An Emergency and Routine Communication
Network for Illinois
Using Packet Radio Techniques

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ABSTRACT

Amateur Radio teletypewriter and computer communication may be enhanced using a packet radio network to time share network nodes, detect and correct errors, expand geographic coverage, and facilitate bulletin broadcasting. The network is based on a common channel carrier sensed multiple access 0 persistent protocol. Application of such an area packet radio network to emergency and routine communication in northern Illinois is discussed.

INTRODUCTION

An excellent opportunity to enhance amateur radio communications for emergency and routine communication is now available to amateurs wishing to experiment with packet radio networking. Imagine, for example, approximately a dozen amateurs located within about one or two hundred miles of Chicago being able to carry on a half-dozen RTTY conversations, seemingly simultaneously, on a VHF frequency. If a heavy storm or tornado approaches one amateur, information concerning the storm could be automatically relayed to the other amateurs and the National Heather Service. General interest QST's, such as the ARRL bulletins. could be broadcast to the group. All this communication between amateurs who have either Baudot or ASCII RTTY systems running at almost any speed with error checking and correction! Using an inter-city land or satellite network, these dozen hams could even communicate with other amateurs around the country or the world.

This paper is intended to describe a proposed local or regional packet radio network, with special emphasis on the advantages of applying packet radio techniques to RTTY communications in Northern Illinois for emergency and routine communication. It is hoped that this article, and the others referenced, will tantalize the reader with the advantages and opportunitie s in experimenting and communicating using a packet radio network.

PACKET RADIO - A REVOLUTIONARY COMMUNICATION NETWORK

A Brief Tutorial Overview

Amateur radio communication has several forms:

- Casual Conversation
- Point-to-Point Messages
- General Amateur Bulletins
- Emergency Messages or Warning Broadcasts
- Experimentation

Each message has a priority, an orginator, and destination station or s ta tions. Messages are generally standarized in format, for example, the messages in the National Traffic System. A protocol of message handeling proceedures is used to move these messages through NTS.

Protocol

Similarily, in this context of automated RTTY communications and repeating (packet radio networking), a standarized format is used for the messages. Messages are broken into packets of' a convenient length, each having a standarized format (ref. 1). Of most interest in this generalized packet is the following header and trailer information:

- Address - destination station (with node or zip code) sending station
- Priority - indicating message urgency
- Sequence number of Packet - used for message reconstruction
- Checksum - eg. Cyclic Redundancy Check for error detection

A complete discussion of protocols and packet switching is beyond the scope of this paper. One reference (ref. 2), besides others referenced elsewhere in this paper, describes protocol layers and packet switching in a readable way. Like structured computer programming of subroutines, layering protocols allows increasing complexity to be implemented while keeping order and transparent operation.

The protocol (ref. 3) currently being used by the KA6M "repeater" and the Vancouver Digital Communications Group (VADCG) seems to lack provision for priori-ty message designation and handeling. Recognition of *emergency* traffic would cause stations to temporarily reduce or suspend non-emergency traffic so that the channel would not be overloaded.

Network

Packets are transmitted from station to station through a network of nodes:

- Terminal node - individual stations
- Repeater node - simultaneous repeating node (separate I/O freq)
- Store-and-forward node - (memory at node stores message for retransmission on the same freq.)

The network and station protocol determining the permissible actions or transmissions of the nodes will be crucial to successful network operation (see ref.4).

Interfaces for Network

Since each message may be broken into several packets, each with sync, header, data, and trailer information, to be sent at high speed according to the network protocol, a computer-based interface is needed for transmission and reception. While some amateur radio operators who already have a computer may sacrifice their time and computer for dedicated programming on a packet network, most amateurs will find a stand-alone interface board desirable for their terminal node packet radio use. This interface board, known as a terminal node controller (TNC), will contain a microprocessor with some RAM, and a multiprotocol serial communications controller (a very smart UART). The TNC (ref. 5, 6, and 7) has EPROM-resident software to convert the terminal data (almost any speed, any code, ie. ASCII or Baudot) into the serial data following the network protocol.

The radio used in a packet radio network should ideally have a short turn-around delay (less than 10 msec,) to reduce dead time between packets and reduce collisions (see ref. 4 for a detailed description of the radio requirements), Commercially available radios will require modifications to achieve low turn-around delay. Typical radios may be used, however, the 400 msec. turn-around time will reduce message throughput.

Repeater or Store-and-Foruard Nodes

A packet radio network will generally rely on multiple "repeaters" on the same frequency to relay packets, using the store and forward method- A store-and-forward node eliminates the need for costly duplexers. By receiving packets, and checking the packet for agreement with the checksum, error detection may he performed. Errors are corrected (by all nodes) by the lack of an ACK acknowledgement for a packet causing automatic resending, (In packet radio systems, where there is multiple contention for the channel, the transmission of a NAK for negative acknowledgement only increases collisions with subsequent data.)

If only one "repeater" is to be used in a particular packet radio network, then the conventional simultaneous retransmission repeater may be advantageous. Such a conventional repeater may receive greater support by certain groups due to the opportunity to repeat voice in additiot to packets, in some cases simultaneously. In this case the terminal nodes would ACK each other's packet through the repeater. A conventional repeater does limit the network in that multiple repeating, multiple routing is not easily supported.

Hank Magnuski, KA6M has succinctly stated the attributes of digital repeaters (ref. 6):

"The repeater serves to increase geographic range due to its advantageous location, it digitally regenerates the packet, providing all stations with a uniform signal, it selectively repeats only those packets addressed to it, allowing the possibility *of* multiple repeaters on the same frequency (an advantage instead of a curse!), and its beacon and packet-repeat facilities allow stations to do full-loopback testing, an invaluable resource in bringing up new equipment and checking out hardware/software modifications."

Features of a Packet Network

A packet radio network, like other forms of cooperation in our society, has much more utility as a system than the sum of its individual parts. Several important features of a packet radio netowrk over an ordinary serial communication link include:

- TDMA - Time Division Multiple Access
- Multiple Retransmission & Multiple Routing
- Error Checking
- Global or Selectjive Broadcasting

TDMA & CSMA

An attractive feature of a packet radio network is the nearly simultaneous use of the network by several commuaicators. The transmission rate through the network is chosen to be 10 to 100 times the message generation rate. Time is divided between various users to allow for multiple access, hence the term Time Division Multiple Access. For example, most people type at about 20 to 40 words per minute and the Baudot tape transmissions are sent at 60 or 100 wpm. With a packet network operating at 1200 baud approximately 6 to 10 different conversations may be on the network "simultaneously."

To reduce collisions between packets, carrier sense is implemented and to reduce repeated collisions, a random delay is allowed to pass before re-try. Thus, the Montreal Packet Net (ref.4) uses a common channel carrier sense multiple access network with 0 persistent protocol (CC CSHA 0 Persistent),

Multiple Retransmission - Multiple Routing

With a large area Packet badio Network, multiple repeater (store-and-forward) nodes extend the radio horizon and provide for multiple routing capability for netwark availability. For such a multiple repeating network, a common channel store and forward node is more appropriate than a conventinal two frequency repeater. The redundancy inherent in a large, multi-path network reduces network collapse due to a single node failure.

At some time in the future the ability to efficiently route packets along the best path (instead of all paths) will increase systen throughput,

Error Checking & Correction

For error reduction, packet radio net works generally use an acknowledgement (ACK) to signify successful packet reception. If an ACR is not received for a given packet, the sending node continues to retransmit and wait for an ACK for a certain number of times- The packet receiving node ascertains error-free reception by comparing the checksum with the data in the packet, This comparison may be done in software or dedicated hardware, The CRC16 (cyclic redundancy check) error checking scheme will detect all errors less than 16 bits in length, and 99% cf longer errors (ref.4).

Error correction may also be implemented using a scheme similar to error correction in dynamic RAM (Hamming codes). Additional bits are appended to each character allowing hardware reconstruction of the character without resending, if only a portion of the character was corrupted by noise.

Global Broadcasting

Global broadcasting of messages to all network users is enhanced in a packet radio network since the act of relaying is automatic, error detection and correction is inherent, and broadcast messages may be so coded in the header.

Examples of Packet Radio Networks

Currently, several groups are implementing and experimenting with packet radio networks. As outlined in ref. 1, the current major groups are:

- ARRL - American Radio Relay League, Newington, CT
- AMRAD - Amateur Radio Research & Development Corp., Washington, DC
- AMSAT - Radio Amateur Satellite Corporation, Washington, DC
- KA6M - Hank Magnuski et. al., San Francisco, CA
- VADCG - Vancouver Amateur Digital Communication Group, BC Canada
- HAPN - Hamilton and Area Packet Network, Ontario, Canada

A PACKET RADIO NETWORK FOR ILLINOIS

Current N. E. Illinois Emergency Network

For many years a Weather net" has been in operation in the greater Chicago area under the sponsorship of the N.E. Illinois Communication Association (ref. 8). The N. E. Il. Network (NEIL), WB9AGH, uses a frequency of 147.06 MHz simplex to transmit weather bulletins and ARRL bulletins at *60* wpm Baudot AFSK. Paper tape punched from the ueather wire is manually placed on a reader for transmission through a 250 watt base station with an antenna at about 80 feet. Several hundred stations continously copy the weather bulletins which during severe weather occupy almost all of the channel's throughput.

The appearance of microcomputers and the recent FCC deregulation allowing ASCII has prompted Robert Hajek, W9QBH, ARRL SEC, to consider semi-automated transmission of ASCII (in addition to Baudot).

operation Skywarn (ref. 9) currently relies on voice reports of severe weather situations to the National Weather Service. Since timly, accurate reports of severe weather, such as tornados, by on-the-scene observers, is essential in reducing damage and saving lives, an automated, error correc ting multiple access network capable of about one or two hundred mile coverage seems to be needed. What a perfect application for a packet radio network! A trained observer initiates a report automatically broadcasted to the appropriate network terminals.

Weather Telemetry

The detection, tracking, and prediction of severe weather using atmospheric radiation from severe weather (ref. 10) could be enhanced through a packet radio network (ref. 11). The needed telemetry in this system is angle, probability (ie. intensity), and time of occurrence for the sferics pulses. Using several unmanned stations scattered around the Central and Southern United States (the Rockies to the Appalachians), data could be collected, coded and sent every few minutes from the monitoring stations uia a terrestrial or satellite packet radio link. Data would be collected at a central processor to triangulate occurrences, weigh data accuracy, and infer expected severe weather trends. This information would then be made available, via the network,, to any interested party.

Other RTTY & Computer Activities in Chicago

The Chicago metropolatian area is home for many RTTY enthusiasts, some of whom use the Chicago Area RTTY Repeater System (CARRS) on 144.71 - 145.31 MHz. CARRS plans to have a mailbox system.

Many computer hobbiests who are also hams live in the Chicago area. In fact, the Computer Bulletin Board System (CBBS) was first described by two Chicagoians: Ward Christensen and Randy Suess, WB9GPM (ref. 12) .

Several other hams who have computers have commented to the authors they are individually developing a radio-accessible CBBS.

In summary, there is the need for an improved automa tic weather data network, potential amateur support exists, and the time is right for packet. radio experimentation. In fact, one logical name for this network would be CAPER - The Chicago Area Packet Emergency Radio Network since it will be a great leap (one meaning of caper) forward in message handling.

Since CAPER may connotate illicit activity, a more acceptable name could be CAPS - Chicago Area Packet radio System, Whatever the name, we look forward to the formation of a packet radio network and offer, in this paper, suggestions for such a network,

Desirable Improvements in N.E. IL Emergency Net for ASCII

As mentioned above, the NE IL Net would like to enhance the 60 wpm Baudot transmissions by offering a complimentary ASCII transmission. (It is assumed for economic reasons many stations will elect to retain their existing Baudot reception systems and will resist conversion to a packet radio network,) While surplus 110 baud Teletype model 33's are available for a modest $100 to $400 expenditure, not much is gained by transmitting at 110 baud ASCII to bardwired machines. For the present Baudot machine owners, this money would probably be better spent on a packet radio terminal node controller board. (It is a well known fact that hams are cheap, or a% least are being squeezed by inflation like everyone else-)

For the few hundred dollars an ASCII machine costs, the RTTY ham is probably better off purchasing a terminal node controller if a packet radio network is available. En fact, the VADCG style TNC boards could provide even more utility and value for the HF RTTY amateurs, A straight ASCII to Baudot and Eaudot to ASCII code and speed Converter, without packet generation, could be programmed if not already available.

Briefly, the desirable improvements proposed for the NE IL Emergency Net are:

- Two way automated communication
- Wider area coverage, especially to the West from where storms originate
- Routine ham-to-ham communication to encourage packet node construction
- Higher throughput, ie. emergency bulletins should be flashed at several times the 60 wpm speed
- Priority queueing and handling of messages
- Bulletin board service for bulleting and messages
- A regional packet radio network using protocol compatable with other area and the eventual worldwide HF and satellite AMSAT International Computer Network (AMICON)
- A protocol compatable with the VADCG TNC board for simple amateur implementation, simplified software upgrade by EPROM replacement, and protocol offloading to a dedicated processor/interface
- Simplified store-and-forward node implementation by amateurs at their home stations
- Two way link with present Baudot users (features of the packet radio network available through a standard, non-packet, Baudot AFSK VHF station)
- Operation of the statewide Common Channel Carrier Sense Multiple Access 0 Persistent network on a 2M FM simplex frequency using 1200 baud Bell 202 compatable modems, 2H FM use would be initially encouraged to ease the transition to packet, ultimately 2.20 MHz may be better due to desense, specturm crowding, etc.

Priority Queueing and Transmission

The literature on packet radio networking as applied to amateur: and HDLC VLSI chip implementation seem to ignore priority queueing and transmission, While compatability with the Intel $273, 8274, and Western Digital 1933 is commendable, we wonder if and how high priority packets should be handled? For example, a message "Tornado spotted at 3 PM in Southwest Suburb headed N.E. at 30 mph" should have priority over almost every other packet on a network and new low priority packets should not be introduced to the network until the emergency has passed. Possibly priority queueing is more appropriately implemented at a different protocol layer (ref. 13), ie. layer 2. Intranet, end-to-end rather than the layer 0. line control or layer 1. Intranet, node-to-node. As an example, priority queueing of certain messages is used in the SITA worldwide airline reservation network. (ref. 14).

Individual Ham Station Implementation

The above list contains advantages of packet radio implementation while at the same time illustrating the complexity of the network implementation. Fortunately, each ham does not need to be an expert computer programmer and data transmission engineer,. Just stuff the TNC printed circuit board with a pre-programmed EPROM, 8085 microprocessor, and the other support parts. Procure or build a 1200 baud modem (TU for you RTTY fans) and use almost any terminal,

Needed FCC Removal of Restrictions

It would seem to us that the FCC should be called upon to remove several restrictive regulations to promote packet radio networks.

- The requirement for a CW ID should be dropped as long as the callsign is sent in a common code eg. Baudot or ASCII
- The restriction on codes other than Baudot or ASCII should be dropped (excepting callsign) to allow synchronous data
- The requirement of a control operator present at a station engaged in digital communication should be dropped to allow unattended acknowledgements for received messages, and radio accessable Computerized Bulletin Board Systems

CONCLUSION

Packet radio networking will tremendously enhance communications in the Greater Chicago and Illinois area. The need for more reliable, automated emergency communication is great, We look forward to receiving comments at the Computer

Networking Ccaference and establishing diaglogue with interested amateurs.

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