

NODE NETWORKING

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ABSTRACT

With the advent of NET/ROM (tm) Software 2000 Inc. and **NORD<>LINK TheNet** software, amateur packet radio networking became possible. However, some of the "factory standard" options in the software tend to limit performance of the **system**. This paper deals with **some** of the networking problems the author has resolved, plus **some** of the hardware considerations that were made in establishing and maintaining the authors' 21 transmitter interconnected node network.

INTRODUCTION

There were (and are) several **"players"** and prime movers in the N.E. Ohio Packet network, and certainly several interconnecting node operators who have joined us in what I believe to be the nations longest - "high-speed" (if you **can** consider 4800 baud as **"high-speed"!**), complex amateur radio packet network. The 4800 baud UHF backbone network as **itis** now configured, stretches from Cleveland on the north to Lexington KY (and perhaps beyond as you read this) **on** the south with branches extending into Fremont in N.W. Ohio and to Cambridge in S.E. Ohio. In addition, there are many collocated tributaries on other bands which extend the range and function of the network to many other locations.

HISTORY

I first set up a single NET/ROM (tm) node in Cuyahoga Falls, OH in 1987 and with some grief, was able to **"network"** to a few distant nodes, but the results were not always the best. As **my** enthusiasm for packet radio increased, so did my investment in packet radio nodes in several locations in N.E. Ohio. Before long, I had in addition to the node in Cuyahoga Falls (Akron ID), node sites in Mt. Gilead, Cleveland, Canton, Wayne County (Wooster) and most recently, Mansfield. It became apparent early on that we needed a better way to move traffic from city to city than on a heavily used **145.01** MHz. **"keyboard"** channel, so the idea of **"back-boning"** the data on a UHF **"trunk"** frequency was born, and implemented. Initially, our efforts on UHF were 1200 baud, but it soon became obvious

that we needed something faster. The 4800 baud H.A.P.N. modem boards were available and seemed to work with the radios we had and so, an upgrade was planned. We determined very quickly that mixing speeds on one RF channel was an invitation to disaster in terms of interference primarily due to lack of proper data carrier detection between modulation types, so the conversion to 4800 baud on the UHF backbone was accelerated.

Figure 1 shows the UHF portion of the Ohio Network as of July 1990.

HARDWARE SELECTION

One of the early objectives in establishing the network was that any hardware needed to be uncomplicated, easy to replace, connectorized, and interchangeable! To accomplish this objective, I chose the **Kenwood TM-221/321/421** series of radios as they were small, reasonably reliable, frequency agile (synthesized), and had the advantage of having fixed level audio available at the mike jack. This meant that we needed only one cable from the TNC to the radio, no pig-tails and no audio pots to tweak (and leave wrong!) The TNC chosen was the MFJ-1270b as it was the least cost TAPR-2 compatible TNC on the market. The TNC is very easy to convert for node operation.

At this point, with very few exceptions, the **K8EIW/WB8BII** network is modularized to the point that one spare radio per band and one TNC and one power supply is all that is needed to effectively replace any of the 21 nodes should there "**minor**" flame-out at any of the sites. As one who has been involved with repeaters from the very early days, it is certainly a relief to not have to disconnect and reconnect 20 or more individual wires to replace a piece of equipment!

NETWORKING PHILOSOPHY

The network as I have configured it consists of three basic elements.

1. User Ports.

First, users need access to the network. By tradition, most amateurs have started out on 2 meters with their **TNCs**, so the logical choice for a "**user**" port is on 2 meters.

2. High Usage Ports.

Second, there are some high-volume users, such as Bulletin Board/message Systems (**BBSs**), and **PacketCluster** DX message systems. As their usage is quite high, they would be an unfair user of the available channel time compared with the individual users. We encouraged the **BBSs** to utilize frequencies in the 220 **MHz** band to enter the network for **forwarding** purposes. I am aware of 9 ****Major** BBSs** and DX **PacketClusters** in N.E. Ohio that are making good use of 220 MHz. Are you listening, F.C.C.???

3. Inter-Node Trunks.

The third element, is the inter-node UHF backbone channel which is the main workhorse of the network.

Into this mix, we need to stir frequency selection of both the user ports and the backbone ports. This also affects one other **"little"** concept of reliability/redundancy vs. the problem of frequency congestion.

In N.E. Ohio, propagation and terrain is such that with a 6 element beam antenna on a 25 watt radio on UHF, we can expect a solid path between the node sites which are between 20 and 45 miles apart, and a **useable** path most of the time over a 45 to 70 mile path, which is about the distance between two non-adjacent nodes. For purposes of redundancy, I have chosen to put all UHF nodes on the same frequency, and by proper selection of the p-persistence parameter, have managed to get the nodes to **"live"** together very well. I have found that data transfer is greatly enhanced if a backbone node **"talks"** only to the immediate adjacent node in serial fashion as opposed to hopping over adjacent nodes. To add to the complexity of this situation, at **most sites**, I have a 220 MHz node and a 2 meter node that can also ****talk**** to the adjacent or perhaps the second adjacent node site. It is here that proper selection of node parameters becomes very important to the smooth operation of the network.

ROUTE QUALITY **VS** NODE QUALITY

Distant nodes often tend to **come** and go with propagation (and other reasons!), but an adjacent node, hence the ROUTE to that adjacent node tends to remain reasonably stable. If NODES are locked in the data base, it is not uncommon for routing loops to be established when propagation changes, and for whatever reason to not be unlooped when things get back to **"normal"**. It is for this reason that I have chosen to lock

the ROUTE values to known good nodes to a predetermined high value and to default itinerant nodes to some low value such that they will show up in a node and/or route list but not propagate through the network as a first choice route. This saves routing loops and at the same time, also gives the users some idea of what the band conditions may be (is it "up" or "down"?). Also, by proper selection of ROUTE values, the desired path value from any node in the network to any other node (user, high usage or backbone) may be preselected numerically, and will change dynamically as nodes or propagation changes without any human intervention. This means that if an intermediate node is "lost" due to a failure, the routing algorithm in the nodes will cause the routing to try the second choice route, which maybe either to "hop" the silent node or possibly to use an alternate frequency to get to the adjacent site.

The point of this exercise is that the node operator's first objective should be to get the data through on the primary route. Should the primary route fail, the second choice route should be a viable path, and if that has also failed, the third choice route is the last hope! This all needs to be done dynamically by the TNC processor and WITHOUT operator intervention. Proper ROUTE quality selection achieves this objective.

ROUTE QUALITY NUMBERS

One of the concepts that needs to be understood by node sysops is the concept of route quality. Basically put, there is an arbitrary "quality" value put on the path between two nodes by the node operator. The quality of a destination node in the originating node list is determined by an algorithm in the firmware based on the route quality. This number is calculated on receipt of each nodes broadcast. The networking routines will select the three best paths to be used in an attempt to establish an end-to-end connection. While the node operators can directly change the path quality to a specific node, it is usually best left to the algorithm to avoid path looping situations.

One of the objectives is to keep all inter-node traffic off the "user" or keyboard channels. By proper assignment of route qualities for adjacent and non-adjacent nodes, we can then determine what the path quality to the node will be, hence, its position on the path list. We can literally force the system to chose an indirect route from one node to another as opposed to a direct route by assigning higher values for the indirect "backbone" routes. In fact, this is what has been done in our network. A 2 meter node will actually chose to connect to an adjacent co-channel 2 meter node via the

backbone route, thereby relieving inter-node traffic congestion on the primary ****keyboard**** channel. Should there be a failure of the UHF links, the path quality algorithm can then permit a direct 2 meter connection, thereby providing redundancy of path. Likewise, if an adjacent backbone node site is completely disabled, the long-haul **logical path** can be maintained on the UHF backbone frequency from the first node to the non-adjacent node prior to the two meter path being utilized. To add complication to the **maze, in at least three locations**, we have a 220 MHz frequency **in use as well**. Once **again**, by proper selection of route qualities, we can force inter-node traffic to use first the UHF channel, then the 220 MHz channel, then as third and final choice, the 2 meter path, or perhaps a slightly more round-about path on UHF.

Figure 2 displays the model that I have developed for use in establishing Route Quality Numbers.

One evident fact is that all node operators need to have similar philosophies about **"DX"** nodes, otherwise convoluted unworkable paths WILL be set up during band openings.

OTHER CONSIDERATIONS

When establishing values for the parameter list, several things need to be considered. First, end to end connections over 3 hops seem to fail when there are more than about **70** nodes in the list. I am sure that the mathematicians in the group can define what that break-point is, but my experience says that anything over about 70 nodes in the list invites disaster. This is especially true if the user attempts the connect using the alias **as** opposed to the call-sign. If the node list is hard-limited by the parameter list to limit the number to **70**, a desired, working, in-use node path could **"fall out"** of the list when another node broadcast was heard and the list overflowed the in-use node out! Therefore, other means of limiting the number of nodes in the list needs to **be** made. I **have** chosen the minimum node quality parameter such that a full-time desired node will have a node propagation distance of approximately six hops. This is usually sufficient for most BBS and TCP/IP purposes. Intermittent nodes, ones that are present only during band openings, will NOT propagate past the initial node stack. This is done by selection of the default node quality (Parameter 3) to be 1 more than the minimum acceptable quality (Parameter 2). Parameter 2 is set sufficiently high so that desired nodes will appear but the number of **"normal"** nodes will not exceed the approximately 70 number.

There might be a case where a node is a **"desired"** destination due to its network function, such as a TCP/IP mail server for the region, and is more than six node hops from the most distant entry point to the network. In those **cases**, the node operator certainly has the option of locking that specific node **path** value to an artificially high value. In N.E. Ohio, I generally choose the adjacent node to **"boost"** the path quality of the **"desired"** node to a very high value. However, should the **"desired"** node be down for ANY reason, network routing loops **will be** set up and the **"desired"** node can expect several hours of no traffic upon its return until the entire network learns of its recovery and/or a sysop intervenes.

As can be plainly seen, path quality determination can be an extremely complex issue and becomes even more so as more nodes are established by more groups. It is certainly not an easy issue when all of the nodes are under one-person control, and is even more complex when there are as many node operators as there are nodes! What is needed is a generalized **"standardized"** list of parameters for use in a populated network. Perhaps the original **"factory standard defaults"** were a place to start, but they are absolutely unsatisfactory in today's environment. Other factors which play an important part in a well-functioning network include p-persistence, time to live, maximum node list, number and frequency of node broadcasts, maximum congestion thresholds, and the list goes on.

Suffice to say, the main objective is to pass the traffic presented in a timely manner with the minimum of congestion created internal to the network. If the nodes are able to communicate with each other on a non-interfering basis during any type of propagation conditions, then we have basically achieved the objective.

It is therefore with a mixture of pleasure and hesitancy that I am suggesting the following list of parameters in Figure 3 as a better place to start than the ****factory standard?** The hesitancy is knowing that there will be places and conditions that will need different **"numbers"**. I present them as what works in N.E. Ohio with our terrain and propagation conditions, and your conditions may vary **"from state to state, local laws prevailing?**

ACKNOWLEDGEMENTS

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Thank you one and all.

Ohio Packet Radio Network

Revised: July 9, 1990

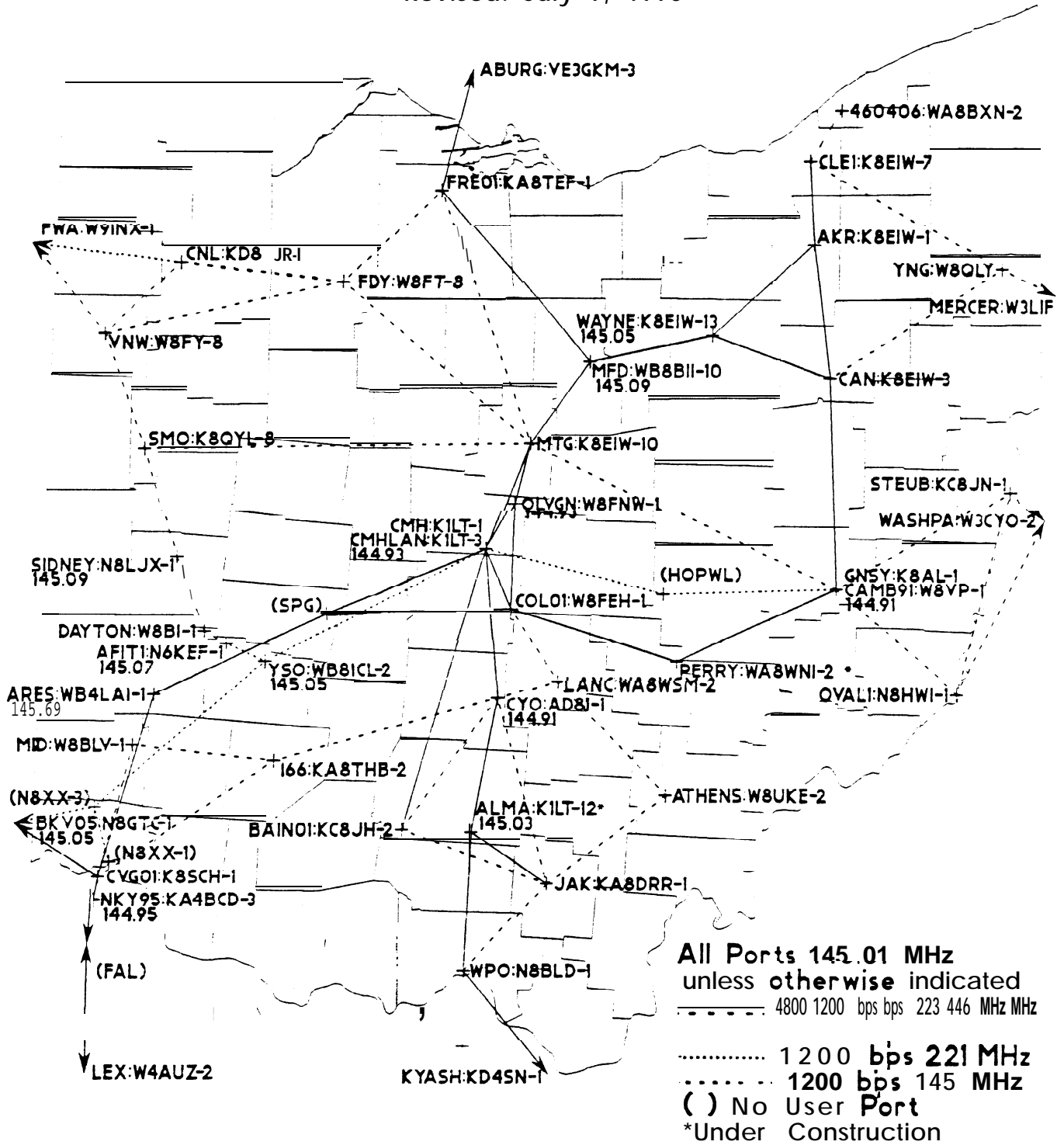
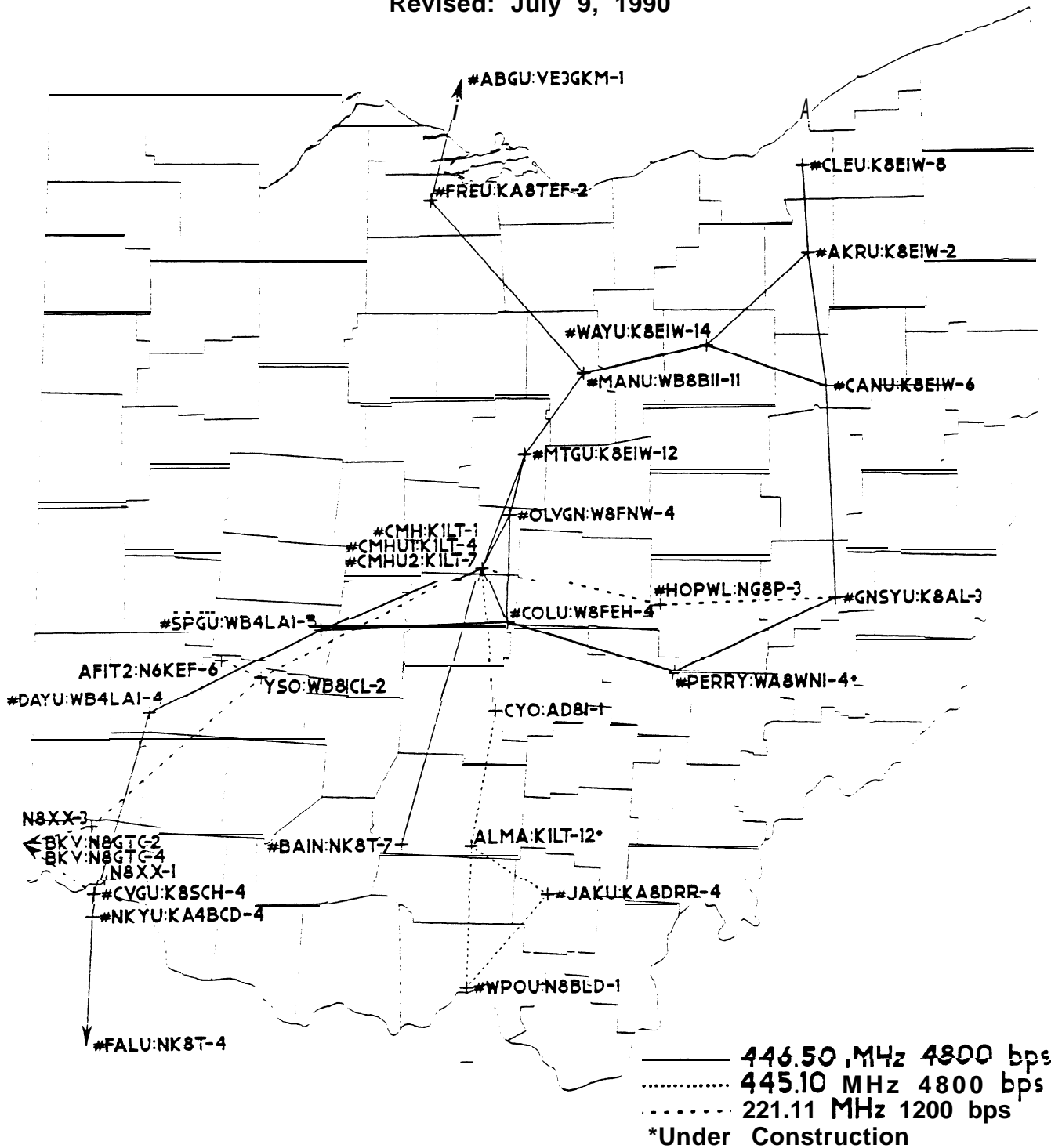


FIGURE 1

Drawn by KILT

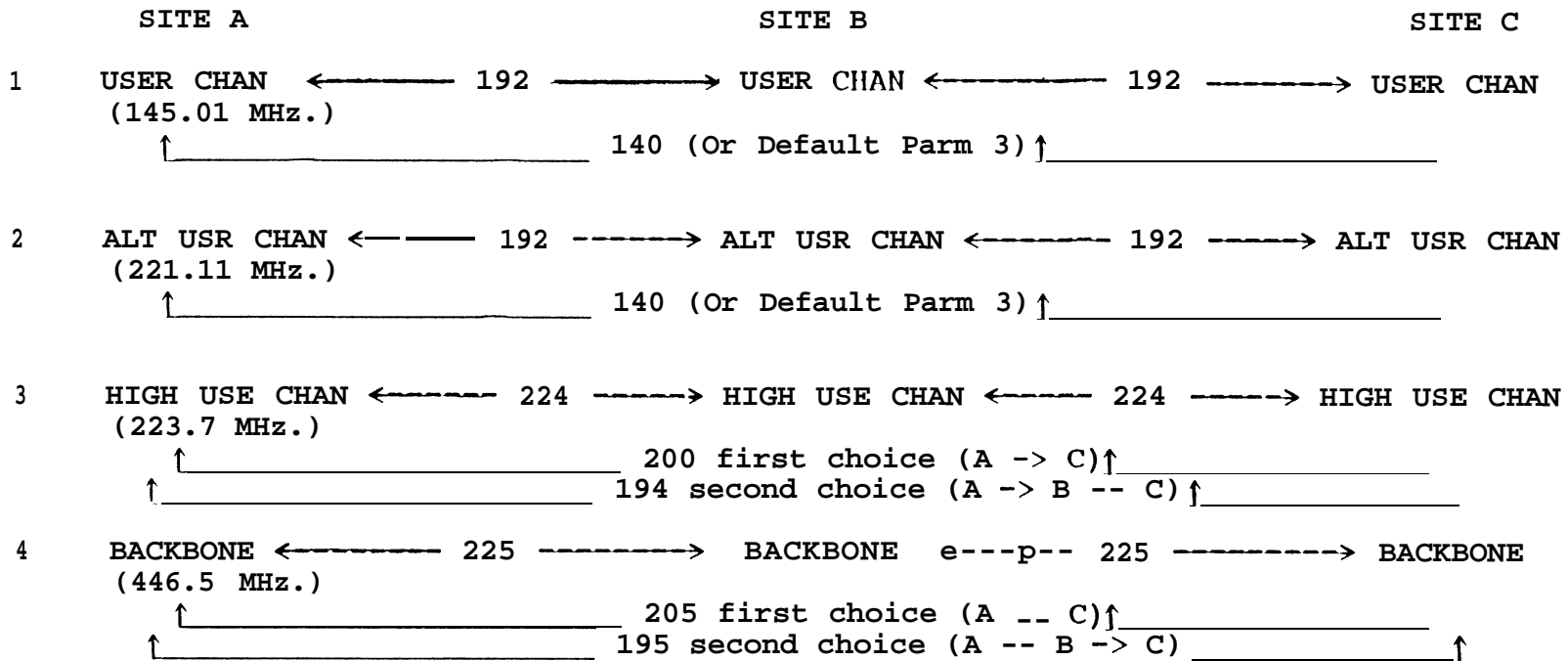
Ohio Packet Radio Backbone

Revised: July 9, 1990



Drawn by KILT

FIGURE 1A



PATH QUALITIES
(Within Node Stack)

(1 <- 2) = 246	(3 <- 1) = 240
(1 <- 3) = 247	(3 <- 2) = 248
(1 <- 4) = 248	(3 <- 4) = 248
(2 <- 1) = 246	(4 <- 1) = 248
(2 <- 3) = 247	(4 <- 2) = 248
(2 <- 4) = 248	(4 <- 3) = 248

e.g. at [1], R 1 [2] +246 at [4], R 1 [1] +248
 R 1 [3] +247 R 1 [2] +248
 R 1 [4] +248 R 1 [3] +248

FIGURE 2.

<u>No.</u>	<u>Description</u>	<u>Value</u>	<u>Comments</u>
1	Max. Dest. List	100	See Text.
2	Worst quality for updates	129	Set so that NodeList < 70
3.	Channel 0 default	130	See Text.
4.	Channel 1 (RS-232) Quality	248	See Text.
5.	Obsolescence Counter	6	
6.	Obs. Count. Min.	4	Insures Bdcast is not "trashed" 1st Time
7.	Auto Update Interval	1800	1/2 hr Helps Keep List "Fresh"
8	Time to live	15	More reasonable!
9:	Transport Time Out (sec.)	120	Give it a chance!
10 .	Transport Max. Tries	5	Give it a chance during busy periods!
11	Transport Ack Delay (sec)	10	
12:	Transport Busy Delay (sec.)	180	
13 .	Transport Window Size (frames)	4	
14 .	Congestion Control (frames)	4	Don't fill the TNC buffers!
15 .	No Activity Time Out	900	Set MUCH Higher for DX PktClstr Access Chan.
16 .	P-persistence	50	Max for Backbone - 64 OK for User Channel
17 .	Keyup slot time	10	
18 .	Link T1 "Frack" (sec)	4	
19 .	"MAXFRAME"	7	Some Opinions say MAXFRAME = 1!
20 .	Link Max tries	7	Enough is Enough!
21 .	Link T2 timeout	100	
22 .	Link T3 Timeout	18000	
23 .	AX.25 digipeating	0	NOT ON BACKBONE! - OK on User Channel.
24	Validate Callsigns	1	Keep 'em Honest!
25:	Station ID beacons	1	Keeps the MSYS/KANODE JHeard lists happy.
26 .	CQ broadcasts	0	NOT ON BACKBONE! - OK on User Channel.

TXD = 500 ms on ALL Synthesized Radios - It takes TIME for TX AND RX PLL's to Lock!

SUGGESTED PARAMETER VALUES
FIGURE 3