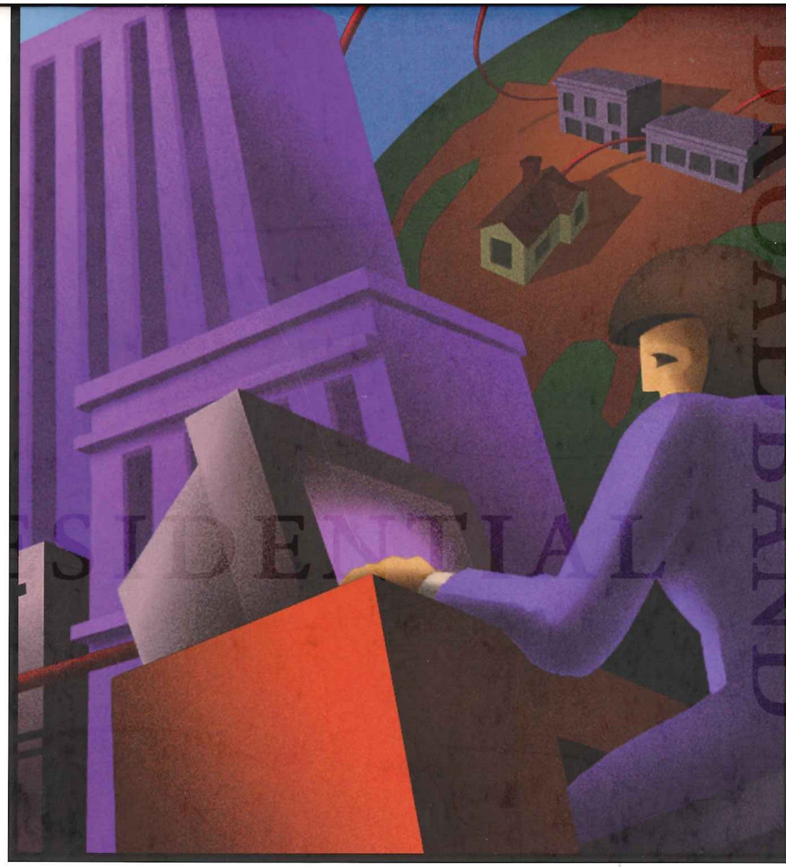

George Abe

A comprehensive review of the technical, business, and regulatory challenges of high-speed residential networks

RESIDENTIAL BROADBAND

SECOND EDITION

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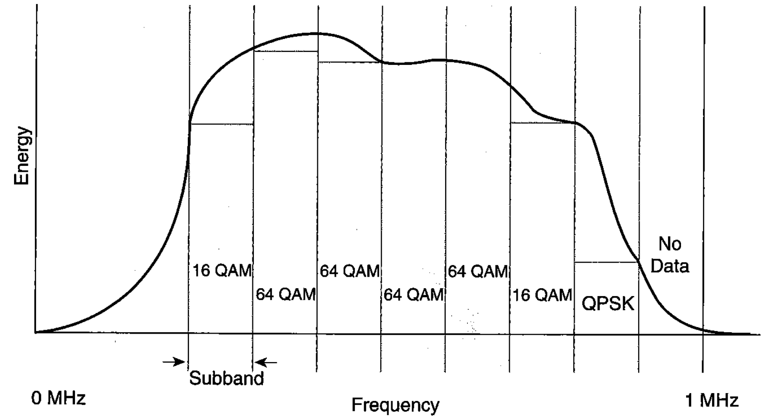
Figure 2-7 *Multicarrier Modulation*



Multicarrier techniques have a latency penalty (time delay to transmit a digital bit) compared with single carrier. In the DMT case for ADSL, there are 256 subbands of 4 kHz each. So no bit can travel faster than allowed by 4 kHz, even if the line was perfectly clean.

One of the noisiest debates about modulation techniques is between proponents of DMT and proponents of CAP for use in ADSL. DMT for ADSL uses 256 subbands, whereas CAP uses a single carrier with amplitude modulation, very similar to QAM. At the time of this writing, CAP has an advantage over DMT in that it consumes less power (thereby generating less heat) and costs less because it is more mature (more units in the field, greater integration). It is easy to see how DMT scales and why DMT has been selected by ANSI T1E1.4 and the International Telecommunications Union (ITU). Furthermore, a number of U.S. telephone companies have selected DMT. Because of these factors (and because of commercial issues with respect to the licensing of CAP), it appears DMT is gaining the upper hand for ADSL.

Considerations in Selecting Modulation Techniques

Selection of modulation technique for each Access Network has been highly contentious, partly because there's a lot of money at stake. Standards organizations for cable TV, xDSL, and HDTV have spent years arguing the requirements of modulation, let alone the choice. While commercial self-interest, academic background, national pride, embedded base and personal ego play a role, there are engineering and cost tradeoffs to consider as well.

Some of the majors engineering considerations are listed here:

- **Scale**—Will the modulation support large systems and fast bit rates?
- **Noise immunity**—Can the modulation scheme operate reliably in with real-world impairments?
- **Packaging**—Can Application Specific Integrated Circuits (ASICs) be built? Can implementations be used in a variety of environments, such as different Access Networks? How large are the components, and how much power does the technique consume?
- **Performance**—What is the spectral efficiency? What is the latency?
- **Cost**—This is the dominant factor when dealing with consumer markets.

The modulation schemes described in this chapter are likely to be residential broadband alternatives. Table 2-2 lists services and their respective modulation schemes, current as of this writing.

Table 2-2 *Modulation Techniques for Current Services*

Service	Modulation Technique
ISDN (United States)	2B1Q
U.S. Direct Broadcast Satellite	QPSK
U.S. Digital Over-the-Air Broadcast	Vestigial Sideband (VSB)
U.S. Digital Cable Forward Channels	QAM-64, QAM-256
U.S. Digital Cable Return Channels	QPSK
European Digital Over-the-Air Broadcast	OFDM
High Bit Rate Digital Subscriber Line (HDSL)	2B1Q
Asymmetric Digital Subscriber Line (ADSL)	DMT, CAP

Viewpoint: Interoperability of Modulation Techniques

The proliferation of modulation techniques raises interoperability problems for most consumer electronics devices. For digital TV, for example, the likelihood now exists that a television built for over-the-air digital broadcasts will not be capable of receiving a cable TV digital transmission without a separate box.

The consumer could end up with three set tops: an analog NTSC descrambler for analog cable, a VSB MPEG decoder for digital over-the-air reception, and a QAM MPEG decoder for digital cable reception. Or there will be new generations of TV with input jacks for all three types of reception. Either way, the results are market confusion and additional costs.

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