D A M A - A NEW METHOD OF HANDLING PACKETS?

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Lately it seems we are hearing more and more stories about hams who are having trouble using their local node or digipeater. It seems that the user has no trouble hearing the digi, but the digi doesn't seem to hear the user at all. The symptoms almost match those where the receiver at the digi site is either dead or close to it. While that kind of failure is always a possibility, it is not the subject of this article.

The condition that this paper will talk about is one where the above symptoms do actually occur, but not from any lack of receiver sensitivity. Instead it is due to the digi's receiver hearing too many signals all at once and the remote user pretty much gets lost in the "noise."

The reason for this becomes obvious when we consider that while all the users may hear the digi/node just fine, they in many cases don't hear each other. Thus in some cases more than one station will transmit at the same time causing packet collisions. This situation is referred to as "a hidden stations" problem, and for remotely located users access to his or her favorite digipeater can become difficult to impossible during rush hour periods.

This is not a new problem, and in fact there are other services experiencing the same difficulties. A real world example is ships on the open sea trying to gain access to a communications satellite.

Several different experiments have been made to overcome this dilemma on amateur packet radio. One possible solution that is being pursued is through the use of full duplex digipeaters (BTMA), however there are several disadvantages to this approach. In a full duplex system the hardware expense will normally be much higher and the system will occupy two frequencies but will only realize the maximum throughput of one. A better approach might be to increase the throughput by reducing the collisions on a single channel system rather than spreading the load onto two channels. It would be ideal if we could incorporate a system that did this with something so minor as a software change (such as replacing the EPROM in a TNC) or by changing some operational parameters.

One of the methods used that attempts to solve the hidden station problem while still using a single frequency is called

DAMA (Demand Assigned Multiple Access). A description of this method follows.

In a connection oriented protocol environment, an end user will try to connect to the master (satellite) by means of a slotted ALOHA method. Collisions might occur during this phase, but they are tolerable since they are relatively rare. Once a connect request is recognized by the master, the connecting stations identification is added to a polling list and from this point on the master controls all connected stations. Permission to send data is granted by means of polls which might be included in ACK packets or even in transferred data frames. So in this case a user will only be allowed to transmit after receiving **"permission"** in the form of a poll sent from the master station. Once permission is granted several frames might be transmitted in a block. However, if the user does not respond within a given time frame (say around 1/2 second) then the master assumes that the poll got clobbered or the user never received it for some reason. The master then passes permission to transmit to all other active stations and when completed comes back to the first user and gives him another chance.

On the other hand, if the user (slave) actually receives the poll and replies with sent I-frames, the master will not acknowledge them until the next time around after serving all the other active stations. If when polled by the master the user responds with an empty frame (Receive Ready/Final), then the master will reduce the user in polling priority and will skip him on the next time around,

As the activity on the frequency increases, the polling priority of inactive users might be further decreased, but when these stations respond with an I-frame they will again regain their original priority.

If you understand the description just given, you might think that you are reading about AX.25 level-2 protocol and this is why **DAMA** has a chance of working over amateur packet radio. AX.25 L2 provides all the protocol elements that are needed to implement **DAMA** and no new syntax is required. Most of the new functions required could be obtained simply by patching existing operational parameters while the rest could be achieved by making some minor changes to the **TNC's** firmware.

So how do we actually go about incorporating **DAMA** using AX.25 protocol?

Due to the fact that there are no new syntax elements required, the following description will only use standard AX.25 terms. Since CSMA as well as **DAMA** is used, please interpret all further references to **DAMA** as **CSMA-DAMA.** The term **"POLL"** used throughout this text in no way refers to the poll bit in the control field of packet frames and this bit remains unchanged to ensure compatibility. The different phases of the protocol will be described separately below.

Connect Establish:

When a node attempts to connect to a user, the node adds the users ID to it's polling list and begins to send SABMs to that station. If after a certain amount of tries no UA is received, the user is assumed to be inoperable and is removed from the polling list.

When a new user starts a connect sequence to the node, he begins by sending SABMs to the master in a simple CSMA manner duplicating the existing method used today. Collisions are possible during this phase, so it might be necessary to repeat the SABMs several times until the node replies with a UA. Once the node recognizes the users connection attempt, the users ID is added to the polling list in a fashion very similar to the one now used by TheNet nodes (TheNet userlist) and the node (master) is now in control of the uplink users station. After the user sends the SABMs and the node replies with a UA, the user replies with an RR#O to signal to the node that it had a successful reception of the UA.

Idle State

As long as no information transfer occurs between user and node, (idles) then the node sends its polls as an RR with the corresponding count. If the response by the user is just an RR#, then the time until the next poll to this user will be lengthened to avoid unnecessary channel load. The exact amount of time added is determined by total channel activity.

If information transfer by other users on the node is high (as determined by the number of I-frames being sent) then the amount of time added before the next poll occurs to an inactive station is longer than in cases where there is only very little channel activity. Thus when the frequency is basically clear, the waiting times are reduced to a minimum so that no decrease in channel throughput takes place. This is the principle of the self-alignment mechanism of DAMA, where a channel is always regulated to insure its maximum possible throughput.

If the node ever fails to receive an RR from the user (due to a collision of the nodes poll or the users RR response) then the node will proceed on to the other stations on its polling list. The node will come back and try this station again after all other users on its list have been serviced. If after a certain number of transmitted polls this station still has not answered, then it is considered to be unavailable by the node and is then dropped completely from the list. This is analogous to those "keep-alive polls" that we have today.

Data transfer: Node -> User

There is no difference between regular CSMA and **DAMA in this case**, Because it is always up to the master (node) to act first, it could send one or more I-frames or a poll to the user. The user will acknowledge I-frames immediately with an RR#, but could also send its own I-frames with the corresponding count (having the correct count on the sent I-frame serves the same purpose as an ACK with AX.25). The meaning of the Poll/Final bit remains unchanged.

Data transfer: User -> Node

As mentioned before, the node will send polls to all users that are **uplinked** to it and the user will not respond until it receives this poll or an I-frame from the node. It may be wise to point out that when a user is polled he must always **come** back with **some** kind of response, even if it is **an** RNR#. If the node fails to hear any kind of response from the user then it assumes something went wrong (such as a collision) and **moves on to the next** user on its polling list.

This method of always waiting for a poll before transmitting is the central aspect used to avoid collisions in a situation where hidden stations exist. This is in contrast to the usual CSMA method where several stations can actually transmit at the **same** time. Additionally the problem of **deadtime** collisions is resolved. **Deadtime** refers to the period from when the TNC realizes the channel is free and starts transmitting, to when he has been on the air long enough for other **TNCs** to recognize his carrier. This is really not a rare case, as exemplified by the case where two or more **TNCs** are waiting for a digipeaters carrier to vanish so that they can leap on the frequency. Using **DAMA** the node will not acknowledge received frames the instant it hears them . Instead it will first service all the other **uplinked** stations and then come back with an RR# to the sending stations I-frames along with a poll to that station. This poll basically says "Have you got anything else for **me?"**

Disconnecting

If the master intends to cut the connection, it will send the usual DISC-frame to the user. The user will then promptly respond with a UA-frame (final bit set). If the node fails to receive the UA and again sends a DISC-frame, the user will respond with a DM-frame+ This is identical to the actual **CSMA version**.

When the user wants to disconnect from the node, he will wait to send his DISC-frame until polled by the master. At this point it makes no major difference whether the node responds to the user right away with a UA or goes through another polling cycle to do so, however an immediate UA is preferred.

UI-frames

In CSMA as well as in a DAMA environment, the UI frames are treated in a special way. I.E. These frames are used to carry some information besides the regular protocol traffic. Normally UI-frames are never sent from a user to a node, and it is not good headwork to make a habit of making UI-frame direct QSOs on the input frequency of a node, However, in contrast to a duplex system it is possible to actually do this. So although the rare UI-frames will reduce the throughput to the CSMA value, it will not drop to the much lower ALOHA value that would occur with a duplex digi having a QSO on its input frequency. UI-frames originated by the node are no problem since all stations receive these frames.

Other protocol elements

So we have gone from the beginning to the end in describing a complete DAMA session. We have not translated each and every AX.25 element into one that has special significance to DAMA. This is not required since many of them will keep their initial meaning. DM, RNR, REJ, etc will all be used as they were before, The only deviation from the pure CSMA version is in the fact that the users will only be allowed to transmit these frames after receiving permission from the master (node) in the form of a poll. The node will only transmit these frames after all other users on its list are served by the completion of one polling cycle .

Compatibility of DAMA and CSMA

One advantage of the DAMA method is that it does not require everybody to change everything all at once. However as additional users convert their TNCs to work with DAMA the more pronounced will become the increase in throughput. Even stations that are waiting to switch over could help to increase the areas throughput by changing a few operational parameters. For example the delay between the reception of a frame and the TNCs response (sometimes called T2 or DWAIT) should be reduced to a value under 1 second. In addition the time interval from when an I-frame is sent to when the TNC sends an RR# to ask for a pending ACK, should be set to a value that is clearly higher than the time between two polls of the master (usually more than 30 seconds at 1200 baud).

To fully benefit from DAMA both the node and the user must work together in the master/slave relationship. Assuming that the users TNC is capable of both the normal and the DAMA mode, there still remains the problem of how to tell the user to "turn DAMA mode on." There are several ways that this could be done:

1. Automatic detection of the protocol version by means of the protocol identifier byte or reserved SSID-octet-bits of the

node (Preferred version).
2. Implementation of a channel specific parameter which controls the protocol version,
3. Implementation of a new **UPLINK** command besides the current CONNECT command.
4. Implement a further protocol element such as a **SARM-frame** (similar to X.25) so that at connect time the node could alert the user to the increased features.

In case **#1** of the above it would be sufficient to tell the user to switch to **DAMA** mode only once, at connect **time.** This state would then remain in effect until disconnect. However since there is no PID field in SABM-frames this information has to be carried in some other way, such as utilizing the dormant bit 5 of the master's SSID address **field.** It is proposed that **DAMA** test versions set this bit to 0 to convey the necessary information to the users **TNC.**

Conclusion

The existing **AX.25** version was established in 1982 when packet radio was not as widespread as it is today. Most stations in the beginning were pretty much equal and there was no distinction made between DTE and DCE **functions.** However with the implementation of wide area networks not all stations are performing the same function. In fact today the network nodes are acting in a DCE function considering their control and information exchanging aspects. These functions will be better served with the implementation of **DAMA.**

The methods discussed in this article could increase the throughput on an AXm25 channel tremendously. One advantage is the avoidance of system breakdown which occurs with channel overload. Using **DAMA,** the throughput will increase continuously up to its maximum. There is no **foldback** effect like that which occurs using CSMA where at a special limit (above ca 60%) the throughput is actually **reduced.**

There is also a strong **"social"** aspect of **DAMA** wherein even the weak stations can work through the node reliably without being overpowered by stations close to the node.

It is possible to make direct connections with other **HAMs** on the **uplink** frequency unlike that of a duplex system. In addition the users **TNCs** still retain the digipeater capability inherent in our present simplex **system.**

All protocol elements keep their original meaning which allows both versions to be utilized on the same frequency, yet throughput increases as more and more users switch over to the new method.

Glossary

DM	Disconnect Mode
DISC	Disconnect Frame
FRMR	Frame Reject
I	Information Frame
REJ	Reject Frame
RNR	Receive not Ready
RR	Receive Ready
SABM	Set asynchronous balanced Mode
SARM	Set asynchronous Response Mode
UA	Unnumbered Acknowledge
UI	Unnumbered Information Frame

ALOHA	channel access without any coordination
CSMA	Carrier sense multiple access
BTMA	Busy tone multiple access

DCE	Data circuit terminating equipment
DTE	Data terminating equipment

Connection oriented protocol: All nodes of a network path know all other stations that are using this path, at least for some time . This version requires more computer power in the network nodes but avoids some unnecessary transfer overhead. In contrast to this is the connectionless protocol, where packets are simply handled over to the next peer (i.e. 'dumb' Level+-digipeating in Packet Radio).

Literature

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