Some Thoughts on AX.25 Level Two

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ABSTRACT

Comparisons are made between commercial packet-switching applications and the unique Amateur radio environment. Suggestions for enhancing the AX.25 Level Two protocol are given.

BACKGROUND

In October, 1982, a special meeting was held in conjunction with the AMSAT Annual Meeting to define a Level Two protocol. Representatives from many Packet groups were present, and adopted a modified version of the AMRAD-sponsored AX.25 Level Two protocol.

Since that time, AX.25 has become the de facto standard Level Two protocol in the United States and many other countries.

Tucson Amateur Packet Radio (TAPR) implemented this new protocol (with a few notable extensions) in December, 1982, on its then-current "Beta" Terminal Node Controller. These devices saw widespread distribution beginning in January, 1983.

Since that time, over 700 TAPR TNCs have been placed in the field and the extensions have had widespread acceptance. With experience have come requests for certain other changes to the protocol -- these requests form the basis of this paper.

COMMERCIAL APPLICATION

X.25 (the basis for AX.25) is used in commercial packet-switching networks. There are specific features to this protocol that allow for such things as assessing connection charges and the like, but a primary philosophical factor reflected in the protocol is that of "point-to-point" connections.

To expand on this thought, X.25 assumes that the "terminal node," or user, is connecting to a "host," or master, node. All communications to and from the user go through this host. This, of course, makes it easy for the host to log connect time and otherwise supervise the network so each user gets his bill on time!

Another feature allowed in X.25 is the so-called "balanced mode," where two nodes are connected as equals; there is no master/slave connotation. This is the mode that has been adapted to Amateur use.

Balanced made has two outstanding features that are particularly useful for radio Amateurs.

First, every station has the same privileges. This is necessary in a "controlled anarchy" environment such as Amateur radio. Any station can initiate a connection (QSO) -- and any connected station can initiate a disconnect.

Second, by not requiring any master station, the system is very robust. Failure of any particular node does not cause the network to fail.

Amateur Needs

Amateur radio has some specific needs, however, that are not addressed by X.25. One of these needs relates to the address field: AX.25 provides a useful solution by encoding the Amateur call sign in the address field of the header and allowing up to16 stations per Amateur call via the Secondary Station ID (SSID) portion of the address.

Another need is related to the geographic area that a "local area" network may have to encompass. What happens if your station is behind ahillandyou cannot access the local Packet bulletin board system?

AX.25 provides for a "digipeater." This is an intermediate station that can be specified by the initiator of a connection to act as a relay between the two end stations. While this application violates "pure" level two protocol, it satisfies a real need.

When TAPR was implementing AX.25 for the first time, the software team (Margaret Morrison, KV7D, David Henderson, KD4NL, and Harold Price, NK6K) saw a need for multiple digipeaters. Since AX.25 didn't allow for this, they decided upon an AX.25 compatible scheme.

Basically, three digipeaters were allowed to be specified in the "VIA" argument in a connect request. Each station that received the packet scanned the digipeat field and looked for the first "I haven't been digipeated yet" bit that wasn't toggled to the "I just digipeated this frame" state. It then toggled the bit and transmitted the resultant packet. The end recipient simply reversed the order of the digipeater list, cleared the digipeated bits and sent the reply.

Since digipeating allows for end-to-end ACKs only, the NAK being implicit, some mechanism had to be found to give digipeated traffic priority in a net. This was solved via the DWAIT parameter. Essentially, every packet transmission that is not a digipeated packet waits the usual random backoff time, but always waits a minimum of DWAIT * 40 mSec. Digipeated packets do not wait this delay; they have priority on the channel.

This feature was found to be very useful in such areas as Los Angeles-San Diego and the greater St. Louis area.

When the TAPR kit TNC was developed, a new software release was simultaneously released. The Version 3 software allows up to eight digipeaters to be specified, and also allows the use of digipeaters in the beacon and unconnected modes of operation.

Since this extension is a violation of the AX.25 protocol as adopted at the AMSAT meeting, the TAPR implementation allows for totally compatible operation as long as not more than one digipeater is specified by the user. It is hoped that other packet groups will recognize the benefits of allowing multiple digipeaters, and at such time as an AX.25 Level Two protocol review meeting is held with participation by interested Packet groups, TAPR will formally propose that these extensions be incorporated in the protocol.

While on the subject of implemented extensions to AX.25 Level Two, TAPR has extended the use of the Disconnected Mode (DM) frame.

AX.25 specifies that this frame will be sent only when the addressed station is in the disconnected mode and receives a frame other than a connect request (SABM).

The TAPR TNC has a command thatallowsthe operator of the station to set a CONnect OK (CONOK) flag to OFF, thus inhibiting his TNC from being connected to. This allows the operator to listen on the channel without having to "talk" to anyone. Under these conditions, a SABM frame will be responded to with a DM frame.

The other non-standard sending of a DM frame occurs when the destination TNC is already connected to another station.

The station requesting the connection, if in CONVERSation mode (not TRANSparent mode), will get a message stating

*** <call> busy

when a DM frame is received. Likewise, the station sending the DM frame will display

*** connect request from <call>

to alert him that a(nother) station wishes to connect.

OTHER EXTENSION

There are two other cases that arise in common Amateur practice that the author believes should be addressed at "Level Two" in Amateur Packet radio.

The first is the case of multiple simultaneous connections. This occurs when more than one station desires to use the services of another station.

A "sort of" case of this occurs when one station is in a good location and becomes a digipeater used by other stations in the local area. While no connection exists to a digipeater (only through it), the station so used is an illustrative example of of multiple connections.

One of Packet's widely touted benefits is its time domain multiplexing (TDM) on a given channel. This allows multiple QSOs to take place, increasing channel utilization. However, when a Packet station connects to the local Packet bulletin board, it becomes apparent that the bulletin board is being underutilized. Other station must wait in line for the first station to disconnect before the next one can connect. Meanwhile, the BBS is often standing idly by while the connected user browses through his mail or digests something just read.

If multiple connections were allowed, many users could potentially access the BBS at the same (apparent) time.

Please note that this is a question of implementation of AX.25 Level Two -- nothing in the protocol prohibits multiple connections. The upcoming Version 4 software release for the TAPR TNC will allow such multiple connections.

One major difference between Amateur operation and commercial practice is in the use of roundtables. This is a mode of operation where there are several stations that are engaged in a multi-way conversation.

Such operation is very useful when one wants inputs from a number of others on a particular subject, or when a traffic net has items of general interest (a swap net comes to mind as a typical example).

AX.25 Level Two does not allow for this mode of connection. While the next layer(s) of protocol will undoubtedly allow some semblance of this kind of operation, it will probably be dependent on some sort of "master@' linking station. This may reduce the robustness of the local system, which could be especially critical in times of local emergency traffic handling.

It is the author's belief that such operation is totally feasible within the Level Two environment by simply making use of the two "reserved" bits in the seventh octetofeachcall in the address field.

While this is not a formal proposal, the idea is as follows.

[1] The use of up to ten call signs is permitted in the address field (in the same manner as implemented in the TAPR-extended digipeater string). This allows up to nine destination stations in the multi-way connection.

[2] If the two bits marked "RR" in the seventh octet of the call are set to a "11", the call is treated like a digipeater -- this allows digipeaters in the case of certain stations in the multi-way connect, but reduces the number of destination stations by the number of digipeaters specified.

[3] If the 6th bit (counting from 0) in the seventh octet is a "Ø", such that the field marked "RR" is "1Ø", the station is treated as a destination station in the multi-way connect. Such a station would scan the previous addresses to see if this framewastohavebeen sent via a digipeater, and if so, if it in fact has been digipeated. The station would then continue the scan to see if it was requested as a digipeater for some other destination station in the multi-way connect.

[4] If the station is a destination station, it would read the control byte and act accordingly.

This mechanism allows a single packet transmission to be explicitly sent to multiple destinations, avoiding the inefficiencies that would result from a channel bandwidth utilization standpoint if the sending station had to use the multiple connection approach and send a packet to each destination individually.

The nextproblem to solveisthemanner in which ACKs are handled.

Each destination station would only have to send an ACK to the station originating the packet in question. Thus, a non-multi-way packet would be sent, the digipeat field being assembled by reading the address list backwards from this destination station to the first encountered non-digipeater.

A variation of the TAPR TNC DWAIT parameter would be used, wherein the station initiating the ACK would hold off for some number of milliseconds times his position in the address field. This would avoid collisions in most cases, while streamlining the ACK process -- a sort of slotted ACK.

To clarify the above, assume a station sent the following address field (an * indicates a digipeater, a # indicates a destination station):

WA7GXD |NØADI *|N7CL #|NK6K #|NØADI #

In this case, WA7GXD is sending a packet to N7CL via NØADI, to NK6K directly and to NØADI directly.

N7CL would ACK via NØADI; NK6K and NØADI would ACK directly, with N7CL sending the first ACK, followed closely by NK6K and NØADI.

If WA7GXD did not correctly receive the ACK from NK6K, the packet transmission would be repeated, but either (a) would only be sent to NK6K (Non-ACKers only) or (b) would be sent to all stations again, but the already-ACKed stations would ignore the packet because the N(R) and/or N(S) counters would not have been updated by WA7GXD.

This informal proposal is not being presented with the idea that it is the best solution to a multi-way connection at Level Two: rather it is suggested as a possible, compatible means of achieving this end.

CONCLUSION

AX.25 Level Two has been proven as a workable protocol in the Amateur Packet radio environment. With suitable extensions, based on field feedback from active Packet users, it can be made even more suitable for long term usage.

Some extensions have been implemented and tested in the field for an extended period of time: these extensions have been outlined.

The need for as-yet unimplemented extensions to allow multiple and multi-way connections has been pointed out and a possible approach for multi-way connections suggested.