IEEE P802.11
Wireless LANs

Should FCC accept High Speed DS?

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In November 1997 members of 802.11 held a conference call with FCC. FCC changed recently its definition of DS "Processing Gain" from one based on bandwidth ratio into one based on "Jamming Margin". One of the byproducts of the discussion was a suggestion of FCC to 802.11 members to come with a recommendation, what constitutes a reasonable definition of "Spread Spectrum".

Recently there has been a wave of systems which keep the ratio of chip rate to symbol rate reasonably high, but load many bits onto each symbol. Of the modulation methods presented to Task Group B most utilize this concept:

Micrilor: 5 bits biorthogonally coded onto a 16 chip sequence (4 bits orthogonal + 1 polarity), Walsh codes for orthogonality. 32 Mchip/s, 10 Mbit/s.

Lucent: 8 bits coded as two groups of 4 bits, each coded biorthogonally - 8 coordinates, 2 polarities, I&Q, 11 chips, orthogonality by position modulation. 11 Mchip/s, 8 Mbit/s

Harris: 8 bits coded as two groups of 4 bits, each coded biorthogonally - 8 coordinates, 2 polarities, I&Q, 8 chips, orthogonality by Walsh functions. 11 Mchip/s, 11 Mbit/s

Golden Gate Technology: 22 bits/symbol - 11 orthogonal 12-bit sequences, each QPSK modulated, all added. 11 Mchip/s, 20 Mbit/s.

The first point I would like to argue is that biorthogonal signaling is a form of coding. In particular, 4 bit biorthogonal signal set is created by a Reed-Muller code with generator matrix:

0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

This code is special in that it is easily soft-decoded by Walsh transform.

This means that, for example, Harris system is no other than a 22 Mbit/sec QPSK transmission with an R=4/8=1/2 error correcting code, achieving thus a 11 Mbit/s rate. So where is the spreading? If the system would be presented this way, FCC would throw it away, but as a DS system with coded modulation it's OK. This general idea can be pushed *ad absurdum*: Let's use a Reed Solomon code with some 2000 bits in it, declare that it is a DS system with processing gain 33 dB and convey 1800 bits in each symbol!

The Golden Gate technology proposal is different in that there is not even coding involved: just 11 overlaid QPSK users emitting synchronously from same antenna.

So, given that the DS concept is by now hardly there, that the systems are fully loaded transmitters with about 1 bit/Hz, should we recommend FCC accept those disguised as DS systems?

Well, in some cases yes! (surprised?)

The first point is that this systems do not cause more harm to others than any regular DS transmitter with same chip rate, as the power is limited to same 1 watt, the bandwidth is same so the Power Spectral Density is same and interference is same.

The main difference is in the ability of the new equipment to accept interference from other emissions, digital or not. As the data rate goes higher, the required Signal-to-Interference ratio rises. One manifestation of that is that many of those systems are jammed even by their own multipath echoes! But, why FCC should bother? It is something between the equipment vendor and the customer, if there are unrealistic performance claims. Given that sufficiently sophisticated receivers are used, the main effect is a reduction in range, and if the customer is aware of that then everything is OK.

But FCC does care. It states specifically that the customer should receive protection by use of robustness-improving techniques, namely Spread-Spectrum. In this situation the least we can do is to prove that we done our best to protect the customer and make the equipment as robust as possible. Usage of good Error Correcting Code does preserve the spirit of that intent. My opinion is that we can recommend the new coded DS systems to FCC, even though those are hardly Spread Spectrum systems anymore.

As a standards body, we have another problem. We specify what should be transmitted, but not how should it be received. In that sense, we do not protect the customer enough from simplistic implementations which are not sufficiently robust to multipath. I would recommend that the standard shall include a clause that a conforming PHY shall perform with less that 10% FER for some reference multipath model which can be reconstructed in laboratory, say, two-ray channel with 200 nsec ray spacing and prescribed amplitude ratio (say, 6 dB). That will cause conformant PHYs to implement some robustness-improving techniques before those are sold to customers, and in that way the spirit of FCC of protecting the customer from fragile equipment will be preserved.

A final note is due regarding FH. If 802.11 takes the route of recommending quasi-DS systems as long as those are robust, same can be done regarding the recommendation to FCC to allow wider channels in FH. The amount of interference caused to other users will be similar, as in case of wider channels the PSD will be lower for same power. I recommend that if 802.11 will issue a positive statement regarding quasi-DS, it will recommend as well a change in rules that will allow FH systems with higher bandwidth as well.

Peace.