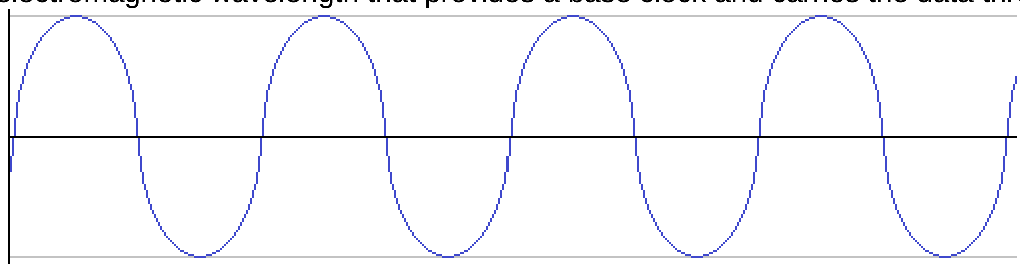
WIRELESS SIGNAL MODULATION

This article doesn't cover anything needed in day-to-day networking, but I've found this useful to give me insights into the workings of wireless. Also, although the article is named 'Wireless signal modulation', the mechanics are the same for every analog medium that has to transport digital signals, such as coax and DSL.

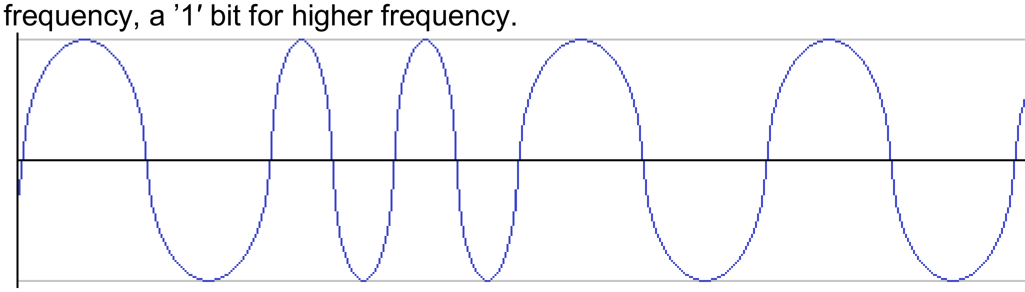
How does digital data go through the air? For starting, it needs a carrier signal: a certain electromagnetic wavelength that provides a base clock and carries the data through the air.



This is a basic carrier wave that does not contain any data. Transporting digital data, bits, over this can be done in different forms:

Frequency Modulation

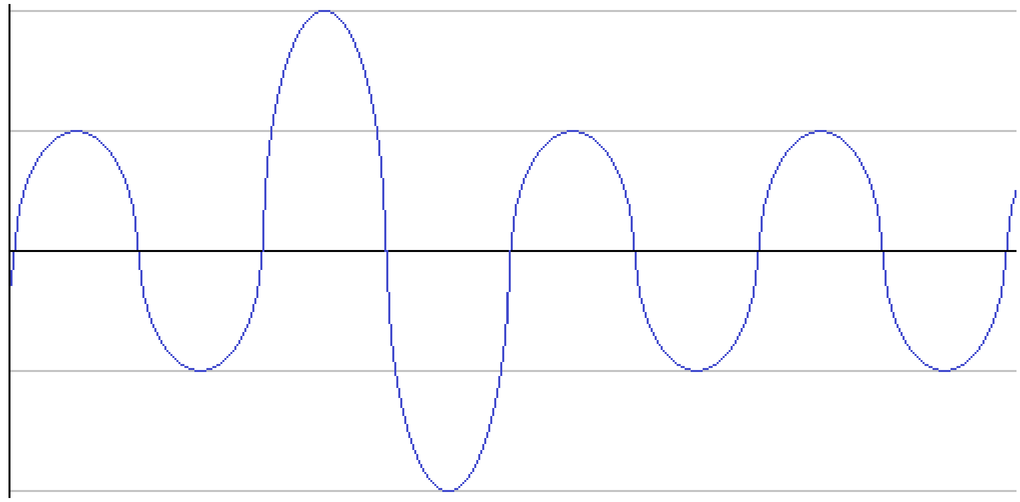
This form of modulation changes the frequency of the carrier wave: a '0′ bit for normal frequency, a '1′ bit for higher frequency.



So the above would be read as '0100′. I'm making an exaggeration here in the picture, displaying the '1′ as double the frequency as a '0′. In reality, it would be just slightly higher.

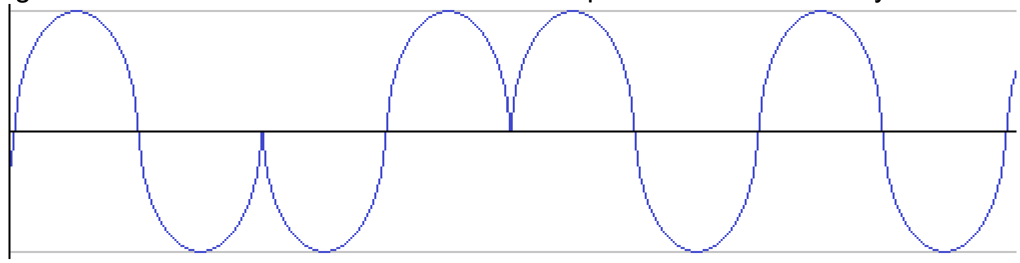
Amplitude Modulation

Changing the amplitude, or intensity of the wave, is another form of modulation. A higher energy wave means a '1′, so the same '0100′ from FM would look like this in AM:



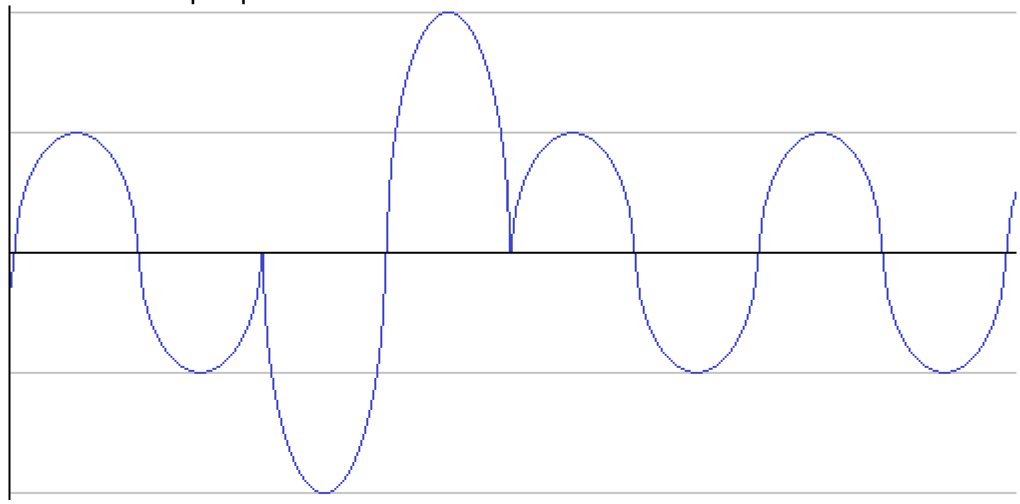
Phase Modulation

This one might be a bit more difficult to see: each 'up and down' from the carrier wave is one phase. By changing the starting point of each phase, it's possible to encode information in it. Again the same '0100' where a '1' means the phase will start halfway:



Quadrature Amplitude Modulation

QAM is what modern wireless uses. It's a combination of the above. In most cases it's AM and PM or AM and FM combined. The use of combining these modulations is that you can encode twice as much per phase.



The above is '00110000' in QAM, using AM and PM combined. But so far, it's only one bit per modulation per phase. This can be extended. For example, by using 4 different wave intensities (amplitudes), two bits at a time can be transmitted (00, 01, 10 and 11 are four combinations). Multiple frequency changes allow for more than one bit as well, and by starting the phase not only halfway, but also at 1/4, or even 1/8, more bits can be carried. For example, QAM-16 looks like this:

Each phase here can carry four bits (a total of 16 combinations) at a time. Each phase here is called a ‘symbol’ because there’s a unique waveform or symbol for each pattern. The first two bits in this example are the amplitude part: ’00′ for a normal wave, ’11′ for the second wave, which have a four times higher amplitude, and so on. The remaining two bits are from the phase: ’00′ for a normal phase, ’01′ for a phase that starts at 1/4.

Modulator and antenna sensitivity

Now, unlike what most people think, a higher quality (and higher priced) access point doesn’t transmit more signal, thus having a better coverage. In most cases it’s just as much as a cheap access point, because of government regulations. In Europe, an access point is not allowed to send out more than 100 mW at 2.4 Ghz. The reason higher quality access points work better is in their ability to more precisely generate the carrier wave, and the higher sensitivity to pick up the signal correctly from other devices.

In reality, the carrier wave isn’t perfect. There are always small deviations from the ideal wave. Within certain thresholds, the receiving station can still correct this. A higher quality access point generates waves that deviate less from the ideal wave, thus making it easier for other devices (laptops,…) to pick up the signal correctly, even over greater distances. In return, these access points have more sensitive antenna’s that can pick up weakened signals that a lower quality access point could not have.

Frequency

The base frequency for most standards is fixed. 802.11b & 802.11g use the 2.4 Ghz band, 802.11a and the new 802.11ac standard use the 5.0 Ghz band. Only exception is 802.11n, the current mainstream standard, which can use both bands. This does have some consequences: while 2.4 Ghz did a better job penetrating through most materials compared to the 5.0 Ghz band, it does work at the same frequency as a microwave oven. Turning a microwave oven on near a laptop does decrease throughput (note: a microwave leaks a small amount of radiation, see this link for study results). My own tests gave a 40% decrease in throughput on 2.4 Ghz wireless at 3 meters distance of a microwave oven.

On the other hand, switching to 5.0 Ghz does often result in a little less coverage (except outside of course). I had about 10% less throughput in my own house when switching to the 5.0 Ghz band. But 10% is not that much and it also depends on what other nearby access points already use. But it does make a point: if you're using the 2.4 Ghz band right now, there's no real guarantee that your brand new 802.11ac router in a year or two will give the same coverage everywhere in the house.

Source : http://reggle.wordpress.com/2013/04/03/wireless-signal-modulation/