IEEE P802.11
Wireless LANs

Comment on clause 10 on NPRM 99-149
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In the NPRM FCC 99-149 the FCC asks for comments on HWN's assumption that wide band frequency hopping systems will be unable to consistency achieve substantially greater data rates than 1 MHz systems.
This comment by Lucent Technologies is to support HWN's view in general.

Currently employed frequency hop systems complying to Part 15 employ 2 or 4 FSK (1 or 2 Mbit/s) while having a 20dB bandwidth of 1 MHz. The benefits of these systems are that they are relatively cheap to manufacture, having non linear signal processing components, while they have reasonable performance in a multipath environment.
The narrow band FH systems work satisfactory in environments where the delayspread figures are up to the range of 100-200 nanoseconds, which figures can be measured in big retail stores and manufacturing facilities. Although these channels in the 2.4 to 2.5 GHz band are characterized by a lot of dips in the frequency spectrum, the FH systems work because of the frequency diversity
capabilities inherent to the hopping. The narrow band frequency hopper experiences a dip in the frequency spectrum as a flat fade. If because of this fade no transmission is possible at the particular frequency, the chance to be in a fade again at the next hop (next 1 MHz frequency channel) is small.

By widening the bandwidth of the frequency hopper to 3 or 5 MHz, the hopper has to deal with multipath in stead of flat frequency fading. The chance to have a frequency dip within the band is higher. Also at the next hop (frequency) the chance that no transmission is possible because of multipath is higher.
Generally speaking, there is a linear relationship between the intersymbol interference caused by multipath and the symbollength: so, widening the bandwidth of a transmission system with a factor x (without changing the modulation method) makes the system x times more susceptible to multipath.

For a 5 MHz wide frequency hopping system employing 2 or 4 FSK (up to 10 Mbit/s) this means that the system can only tolerate delayspread figures up to 20-40 nanoseconds. These delayspread figures are measured in ordinary rooms. Further, in low cost implementations, these figures can be introduced by the transmit and receive filters, thus reducing tolerance to multipath to almost zero. Such systems would not be viable from a user point of view.

From above reasoning we conclude that a 5 MHz wide frequency hopper employing FSK will not work in a normal environment. If a transmission at one hop frequency fails, a retransmission at the next hop has the same chance on failure. To get data through the frequency hopper has to fall back to a narrower bandwidth with a lower data rate.

Of course, a wide band FH system can be designed to be more robust against delayspread. If the same modulation method is maintained, then a form of equalization is necessary. Apart from the higher amount of (signal) processing, which increases component cost, equalization also requires linear processing in both transmitter and receiver increasing the cost of (linear) components.
Other modulation methods, that are by nature more robust against multipath, can be employed in wide band FH systems. These methods however require linear components and a high amount of signal processing.

To bring the delayspread robustness for a wide band hopper to the level required for normal operation, there is a cost increase (nothing is free). The required components (linear power amplifiers, linear receive functions (AGC), DSP components) bring the cost to the level of currently employed Direct Sequence systems or higher. Direct Sequence systems are running at 11 Mbit/s and with adequate robustness against delay spread effects. The costs of these type of equipment are decreasing rapidly (refer to the Apple's Airport product announcement in August this year).

Based on above arguments it can be concluded that HRFWG's claim that wideband FH services in the future could be implemented at lower cost and with greater multipath robustness than nowadays DS systems operating at comparable speeds does not hold and is misleading.