AMATEUR NETWORK ADDRESSING AND ROUTING

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Abstract

Now that we have actual packet switches on the air, it is time to take a hard look at the addressing and routing schemes proposed for use at the Network Layer. In this this paper I give my impression of how I believe addressing and routing will evolve. I will also recommend the use of certain "direction implicit" addresses as an interim step of Network address and routing operation.

Background

There are two major types of devices involved in Network Layer connections within the Network. The source and destination end-points are where the packets enter and leave the Amateur Packet Network, and the transit packet switches (if any) are the intermediate devices that pass the data between the these end-points. In order for each of these devices along a Network Layer connection to understand where packets came from, and where to send them, the various devices along the connection must have a unique descriptor. This is analagous to the source, destination, and repeater addresses in the AX.25 Level 2 Protocol addressing, where the source and destination end-points are the source and destination AX.25 Amateurs, and the packet switches are the digipeaters that allow the two Amateurs to connect to each other.

In the AX.25 Level 2 design, we used the same address technique for the end-point stations and the digipeaters, Amateur callsigns. I suggested the use of Amateur callsigns because they were already assigned to all Amateur stations by the FCC, removing the requirement for some other organization or group of organizations to assign unique addresses.

Since the digipeaters also used Amateur callsigns, their use and identification was made easier. To go through the local digipeater, all an Amateur had to do was specify the digipeater's callsign. If more than one digipeater was required, the additional digipeater callsigns were added at the end of the previous one, forming a list of digipeaters that the Level 2 frame was to pass through. The spec allows for up to eight digipeaters to be used in this fashion. Since the source Amateur has to know the exact list of digipeaters in the proper sequence when the connection is requested, this is called explicit source routing information. Yes, the route comes hand-in-hand as part of the addressing scheme. Even though these are two, separate functions, they are conveyed by the same piece of information, the digipeater callsigns.

Since a similar architecture exists at the Network Layer, we may be able to use some of the same techniques for it as we did at Level 2.

Names vs Addresses

We are all familiar with the concept of names and addresses. Your name is how you are uniquely identified as a person from the rest of the people in the world (well, not quite uniquely, but usually adequately identified). Your address describes where you can be found if some other poerson wishes to communicate with you (in whatever form). It can be argued that the addressing information can imply some additional information, how to get to the named individual (routing information). Sometimes the routing information cannot easily be implied, but must be explicitly given. An example of this is when you give someone directions to your location because they do not have a map.

Such is the case in Network addressing. The Network address may contain the "name" of the Amateur as the callsign of the Amateur that communications is being requested with, the "address" of the Amateur, which would be where in the Amateur Network the named Amateur can be found, and implied by the address information, the route necessary to make the connection to the Amateur. An alternative to the implicit routing would be to use some form explicit routing, similar to the digipeater system mentioned above.

The reason I have the above "philosophical" discussion is to indicate that Network Layer addressing may be called upon to convey more than the simple address information it's name implies. With the FCC no longer maintaining the fairly rigid callsign-to-geographical-area mapping they once did, simply using destination Amateur callsigns may no longer convey enough information to process a connection request. Also, while the Amateur's callsign is a good "handle" for the human to understand, it may not be the best method of identifying someone or something for the network.

Types Of Packet Devices on the Network

The Amateur Packet Network will have several different types of devices running on it. There will be user Amateurs, end-point switches, and transit switches in the broadest terms, with the user Amateurs broken up into smaller sub-sections. Not all of these devices will want or need the same Network addressing information. As the Network develops, less information will need to be present or implied in the addresses. Let's see what information needs to be used in the case of each of the above named devices.

I will start with the user Amateur, since we can all relate to him or her. To start off, let's say a user Amateur (Amateur A) wants to establish a dialog to another user Amateur (Amateur B) directly (without the use of any other device). The only address information needed for this is the "name" of the Amateur B. Simplicity itself. Figure 1 indicates this wonderful scenario.

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 -----------              -----------
! Amateur ! <---------> ! Amateur !
!    A    !              !    B    !
 -----------              -----------
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Figure 1. Amateur A to Amateur B Direct

What if Amateur A does not have a direct RF path to Amateur B? Some other device must be used to allow the two to communicate. (Those of you who said a digipeater will stay after this paper to clean the erasers..) Since both Amateurs can communicate with a common end-point packet switch (Switch A), Amateur A requests a connection with Amateur B through Switch A. This is diagrammed in Figure 2.

```
 -----------          ----------          -----------
! Amateur ! <---> ! Switch ! <---> ! Amateur !
!    A    !         !   A    !         !    B    !
 -----------          ----------          -----------
```

Figure 2. Amateur A to Amateur B-Through Switch A

At the beginning of the Amateur Network development cycle, Amateur A will have to explicitly tell Switch A that a connection is requested through it to Amateur B. As the local area Network switches develop, Switch A may be able to look in a User directory database, find out that it services both Amateurs, and automatically attempt to make the connection between the two.

If Amateur A and Amateur B are far apart, they may not be able to communicate through a common switch. Instead, the Network connection will have to be made through a series of switches. This is shown in Figure 3, at the end of the paper. At the start of the Amateur Network, Amateur A will now have to know (and pass along) the following:

1. It's own Network end-point Switch name and/or address. This is treated as Amateur A's address by the Network.

2. The route the connection must take to get to Amateur B's end-point switch, and the name and/or the address of all transit switches in that route.

3. The name and/or the address of Amateur B's end-point switch. The Network treats this as the address of Amateur B.

4. The name of Amateur B.

That looks like a lot of information to know, let alone pass along. Actually, items two and three can be though of as the same item, with the first and last name/address being the two end-points. Neverless, with a coast-to-coast connection taking up to 100 switches over VHF, there has got to be a better way. I will call this system Method 1A.

A method of lessening the amount of routing data passed in the packet would be to use addresses for the end-point user Amateur that imply where he/she is located. This way, rather than having to explicitly tell the route, Amateur A could say the equivalent of "Amateur B is in San F'rancisco, CA, USA", Get me there the best way possible. This system will be referred to as method 1B.

The next step in the Amateur Network development will be the capability (through some mysterious magic) of switches to either know automatically, or be able to find the route without getting it from the user Amateurs. One method of doing this would be to have all end-point switches maintain databases containing routes to all other end-point switches. Another method would be to have several Route Server devices spread throughout the Network that the end-point switches would uery whenever they need routing information. The 4ormer has the advantage of speed, while the latter allows the switches to be smaller, and allows for dynamic routing of connections to reduce congestion of frequently used pathes.

Using either system, Amateur A no longer needs to know and specify exactly how the packets get to Amateur B, but rather just what the two end-point names and/or addresses are, and Amateur B's name. Again, the Network treats the two end-point switches as addresses to the Amateur stations (where the Amateurs are on the Network). I call this system method 2.

Method 2 is similar to how some of the present packet networks operate. When Person A wishes to communicate with Person B, Person A dials a local phone number (end-point Switch A address), and asks for a connection to Person B at end-point Switch B (using end-point Switch B's name). As an example in the Amateur Network I might type: connect to WB4JFI-4 @ WB4JFI-5, where WB4JDI-4 is my station at work, and WB4JFI-5 is the end-point switch it normally monitors.

As the Amateur Network progresses even further, all Amateur A may need to do is indicate that he/she wishes to communicate with Amateur B. The Network itself will maintain a list of all Amateurs on the Network, with the end-point switch that normally serves each Amateur as t-hat Amateur's "address", If an Amateur is" away from home", he/she can leave a packet-forwarding address of a different end-point switch on his/hers "home" switch. This is called method 3.

Emphasizing the above Network development stages from the end-point switch side yields the following information requirements.

At initial Network development, the end-point switches will be relatively dumb regarding the "connectivity" of the 'Network. All routing, information will have to come from the user Amateurs in one form or another. Using method LA means that the user Amateur will explicitly tell the end-point exactly which switches to use to make the connection, and in what order. The end-point switch would use this information to build the connection to the destination end-point switch, using any transit switches indicated.

The use of method 113 means the user will inform the switch how to make the connection by adding some "directionality" to the address information supplied. The end-point switch would then make some routing decisions on it's own based on the direction information supplied. It would then pass the packet to the switch it thinks is in the right direction, possibly adding it's name or address to a list somewhere in the packet.

The next step along the Network development cycle (using method 2) would allow the switch to either maintain it's own list of routes to all other end-point switches, or have access to one or more "Route Server' devices (considered User devices by the Network). When an end-point switch receives a connection request from an Amateur, it will look up the indicated destination end-point switch (really, the other Amateur's Network "address") in it's routing database, or inqure of the Route Server the best route to the destination end-point switch. Once the routing information is obtained, the source end-point switch will then attempt to build the connection, going through any transit switches indicated.

After further Network development it may be possible for the end-point switches to find out which end-point switch normally serves as "home"' for the destination Amateur (once again, the destination Amateur's Network "address"). This is method 3, and will will most likely work by having 'User Directory Servers" available on the Network. They would work much like the 'Route Server" except that they would contain the "home"' address of all Amateur stations that have appeared on the Network. When a connection request to a destination Amateur is received, the source end-point switch will ask the User Directory Server which end-point switch serves that destination Amateur, and then find the routing information to that end-point switch, and then make the connection, using any transit switches indicated in the routing information.

Transit switches are switches that connections are made through, but not not ended at (except for maintenance connections). As such, the transit switch function does not have any users to worry about. I should mention that end-point switches can function as transit switches also, but the end-point switch functions can be treated as separate functions.

In the beginning of the Amateur Network, transit switches will operate in one of two modes. Using method 1A from above, if a connection request to the transit switch is received from another switch (either another transit switch, or an end-point switch) that contains explicit routing instructions, the transit switch should attempt to pass the connection request along to the next switch indicated. If that connection is not possible, the transit switch should return a packet to the source end-point switch (via the reverse of the path specified) indicating the reason (switch failure, wrong path, etc.).

If a transit switch receives a packet containing implicit routing in the form of directional information, method 1B described above, it should attempt to send the packet in the proper direction, using a "best guess" algorithm. There will most likely be a list somewhere in the packet for the transit switch to append it's identity, so that the destination end-point switch knows how to reach the source end-point switch.

As the Network progresses, methods 2 and 3 from above will be used more and more. If source-routing is used, this may relax the requirements place on transit switches, since they may no longer need to make routing decisions, but rather just pass connections through them based on routes created by end-point switches.

If the Network does not use source-routing, the transit switches may have to make more routing decisions. This reduces the overhead in the packet that contains routing information. It also allows some degree of Network connection flexibility, since decisions about routes are made along the way, possibly bypassing bad areas of congestion. This will add to to the complexity of the transit switch, since it must now have enough information available to it to make intelligent routing decisions.

Another method of reducing route information overhead is to compress the route information. When the Network gets larger, it may take one hundred or more switches to amke the proper connection. Since there isn't enough room in the packet headers for this amount of routing information (even if we remove the user data). Some of the routing information will have to be "compressed" into a smaller amount of data. This compressed data may have to be expanded by transit switches in order for them to obtain the indicated route information.

Who Gets Assigned What

Another area that should be discussed is who should be assigned Network Layer addressing information, and what kind of addressing information do they need to be assigned. Huh? Let me try to clarify this a little bit.

In the above discussion, I mentioned that the involved user Amateur stations will be indicated by their "names", most likely callsigns. The Network "address" of those Amateurs could be the end-point switches they either are presently on, or frequent. This being the case, those end-point switches now have two means of identification, their own "name" and as an "address" of a user Amateur.

The transit switches also can be identified by their "name" (for maintenance connections), as part of a connection through them their "address", and for routing information their location, once again their "address".

How and what we use to specify each entity may not be thought of as important at first, but if done correctly can help tremendously to ease the growing pains of the Amateur Packet Network.

User Amateur Identification

This one is fairly simple. I feel we shold identify the user Amateur with the FCC assigned callsign and an SSID, similar to AX.25 Level 2. In addition, using method 1B above, it may be necessary to add some directional information for the Network to base it's routing decisions on. The possible types of directional information used will be expanded on shortly.

End-Point Switch Identification

When an end-point switch is itself the destination of a connection, the Amateur callsign plus SSID of the switch should be used.

When an end-point switch is used as the source end-point, it should be identified by its callsign plus SSID. Since it is the source of the connection request, all stations will know how to retrace the path to it. This does not preclude the use of alternate paths for the return connection once the network is smart enough to allow such a thing to occur. By then, routing decisions will be made using methods 2 or 3 above anyway.

If an end-point switch is the destination end-point (Network address of the destination Amateur), it's callsign plus SSID should be used, if known. Additional information may be required as follows:

Under method 1A above, since the whole path is explicitly given, no other information needs to be given.

If the callsign of the destination end-point switch is not known (under method 1B above), some directional information must be passed on, so the Network can make routing decisions.

If the callsign of the destination end-point switch is known, it should be sent along with the direction information, reducing the chances of more than one end-point switch answering the connection request.

Using method 2 and 3 above, no additional information needs to be supplied, as the network has the resources to find the routing information from the switch name (the end-user's address).

If the destination end-point switch is part of a path that was compressed as mentioned above, it may need to expand all compressed routes it receives to make sure it is not the destination.

Transit Switch Identification

There are two reasons to need to identify a transit switch. The first is if a maintenance connection is required. This is in effect making the transit switch an end-user rather than a transit switch, and as such the callsign plus SSID of the switch should be used.

The other case is when the transit switch is being used for it's normal, inter-switch communication function. This case is broken down as follows:

If method 1A is being employed, the transit switch should check for it's callsign/SSID in the list of explicit stations. If it's callsign/SSID is found it should attempt to pass the connection to the next switch on the list.

If method 1B is being used, the transit switch look at the end-point directional information supplied, make a best-guess how to route the packet, add it's callsign/SSID to the end of the switch list located in the packet, and send the packet along the route it calculated.

If method 2 or 3 is used, the switch should be identified by it's callsign for source routing, or possibly as part of a "compressed route" that it expands to test. If source routing is not employed, the switch may have to look in it s routing table for the next switch in the route, whose callsign/SSID it uses to pass the connection request along.

With the above background, it is time to look at some of the actual address schemes suggested by the amateur community over the last year.

Address Methods Suggested

It would be difficult for me to list all the possible addressing schemes that have been proposed for use on the Amateur Network. I will concentrate on some of the more popular ones, which are:

1. Callsign only.
2. Callsign plus Area Code/Phone Number.
3. Callsign plus Airport Designators.
4. Callsign plus Zip Code.
5. Callsign Plus Latitude and Longitude.
6. Callsign plus Gridsquares.
7. Assigned numbers based on geographical location.
8. Assigned numbers given by an organization or group of organizations.

Callsign Only

The first one on the list, callsign only, (really callsign plus SSID) is what I hope we all shoot for. It is the most "user friendly" to the general Amateur community, and therefore the easiest to convince the Amateurs to use. I think we will need some stepping stones to get to that point, however.

Callsign plus Area Code/Phone Number

If additional information must be present, some would say that the easiest system to use is one that is already present. Of the pre-existing systems, the telephone network is probably the best. It provides a large degree of directional information (through country codes and area codes) yet it also offers a high amount of resolution (down to the phone number). Since the numbers are already assigned, and often listed, it should be possible to have fairly quick access to look up needed numbers.

One of the disadvantages is that the phone numbers, and sometimes the exchanges change. This can happen when one moves, often as little as a few blocks. Another disadvantage is that not all Amateurs wish to have their phone number known. For them, it may be necessary to have a set of "false phone numbers" that could be assigned as needed.. Also, numbering schemes used by other countries may not be as well organized as that of the United States phone system,, particularly those in Europe that have variable length numbers.

The present AX.25 Network code being developed on the TAPR TNC-2 uses area codes and phone numbers, prefixed by another set of digits,, called the DNIC, or Data Network Identification Code. The DNIC code is covered by Gordon Beattie in the 1985 ARRL Computer Networkin Conference proceedings, along with an additional paper found elsewhere in these proceedings. In addition to the area code/phone number information, the TNC-2 code also passes along the source and destination user Amateur Callsigns. The area code/phone number information is contained in the normal AX.25 Level 3 address space, while the callsigns are in the optional facilities section of a call request packet, using the calling and called address extension facilities.

This system seems to be an acceptable scheme to encode both directional information for routing and the Amateur callsign for specific station identification.

Callsign Plus Airport Designators

All major airports around the world now have unique identifiers (that's what the mumbo-jumbo of characters on the tag on your suitcase means). Some have suggested using these as identifiers for a geographical area that an Amateur may be found in. Since airports are scattered randomly about the world, often with large gaps between them, this system would mean that the coverage area of each identifier would vary drastically. The method of assigning airport designators is also not intuitively obvious to the casual observer, making it difficult to extrapolate where one is. In addition, it might be difficult for the average Amateur to find out what the proper airport designator is for unfamiliar areas. I feel this method should not be used.

Callsign plus Zip Code

Once again, the government comes through for us! The postal system has assigned each post office with a unique identifying number, the Zip Code. In addition, if more resolution is needed, we now have Zip Plus Four! Wonderful. Seriously, using Zip codes would work fairly good here in the United States. If one chops off all but the first couple of digits, a reasonable degree of directionality can be obtained. Zip codes are easily found (I believe they are even in the Callbook). The problem with Zip Codes is that outside the U.S. their assignment is not consistant at best, if they are used at all. I think we need a world-wide system for our address scheme, which requires additional "patching" on the Zip Code system.

Callsign Plus Latitude and Longitude

Well, you can't get much better location information about someone than their Latitude and Longitude. Almost. Will we use the East or West Longitude system? Have you looked at your house platte lately? I did a little while back, and found out the numbers there weren't any where near my real Latitude/Longitude. The Latitude and Longitude system would be good except that there is too much information needed to be conveyed if we use them directly, and they can be difficult to find out, especially for an unknown area.

Callsign Plus Gridsquares

In 1980 there was a meeting of European VHF Managers in Maidenhead, Berkshire to establish a world locator system that would accurately define any location in the world with as few symbols as possible. The result of this meeting is the Maidenhead Squares system, often referred to as gridsquares. Gridsquares have been used ever since as the favored system of identifying locations for VHF enthusiasts world-wide. The system is based on placing a grid over the world, with each square twenty deggrees east-to-west by ten degrees north-to-south. Inside each of these squares (called fields) is a smaller grid system, with those squares (called squares) being two degrees east-to-west by one degree north-to-south. If more resolution is needed, the squares are further divided into sub-squares, sized five minutes east-to-west by two-and-one-half minutes north-to-south.

Using gridsquares, a very small section of the world can be described with only six characters. Since gridsquares are based on Latitude and Longitude, directionality can be easily calculated (without having to know Lat/Lon information). Gridsquares can be chopped off at any of the three size boundries to provide the amount of direction information necessary.

The disadvantage of gridsquares is that they may not be easily found. Either a database of them must be maintained, or the Latitude and Longitude information must be converted to the gridsquare needed. Also, no political boundaries are implied by the gridsquares, so callsigns must be referenced for political boundary information.

When I wrote the AX.25 Level 3 Protocol spec (Third ARRL Computer Networking Conference), I was in favor of using gridsquares for the optional locator information. I am still in favor of using them, and will expand on their use shortly.

Assigned Numbers Based On Geographical Location----

See Gridsquares above. Seriously, there are many different methods of assigning numbers based on geographical location. I am not sure why someone would want a system other than gridsquares, but it might be possible to come up with a numbering scheme that is better "computer friendly" for the Network, or more compact.

Assigned Numbers by Organization or Groups of Organizations

One method of assigning addresses sometimes suggested is based on a group of hierarchical organizations assigning binary numbers in ever decreasing geographical sizes. In other words, an international group assigns most-significant digits of numbers to countries. An organization inside each country then assigns the next-significant digits. Then smaller, more regional organizations assign ever decreasing numbers, until each Amateur that needs one gets a number.

I am totally opposed to this scheme for several reasons. First of all, it requires the setting up of a wonderful bureaucracy, just what we need. Secondly, magic numbers have to be looked up to gain some idea of location (the bureaucrats won't assign numbers in a rational, geographical method since that would make the job too easy). Third, who is going to want to remember binary addresses? Not me. Fourth, where do we go to find out these numbers. Again, not me.

My Proposal For Network Addressing

With the above information in mind, let me now suggest an addressing system that I feel we can grow with.

As mentioned earlier, the user Amateurs should always be identified by their callsigns/SSIDs. The source user Amateur does not need to have provided any locator information for him/her, except for the source end-point switch identification. Therefore, no gridsquares are needed for the source user Amateur.

In may be necessary on occasion to also indicate where a destination user Amateur is located (method 1B above). If this is the case, gridsquares should be added to the destination Amateur's callsign/SSID.

Source end-point switches should also be identified by their callsign/SSID. If there is a reason to add locator information, gridsquares should be added. I'm not sure there is a need for this, since the path is established from the source end-point switch, it should always be known. For now, callsigns should be enough for the source end-point switch.

The destination end-point switch is a different matter. If the callsign/SSID is known, then that should be used as the address of the destination end-point switch. If the callsign/SSID of the destination end-point switch is not known, or of implicit routing is being used in method 1B, the gridsquare of the destination END USER AMATEUR should be included. This should be in the form of gridsquares, using either the two most significant characters if the destination area is not well known or the first four gridsquare characters. Using all six gridsquare characters may provide too much resolution for finding the proper destination end-point switch.

Transit switches should always be identified by their callsign/SSID. It is unclear why one would want to identify transit switches in any other method, other than forgetting one transit switch callsign/SSID when using explicit routing. In any event, callsign/SSID's for transit switches.

How Much Room is Available For Addresses

In AX.25 Level 3, there are three places addressing information may be placed. The first is in the calling and called DTE address fields. Each of these may be up to sixteen nibbles long. I specify nibbles because the DTE addresses are still thought of as numbers, so each nibble is capable of holding one BCD coded digit. This means binary encodings greater than 1001 are not allowed. What a pain.

The second place address information is allowed is in the calling and called address extension facility. Each of these facilities may contain up to 32 nibbles of address information. Once again, the BCD encoding method is imposed. At least here we have room to breath.

The third place where address information can be found is in the two optional routing facilities of AX.25 Level 3. We added these Amateur specific facilities to allow us a mehtod of conveying routing information as the Network was starting. There are two types of routing facilities. The explicit routing facility contains the callsign/SSID of each packet switch the call must go through. The second optional routing facility is the implicit routing facility. The data conveyed in this facility should be some geographical locator information regarding the destination user Amateur.

Now that we know how much room we have, let's look at how to encode our addressing information into AX.25 Layer 3 connection request packets.

Proposed Address Encoding Technique for AX.25 L3

The addressing information I plan to use is gridsquares for location, and callsign/SSID for names. The two are encoded differently, since they have different lengths and are located in different places. I propose that gridsquare information (if needed) be placed as the locator information in the calling and called DTE address fields.

I further propose that the callsign/SSID information be placed in the optional facilities fields (making them less of an option).

Encoding of the Gridsquare Information

Both the proposed address methods (my gridsquare and Gordon Beattie's area code/phone number) include the Data Network Identification Code (DNIC) in them as part of the addressing plan. This inclusion may help us in the future, if we need to tie the Amateur Network to a commercial network. Gordon discusses the encoding of the DNIC in a paper in the 1985 ARRL Amateur Radio Computer Networking Conference, and in a follow-on paper in these proceedings, so I will not describe it in depth here. Keep in mind the nibble and octet (byte) numbers I use below are referenced to the first nibble or octet of the address sub-field in uestion, NOT the absolute count from the start of the packet.

The DNIC fits in five semi-octets, or nibbles (including the prefix). A sixth nibble has been added to the end as a compromise between the phone number and gridsquare groups. This sixth nibble is encoded as follows at this time:

4321 <--- Bit pattern in nibble 5.

0000 indicates area code/phone number addressing system.

0001 indicates gridsquare addressing.

The seventh: and succeeding nibbles contain the actual location addressing information, up to sixteen nibbles. This leaves us with ten nibbles to put the gridsquare information. Unfortunately, the BCD requirement raises it's ugly head, so we have to get cute. In my paper on optional facilities for AX.25 Level 3 (Third ARRL Amateur Radio Computer Networking Conference), as part of ANNEX G I briefly discussed a method of encoding the gridsquare information. Gridsquares are described by six alpha and numeric characters as follows. The first two alpha characters indicate the most significant area (the fields), followed by two numeric digits (for the square), followed by two more alpha characters for the sub-square.

If we take the first two alpha characters and divide each character such that bits 4, 5, and 6 are conveyed in the high order digit, and bits 1, 2, and 3 are in the low order digit, we should be able to put each alpha character in an octet!, while staying within the letter of the protocol. Bits seven and eight are redundant in this case anyway, since upper case alpha is assumed. This uses two octets (four nibbles) for both alpha characters, leaving us with six nibbles. The first alpha character will take up the fourth octet, while the second alpha character is in the the fifth octet. Those who remember the old TV Typewriter I should be familiar with the Half-ASCII this six-bit system uses.

Since the third and fourth gridsquare characters are numeric, they will fit nicely in the two nibbles of octet six, BCD coded anturally.

The fifth and sixth gridsquare characters are not really needed. They describe almost too small of a location, since we may not know exactly where the station in question is. If they are needed, since they are also alpha, we must play the same byte-splitting game with them that we did with the first two gridsquare characters. The fifth and sixth characters will be placed in octets seven and eight of the address field, respectively. This fills up the calling and called DTE address fields in the call request type packets.

Figure 4 shows the encoding of the called address fields for a call request packet to the WB4JFI-5 packet switch at 77 Deg, 4 Minutes, and 47 seconds west by 38 degrees 57 minutes and 7 seconds north (the WDVM-TV tower it resides on). The gridsquare information for it is FM18LW.

```
----------------------------
! High Nibble  ! how Nibble !
!--------------!------------!
!    Prefix    !   Data..   ! Byte 1, DNIC
!--------------!------------!
! ..Network... ! ...Ident.. ! Byte 2, DNIC
!--------------!------------!
! ... Code     ! Grid= 0001 ! Byte 3, DNIC, Grid
!--------------!------------!
! (Hi F)=0000  !(Lo F)=0110 ! Byte 4, Grid #1 = F
!--------------!------------!
! (Hi M)=0001  ! (Lo M)=0101 ! Byte 5, Grid #2 = M
!--------------!------------!
! 1 = 0001     ! 8 = 1000   ! Byte 6, Grid 3,4= 18
!--------------!------------!
! (Hi L)=0001  !(Lo L)=0100 ! Byte 7, Grid #5 = L
!--------------!------------!
! (Hi W)=0100  !(Lo W)=0111 ! Byte 8, Grid #6 = W
----------------------------
```

Figure 4. Gridsquare Encoding in DTE Address

Now that we have encoded the gridsquare information, let's put the callsign/SSID information into the optional address facilities.

Callsign/SSID Encoding In Facilities

While I played by the letter of the X.25 Protocol for the calling and called DTE address fields, I think we don't need to go to extremes in the calling and called address extension facilities. Here we can just throw in the Amateur callsign plus a FIVE-bit SSID. The SSID should be justified to the LSB, filling bits 8, 7, and 6 with zeros. The result is that WB4JFI-5 would look like this:

```
            ------------
Byte 1    ! 01010111 !   57 hex = "W"
Byte 3    ! 01000010 !   42 hex = "B"
Byte 3    ! 00110100 !   34 hex = "4"
Byte 4    ! 01001010 !   4A hex = "J"
Byte 5    ! 01000110 !   46 hex = "F"
Byte 6    ! 01001001 !   49 hex = "I"
Byte 7    ! 00000101 !     SSID =  5
            ------------
```

If we do run into problems interfacing to commercial networks using this scheme, we can transform these seven bytes into the Half-ASCII system used for the alpha characters of the gridsquares above. There is room to do this, since up to sixteen octets are allowed in each facility.

Implicit Route Facility Encoding

The last encoding scheme to discuss is how we place the locator information in the optional implicit routing facility. I think we should place a marker at the beginning of the facility coded as follows:

00000000 Area code/phone number system.

00000001 gridsquares used.

00000010 Amateur Callsign of destination switch used.

The rest reserved for now.

This will allow expansion for almost any scheme of implicit routing the future may bring, especially for experimentation.

For gridsquare encoding, the six, actual ASCII gridsquare characters of the destination user Amateur can be used, since no BCD rule applies here.

Gridsquare Calculation

There must be some method of finding out the gridsquare information if it is to be used. There are several ways to do this, almost all based on knowing the Latitude and Longitude of the target location. The best way to find out the gridsquare information without knowing the Latitude and Longitude is to ask someone.

Another method of determining the gridsquare of a target location is to use The ARRL World Grid Locator Atlas, available from the ARRL for $4.00. It is a series of maps with the first four characters of the gridsquare information superimposed on them. It also contains a list of the most common cities, states, and countries and their gridsquares. It can be a little hard to extrapolate from these maps the exact grid, so the list is the best bet.

If the Latitude and Longitude is known, the gridsquare information can be obtained, either by computer programs, or by tables. The Latitude and Longitude can usually be obtained to a close enough degree just by looking on a map or atlas (such as the famous Callbook maps).

There are a couple programs written in Basic and Fortran to do the gridsquare calculations, plus I am working on one written in C. Unfortunately, my program doesn't work so hot south of the equator, so I won't include it here. Instead, I will describe the Gridsquare system and provide some charts for manual conversions. The following information comes from a fine article called "Maidenhead Squares, A World Locator System" by N. A. S. Fitch in the January, 1984 issue of The Shortwave Magazine.

The starting point for the gridsquare system is 180 degrees west Longitude at the south pole. Lettering and numbering runs from west to east, and south to north from that location.

The Gridsquare locator system is made up of six alpha characters. The first, third, and fifth characters are based on longitude, while the second, fourth, and sixth characters are based on Latitude.

The first alpha character is based on twenty degree spacing and identifies the Field in question. This can be looked up in Table 1, which has been converted for west Longitudes.

Degrees West of Greenwich	Field Letter
0 - 20	I
20 - 40	H
40 - 60	G
60 - 80	F
80 -100	E
100 -120	D
120 -140	C
140 -160	B
160 -180	A
180 -200	R
200 -220	Q
220 -240	P
240 -260	0
260 -280	N
280 -300	M
300 -320	L
320 -340	K
340 -360	J

Table 1. First Gridsquare Character

The third character is numeric and is based on two degree spacing from the east side of the defined Field. Table 2 contains the third character information, converted to using the west side for west Longitude calculations.

Degrees West of eastern side of field	Square Number
0 - 2	9
2 - 4	8
4 - 6	7
6 - 8	6
8 - 10	5
10 - 12	4
12 - 14	3
14 - 16	2
16 - 18	1
18 - 20	0

Table 2. Third Digit of Gridsquare.

The fifth character is alpha, and is based on five minute intervals within the previously found square. Table 3 contains the look-up information. Once again, it has been converted for those of us who prefer west Longitudes. Be sure to add **60** to the minutes if your degrees is an odd number.

Minutes West of eastern side of square	Sub-Square Letter	!	Minutes West of eastern side of square	Sub-Sub-Letter
0 - 5	X	!	60 - 65	L
5 - 10	W	!	65 - 70	K
10 - 15	V	!	70 - 75	J
15 - 20	U	!	75 - 80	I
20 - 25	T	!	80 - 85	H
25 - 30	S	!	85 - 90	G
30 - 35	R	!	90 - 95	F
35 - 40	Q	!	95 - 100	E
40 - 45	P	!	100 - 105	D
45 - 50	O	!	105 - 110	C
50 - 55	N	!	110 - 115	B
55 - 60	M	!	115 - 120	A

Table 3. Fifth Gridsquare Character Table.

Now, on to the Latitude calculation. As mentioned earlier, the Latitude information is conveyed in the second, fourth, and sixth characeters. The second character is an alpha, and is based on ten degree spacing from the south pole. Table 4 contains the information based on degrees north or south of the equator.

Latitude North of Equator	Field Letter	!	Latitude South of Equator	Field Letter
+ 80 - 90	R	!	-0 -10	I
+ 70 - 80	Q	!	-10 -20	H
+ 60 - 70	P	!	-20 -30	G
+ 50 - 60	O	!	-30 -40	F
+ 40 - 50	N	!	-40 -50	E
+ 30 - 40	M	!	-50 -60	D
+ 20 - 30	L	!	-60 -70	C
+ 10 - 20	K	!	-70 -80	B
+ 0 - 10	J	!	-80 -90	A

Table 4. Second Gridsquare Character.

The fourth gridsquare is numeric and is based on one degree increments from the bottom of the Field. Table 5 is used to find the fourth digit.

Degrees North	Square Number	Degrees South
+9 - 10	9	-0 -1
+8 - 9	8	-1 -2
+7 - 8	7	-2 -3
+6 - 7	6	-3 -4
+5 - 6	5	-4 -5
+4 - 5	4	-5 -6
+3 - 4	3	-6 -7
+2 - 3	2	-7 -8
+1 - 2	1	-8 -9
+0 - 1	0	-9 -10

Table 5. Gridsquare Fourth Character Table

The sixth and last gridsquare character is an alpha based on 2.5 minute increments from the bottom of the Square. Table 6 contains the information on it.

Minutes North	Sub-Square Letter	Minutes South
+57.5 - 60	X	-0 - 2.5
+55 - 57.5	W	-2.5 - 5
+52.5 - 55	V	-5 - 7.5
+50 - 52.5	U	-7.5 - 10
+47.5 - 50	T	-10 - 12.5
+45 - 47.5	S	-12.5 - 15
+42.5 - 45	R	-15 - 17.5
+40 - 42.5	Q	-17.5 - 20
+37.5 - 40	P	-20 - 22.5
+35 - 37.5	O	-22.5 - 25
+32.5 - 35	N	
+30 - 32.5	M	-27.5 - 30
+27.5 - 30	L	-30 - 32.5
+25 - 27.5	K	-32.5 - 35
+22.5 - 25	J	-35 - 37.5
+20 - 22.5	I	-37.5 - 40
+17.5 - 20	H	-40 - 42.5
+15 - 17.5	G	-42.5 - 45
+12.5 - 15	F	-45 - 47.5
+10 - 12.5	E	-47.5 - 50
+7.5 - 10	D	-50 - 52.5
+5 - 7.5	C	-52.5 - 55
+2.5 - 5	B	-55 - 57.5
+0 - 2.5	A	-57.5 - 60

Table 6. Sixth Gridsquare Character Table

With the above information and the Latitude and Longitude, anyone should be able to figure out what their gridsquare is, along with those of other Amateur stations.

Conclusion

Not all Amateur stations on the Network will need to supply location information. As the Network builds, less addressing and routing information will be required from the user Amateur, and more will be maintained by the switches. In the interim, I feel we should use the callsign/SSID plus Gridsquare information as needed. I hope the gridsquare tables help to allieviate some of the negative comments I have heard about using them.

References

Fox, T., "AX.25 Amateur Packet-Radio Link-Layer Protocol", ARRL, 1984

Tanenbaum, A. S., "Computer Networks", Prentice Hall, 1981

Beattie, J. G., "Proposal: Recommendation AX.121NA Numbering Plan For The Amateur Radio Network in North America", Fourth ARRL Amateur Radio Computer Networking Conference, ARRL, 1985

Fox, T., "AX.25 Network Sublayer Protocol Recommendation", Third ARRL Amateur Radio Computer Networking Conference, ARRL, 1984

Fox, T., "Packet Formats of AX.25 Level 3 Protocol", Third ARRL Amateur Radio Computer Networking Conference, ARRL, 1984

Fox, T., "Optional Facilities For AX.25 Level 3 Protocol". Third ARRL Amateur Radio Computer Networking Conference, ARRL, 1984

Fox, T., "Annex A Through F For AX.25 Level 3 Protocol". Third ARRL Amateur Radio Computer Networking Conference, ARRL, 1984

Meijer, A. and Peeters, P., "Computer Network Architectures", Computer Science Press, 1982

Fitch, N. A. S., "Maidenhead Squares A Worldwide Locator System", The Shortwave Magazine, January 1984

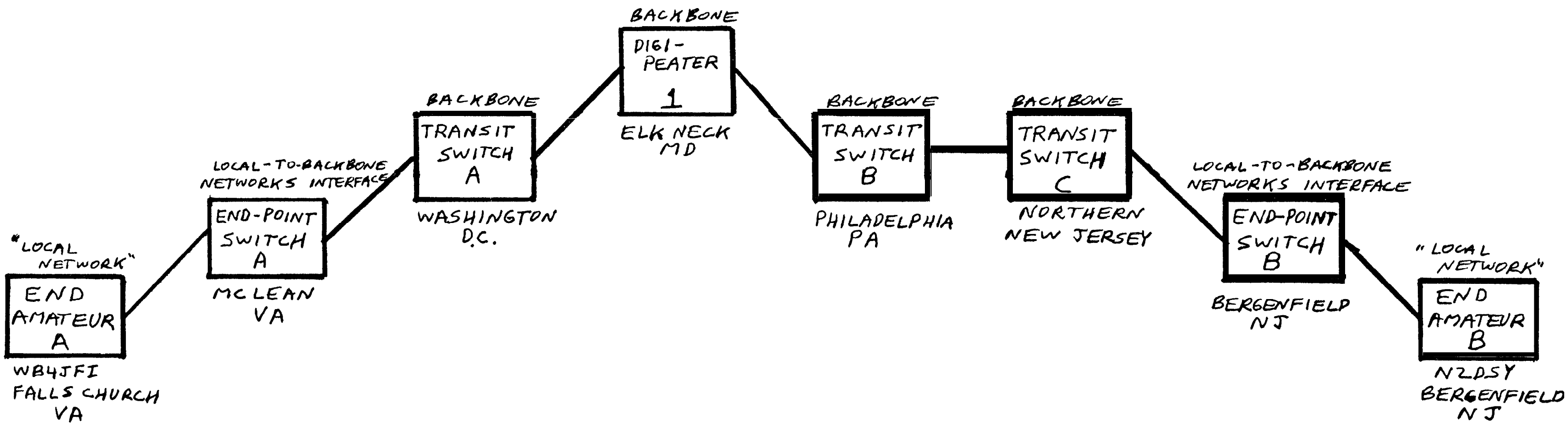

FIGURE 3. MULTIPLE SWITCH OPERATION.