Some of the route management improvements are items I have been thinking about for the past four years or so,, as I have watched the network routing get corrupted myself, and listened to Harry's observations also. Most of the weather PMS improvements came out of a meeting held at the Green Country Hamfest in 1994 and some more came from Steve Piltz and Brad Smith in Tulsa.

I have plans for a subsequent version. Some of the revisions I would like to add would require that all Eproms on the network prior to 1.72 be replaced with 1.72, since I foresee some incompatibilities being made. My biggest reason to want to get 1.72 installed quickly is to solve our routing corruption problems, and those sites experiencing unnecessary trunk connects during openings are the prime priority. The downside to future code development is that about 30 bytes of space is left in the NCP Eprom, so there isn't a lot to work with. Some space will come from shrinking existing programs by either eliminating lesser used functions, or from time consuming recoding to make the code shorter. Some of the new features have actually been implemented by programming tricks which resulted in shorter code. There are also efforts underway to integrate and/or supplant this code with a TCP/IP interface to extend the range and the lifetime of the existing and growing network.

Network Code Development

The code itself is written in multiple linked modules of Z80 assembly language, using a native CP/M assembler/linker running as a CP/M program under ZSOMU,, which is a 280 emulator and CR/M emulator running under DOS on a PC. A complete assembly and link process can be performed in about 20 minutes on a fairly fast 386 system, producing a generic binary load of either the NCP or the TNC-2 code. We then use an editing process to perform a binary edit to customize an image for any particular node, to add its callsign, net ID, parameters and so forth, and all of that is burned into an eprom. Except for abnormal operating conditions, no further entering of parameters is required after the node is started up.

The NW-PC and NetMgr Projects

The NCP-PC project continues, although no more kits are planned. The NCP-PC is an I/O card for the PC, which includes the cpu section, less modems, of the TexNet Z80 NCP, and behaves as a very loosely coupled coprocessor. It behaves as an EPROM to the 280, since writes are inhibited from the 280 for that portion of the memory map. It is entirely RAM and can be written by the PC at random. It makes a fine development system, since the step of EPROM burning is not needed. All of versions of 1.6x and 1.7x were developed using a NCP-PC. While it doesn't emulate a TNC-2, the only differences between the TexNet NCP and TNC-2 code are the number of serial ports, differing addresses, differences in the memory boundary between EPROM/RAM, and the presence of a CTC chip on the NCP or NC&PC. These differences are allowed for in the conditional assembly of the standard software suite for both products. When acceptable code for the NCP is achieved, the conditional assembly is rerun for the TNC-2 product, and burned into an EPROM and tested conventionally in a TNC-2, usually with no surprises. The TNC-2 code has in fact been released in finished form under 1.70, 1.71 and 1.72 without further modification.

The automated NetMgr (Network Manager), a NCP-PC project kept on line co-located at the Murphy node (the town of Murphy, Texas, not the errant destroyer of mankind's engineering achievements by the same name) continuously monitors and logs network activity. This information is then analvzed to determine potential network problems. There has bien slow progress made on the automated route management R&D phase of this project. The release of ~1.72 added a needed inquiry function to help facilitate that project. The eventual goal of the project is to have all automated route management handled by the Network Management system. The statistics it generates enables better manual routing maintenance to be performed, than would be possible were the statistics not available. In defense of the goals of automated NetMgr, it should be noted that the energies of the developer (Tom McDermott, NSEG) were diverted to not one, but two DSP projects. The first being the TPRS DSP land-line modem and the second one being the TAPR/AMSAT DSP-93 project. The NetMgr is still functioning at ~1.6~ and there is some programming effort planned in the near future to bring this one node up to current. That is expected to be a minor job, but crucial to NetMgr's operation.

Network Administration

The network still relies on human beings to perform network routing management manually. This job is being made easier under ~1.72 with a remote route editing command. This manual command makes use of some logic added in ~1.6~ to allow for the automated NetMgr to add and change routing remotely. At that time, we had no manual means to do so, other than a remote memory patch, or to selectively announce or reset nodes to reinitialize the autorouting. This follows the general trend of all automation, that the human is still sometimes not replaceable, but some of the drudgery can be automated, leaving the human to take care of the exceptions. Goals in ~1.72 were to reduce some of the extraneous inputs which disrupt the routing in the first place, to give the human manager the editing command he needed, and to add the missing inquiry function that the automated NetMgr needed. Eventually the NetMgr can take over some jobs from the human in the future. It should be noted that we are blessed with a human net manager, Harry Ridenour, NOCCW, who spends some time every day watching over the network and seeing to its integrity. A lot of the things he does are not of the nature that can be automated. These include coordinating with site owners for site access, wire line troubleshooting, arranging new site installations, and handing out new node numbers. The new network remote function allows the network administrtor to easily change network routing information from anywhere on the network, thus creating more time to devote to other tasks.

TexNet enjoys an environment of administered planning. Our administrator governs the distribution of node numbers to sponsors who fit into an overall plan for a network. It is not a network that expands and contracts on a cyclic or a whimsical basis. We know in advance when a node will be added or repaired, and can make the necessary commands to the system, to either preinstall the proper entry in a routing table, or start the timers at the proper time. We have learned very well not to bring up or reset new nodes during band openings, and if we have to, how to get the route tables into a proper state after we have done so. Version 1.72 will make this job a lot easier. We anticipate development of some automated NetMgr algorithms and eventual auto routing control.

Other services provided by the CARDNAL node include a multiuser file server, an amateur callsign lookup database based on a CD-ROM callbook, an ARRL bulletin capture system based on reception of the AMTOR-FEC bulletins (retaining the most complete recent copy), and a network wide conference bridge. The file server is also the delivery vehicle for the ARRL bulletins and the NetMgr statistics files, in addition to other files loaded to the system by the users or the host.

Other TPRS Projects

TexNet has several donated land line circuits that make up some of its routes, although TexNet is primarily an amateur RF based network. We have access to 200+ miles of point to point circuits which are used, from various land line commercial providers, for nothing but our good will, a smile, and probably our tax exemption number.

Land-line circuits are an integral part of the network, since ninety miles on a calm damp evening is the best intermittent RF circuit we can boast of, or 65 miles if you want a "reliable" RF circuit. Without these long-haul paths in the network, several sections would be unattainable as network paths (i.e. trying to find enough amateurs between Austin/Dallas/San Antonio and the West Texas cities to support nodes).

Surplus GDC 209 synchronous modems are used to drive these land line circuits. Due to reliability problems with the GDC modems, a project was started to design a modem that would give us the necessary interface as well as provide. needed monitoring and testing functions. Tom McDermott, NSEG, set about to solve two problems with this modem with a replacement based on current DSP techniques. The first goal was to put a reliable modem into service. The second goal was to speed up the circuits we were using them on, because the 209 standard has an abysmally long training sequence which it must perform on each transmission of a multidropped circuit. While it is 96OObaud, the txdelay required to support the modem training sequence is about 400 mS. In most cases, this is longer than the packet itself, and certainly so for the acks and supervisory packets. These circuits have a real throughput problem even when the modems are in good shape. Tom has designed and tested a prototype replacement which will emulate the constellation of the 209, and can either emulate the training sequence, or use an abbreviated training sequence which is based on recognition of previous recent transmissions of the various modems operating together on the circuit. The design includes remotely commanded diagnostics and remote level adjusting software, designed to work on an entire circuit of modems from onlv one end. These remote diagnostics features allow one network manager at a site to test all land-line modems without requiring operators on both ends of the circuit. Oftentimes on our freebie "leased" circuits, we never have the luxury of a technician on each end of a circuit under maintenance, and this software should solve that problem. In the past, trying to arrange access to sites at the same time-for end-to-end testing has proved an impossible task.

Current status of the new modem is that boards and parts have been gathered and are awaiting to be built-up for installation in the next few months. Withluck, this new device will improve performance and reliability on our land-line circuits a good deal.

Conclusion

TPRS and TexNet are alive and well and continue to develop and expand. We hope to be able to update their status many more times in this venue in the years to come. The success of the design of TexNet can be attributed to: higher speed trunks, separated user and trunk channels, low network-ip overhead, low installation cost per port, tight trunk bandwidth with low error rates, network planning/administration, and multiple applications available via the network to the user population.

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