

Title: **Proposal for 802.11 reply to FCC NPRM 96-8**

Date: May 1996

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Dear Sirs,

The IEEE P802.11 committee would like to address the FCC NPRM 96-8, and specifically regarding the Petition for Rule Making by Symbol Technology regarding decreasing the number of channels, which was denied by FCC. The initiative to reply to the NPRM started in the Frequency Hopping subcommittee and was approved by the whole IEEE P802.11 Committee.

Summary of IEEE P802.11 position

We would like to speak in general support of Symbol's proposal. We propose to amend it by a requirement saying "For a system occupying a total bandwidth of at least 75 MHz the number of hopping channels will be no less than 20" in order to resolve the concern about uneven use of the band. We recommend to increase the allowable FH bandwidth from 1 MHz to 4 MHz to enable use of the previously described amendment.

We feel that the permission to use fewer but wider channels should be issued without transmit power penalty. The arguments for that are described below. Yet, if we need to prioritize issues, it is of higher priority to us to allow higher bandwidth than to maintain the full power level.

Disbalance between DS and FH systems in current regulation

When comparing DS and FH portions of the IEEE P802.11 standard it can be seen that although both types of systems achieve 1 and 2 Mbit/sec operation, the theoretical difference in sensitivity between the DS and FH system is around 8 dB. This difference results from the need, when operating with the chosen GFSK method at 1 Mbaud/sec, to reduce the frequency deviation to the extent that the resulting signal fits within the 1 MHz bandwidth.

The current regulation 15.247 of CFR 47 enables DS system to increase its baud rate up to 8.35 MHz (83.5 MHz divided by processing gain of 10). Although no company went to such extreme, the most popular DS wireless LANs (AT&T, Aironet etc.) operate at 1 Mbaud/sec, achieving 2 Mbit/sec operation, and there are systems with 2 Mbaud/sec (Windata) achieving 6 Mbit/sec. On the other hand, FH systems, with the 1 MHz channel bandwidth limitation cannot practically exceed the 1 Mbaud operation. It is correctly stated in the NPRM that future FH systems may utilize quadrature modulation for increased efficiency. Even then, the baud rate of such system will be limited practically to about 700-800 kBaud/sec (e.g. quadrature modulation with rolloff factor of 0.3-0.4) and therefore will still be in disadvantage with respect to DS systems. In order to enable future FH systems to compete fairly with DS systems which can be practically constructed under current regulations (in the sense of using same baud rate and utilizing modulation methods with similar E_b/N_0 requirements), FH channel bandwidth needs to be increased to about 2.5-3 MHz.

It may be argued that FH systems have an advantage of having larger number of simultaneously operated frequency channels. On the other hand this advantage comes with the penalty of reduced instantaneous data rate. In many applications (such as software upload, file transfer, printing) systems are judged by the instantaneous bit rate and not by aggregate bit rate over the whole system. By allowing system designers to trade the number of simultaneously available channels for instantaneous bandwidth a better service to the customers can be provided.

We believe that inclusion of both DS and FH systems in 15.247 regulation meant providing for equal opportunity to both types of systems to compete in the market. In this respect, allowing wider channels for the hopping channels will improve the balance in capabilities of both types of systems.

Coexistence and mutual interference discussion

It will be shown below that for wideband FH hopping over same total bandwidth the interference either caused to or accepted from other systems (DS and narrowband FH) is not worse than today.

Interference caused by FH system to DS system

It was argued in replies stated in the NPRM that FH systems with wider bandwidth will interfere more with DS systems. This argument is incorrect, to our opinion. Let us look at the example of 1 Mbaud system with 13 dB of processing gain, i.e. 20 MHz bandwidth. When disturbing signal appears within its bandwidth the interference caused to the DS system is the total received power of the interferer reduced by the processing gain factor (in our example 13 dB), irrespective of its bandwidth, be it 1 MHz, 2 MHz or 4 MHz. The probability of collision between the FH interferer and the DS system is also determined mainly by the DS bandwidth. In the case of same example, FH system hopping over 80 MHz will interfere with 20 MHz DS system in 25% of its hops, irrespective of its bandwidth.

Susceptibility of FH system to interference caused by DS system

The degradation experienced by FH system due to presence of DS interferer depends solely on the power spectral density of the DS interferer versus the thermal noise spectral density. Wideband FH system will collect more interference power in its receive filter than a narrowband FH system, but it will also receive more thermal noise, so that the degradation factor will remain the same. The percentage of hops in which the FH system will receive interference from the DS system depends mainly on the DS system bandwidth relative to the hopping bandwidth; for example, 20 MHz wide DS transmitter will interfere with FH receiver hopping over 80 MHz bandwidth in 25% of the hopping channels.

Interference caused by Wideband FH system to Narrowband FH system

The degradation experienced by a narrowband FH system from another FH system being received at given power depends on the fraction of the power within the receiver bandwidth. For example a 1 MHz wide receiver, when receiving interference from a 4 MHz wide FH system, will receive only 1/4 of the interferers power. This is better than being interfered by 1 MHz wide system. On the other hand 1 MHz system will collide with 4 MHz system 4 times as often than with a 1 MHz system. The two factors (decrease in interference power and increase in percentage of collided channels) offset each other in the same manner as when examining interference caused by a DS system to a FH system. Assuming that FH systems can coexist with interference from DS systems, they can coexist also with wider FH systems.

Susceptibility of Wideband FH system to interference caused by Narrowband FH system

When FH system receives interference from same or narrower FH system, degradation experienced by it depends on total received power. Therefore, as long as the regulatory power limit remains the same, the amount of interference received will not vary. The percentage of time in which collisions will occur will be dominated by the number of channels of the wider system.

Fairness in occupying the ISM band evenly

Some remarks to NPRM state that reducing the number of hop channels creates a possibility to abuse the ruling by implementing a 1 MHz bandwidth FH system with 20 channels and crowding all of them on one edge of the band. As discussed earlier, the coexistence properties of FH depend on total system bandwidth. Therefore we propose to accept the Symbol's petition with the following amendments:

“For frequency hopping systems operating in the 2400-2483.5 MHz or 5725-5850 MHz band the occupied bandwidth will be no more than 4 MHz”

“For frequency hopping systems operating in the 2400-2483.5 MHz or 5725-5850 MHz band the minimum amount of nonoverlapping hopping channels will be no less than 75 for systems utilizing up to 1 MHz wide channels. For a system occupying a total bandwidth of at least 75 MHz the number of hopping channels will be no less than 20. “

Transmit power considerations

As indicated in the analysis above, the amount of interference produced by a FH system to DS systems is dominated by its power rather than bandwidth. Therefore we recommend to allow wider channels without requiring reducing the power for wider transmitters.

Why modify ISM regulations when other bands are being considered?

It was argued in NPRM that opening new frequency bands reduces the need to modify the ISM band ruling. We feel that providing a growth path within the ISM band is important in order to take advantage from the investment in technology for that band, for harmonization with the European CEPT rulings which apply to this band and improving worldwide competitiveness of the US industry.

Summary

The IEEE P802.11 committee members feel that in spite of being just in the last stages of finalization of the first version of the standard there is a need to approach FCC with a request to modify it's ruling so as to enable future improvements in the standard and enable growth in performance in future versions. Therefore we speak strongly in support of Symbol's petition, with the amendments and changes outlined along the text.

Yours sincerely,

Signature