Results of HF Digital Protocol Survey

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On February 22, 2007, the ARRL Web site carried a Request For Information (RFI) on HF digital protocols. Input was sought toward development of non-proprietary, open- source protocols suitable for use by amateurs over HF fading paths. The RFI asked for views on the following:

- Access Method
- Data Rate and Bandwidth
- Adaptivity
- Robustness
- Error Control
- Activity Detection
- Operating System
- Hardware

By the end of July, 83 respondents emailed their views. We thank those who have taken the time to consider these questions and share their insights. Many of the responses were general and non-technical. Nevertheless, some provided valuable technical information. They were supportive of the League's initiative to develop new non-proprietary HF protocols. A few asked *why* the ARRL was getting involved in this protocol development. Some pointed to existing technologies that could satisfy Amateur Radio needs.

The following is a restatement of the questions (Q.) posed along with a summary of representative majority of comments of the respondents and some different views.

Access Method

Q. Is Orthogonal Frequency-Division Multiplexing (OFDM) the best candidate technology, or should other competitive technologies be considered?

Many comments supported OFDM as the best candidate but some said there should not be a single method as it discourages innovation.

One respondent said that OFDM may not be effective because of ionospheric changes as it is not resistive to Doppler.

Another respondent said, "I do not think OFDM is a suitable mode because of the high crest-factor. Amateur equipment is typically designed for SSB or CW with a peak to average power ratio in the order of 3 dB. With reasonable precautions to avoid a coding scheme that uses too many carriers simultaneously one might keep the crest-factor as low as 10 dB. With an amateur transmitter designed for 100 W the maximum average power output would be 10 W."

A number of respondents familiar with US military and NATO HF data protocols said that tests have shown "better success with adaptive equalizers and PSK/QAM, but that does require a fair amount of DSP horsepower. OFDM candidates have not compared well with the serial-tone approach, but perhaps the performance loss is acceptable if you can implement it on a sound card."

Another respondent said: "The interoperability and performance standards for data modulators/demodulators (modems) described in open-source (non-proprietary) MIL-STD-188-110B should be considered as a competitive technology for amateur use over HF fading paths. This document contains technical standards and design objectives for minimum interface and performance standards pertinent to voice frequency modems which have been

designed to operate in both long-haul and tactical communications. As an example, Appendix B of MIL-STD-188-110B describes, in detail, a protocol and overall set of requirements for a parallel tone-mode using 39 orthogonal sub-carrier tones in the audio frequency band using quadrature differential phase shift keying (QDPSK) modulation for both bit synchronous and asynchronous data transmission. Comparison of Orthogonal Frequency Division Multiplexing (OFDM) with already developed and implemented standards and protocols used for military hardware modems for QDPSK (and other possible modes) need to be accomplished before a decision can be made on best candidate technology."

Data Rate and Bandwidth

Q. What data rates/throughputs are achievable at various bandwidths up to 3 kHz bandwidth?

Most respondents realized the relationship between bandwidth and possible data rates. Some favored specific bandwidths and data rates for different applications, such as less than 300 Hz for keyboard-to-keyboard QSOs but wider bandwidths for data, images and e-mail file transfer. Some said not to exceed 3 kHz but others advised against mixing wider and narrower band signals in the parts of a band.

Advocates of MIL-STD protocols said that NATO STANAG 5066 can adjust data rate for each transmission. It is used today with military modems having data rates from 75 to 19,200 bit/s (the higher speed works only in 6-kHz wide channels).

Adaptivity

Q. What adaptive features should be considered, such as automatic adjustment of transmitter power, modulation waveform and coding, in order to maximize throughput and efficiency in two-way contacts?

Several respondents advocated the ability of automatic adjustment of data rates up or down according to conditions. Others suggested changing a combination of baud rate and coding level. Some said that transmitter power level could be hard to automate and advised against changing modulation waveform.

Some respondents promoted the use of Automatic Link Establishment (ALE), which includes adaptive features.

Robustness

Q. What is achievable for reliable operation at power levels typical in the Amateur Radio Service and low signal/noise and interference ratios?

There was not a common theme among the responses but a list of different ideas that would contribute to robustness. For example, one respondent said that OFDM is more robust against multipath distortion. Another recommended coding gain and ARQ. Yet another noted that the MIL-STD has a table of bit error rates vs signal-to-noise ratios.

Error Control

Q. What are the appropriate applications of error control suitable for HF channels? For example, how should Automatic Repeat request (ARQ) and Forward Error Control (FEC) be applied to two-way contacts and one-to-many (roundtable and bulletin) transmissions?

Respondents recognized the value of ARQ for two-way contacts and FEC for one-way transmissions. One respondent said that the protocol should support point-to-point and one-to-many QSOs. Another said to use FEC with optional interleaving but not to use arcane interleaving like SITOR-B. Some respondents said that a modest amount of FEC should be used in each mode. The error-control provisions of the MIL-STD were mentioned by one respondent.

Activity Detection:

Q. What is an effective method of determining whether a frequency is busy prior to transmission?

There were different views on the potential effectiveness of an automatic listen-before-transmit (LBT) scheme. One respondent said that KN6KB's SCAMP already incorporated an effective LBT method.

Operating System

Q. What operating systems (such as Windows or Linux) are appropriate for Amateur Radio use with this protocol?

While there were proponents of various computer operating systems, a number of respondents recommended that any new protocol be independent of the operating system, in other words they should be "OS agnostic."

Some advocated Linux over Windows or Vista, while one respondent suggested Windows XP.

Hardware

Q. What practical and affordable hardware platforms are suitable for amateur stations? Consider the use of personal computers with or without sound cards. Provide any information about the need for an additional "box" if needed.

While some respondents said that the protocols should operate on personal computers and sound cards, there was a common thread that any new protocol should be *independent* of the specific hardware platform. However, there was a recognition that hardware would have to be considered in *implementations* of the protocol.

Conclusions

In the Amateur Radio community, there is an interest in new HF digital protocols that are non-proprietary and open.

There is a divergence of views on the technical features of any new protocols.

There is a small but growing group interested in and using, MIL-STD HF protocols including ALE.

The general view was that protocols should be independent of hardware and computer operating systems.

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