4. METCALFE'S LAW: A network's value grows proportionately to the number of its users squared

Metcalfe's Law asserts that the value of a network grows as the square of the number of its users. "Having the only telephone in the world would be of zero value, but this value increases for each new telephone it can call," explained its author, Robert Metcalfe, in *The New York Times*, in 1996. Metcalfe, the inventor of the Ethernet standard and founder of the networking company 3Com Corp., in Santa Clara, Calif., first talked about the idea around 1980, but it was the journalist George Gilder who dubbed it a law, in an article he wrote for *Forbes ASAP* in 1993. Gilder maintained that Metcalfe's Law would amplify Moore's and, in so doing, remake the world.

Unlike the previous laws, Metcalfe's can't be quantified, because value—what economists call utility—can't be measured; you just know it when you see it. But that failing doesn't prevent economists from analyzing the law and correcting it. Consider the argument that most of the value you get from your telephone comes from being able to dial your 50 most frequently called numbers, and the rest of the network doesn't matter all that much. "You, like most human beings, may connect mostly to only 50 to 100 people, but those people, too, need 50 to 100 more. So adding to the network encourages them to join," says Hutcheson. That same sort of economy of network scale, he adds, explains why well-established standards, such as Windows, are well-nigh unbeatable.

Not all additions to a network make it more valuable, however, and some make it less so. "Some members of the network—we call them contaminants—subtract from the value, at least from your point of view," says Andrew P. McAfee, an assistant professor at Harvard Business School, in Boston. Examples include telemarketing firms that cold-call you while you're eating dinner, spam e-mail that promises larger body parts, and defective nodes that misroute the bytes you're trying to download.

In an article last year in *MIT Sloan Management Review*, "Confronting the Limits of Networks," McAfee and François-Xavier Oliveau, a consultant in the Boston Consulting Group's Paris office, identified four other problems in burgeoning networks—saturation, cacophony, clustering, and search. Saturation occurs when a network already contains most of the valuable material that new members can bring to it, say, all the music files that a file-sharing service can hope to glean from new members. Cacophony occurs when the interplay among members becomes too complex to follow, as in an Internet discussion group that spawns a "thread" containing hundreds of responses. Clustering occurs when members split into groups that use only part of the network, as happens when upper-class ladies try to raise money for charity through chain letters and end up corresponding only with each other. Finally, search costs grow to the point where most of the riches of a network remain inaccessible in practice.

There are ways around some of these problems, the authors argue. You can try to recruit new members possessing particularly valuable assets (as when a phone company offers incentives to sign up friends and family—people whom a subscriber is likely to call often). You can guide clustering in a logical and transparent manner by deliberately subdividing networks into formal subunits, as happens when a medical specialty produces a subspecialization. As for contaminants, such as spammers, "flamers," and other lowlife of the Internet, well, you can banish them from the network or filter their messages robotically or by hand (as is done in moderated newsgroups).

Networks aren't the only thing that doesn't pay off quite as well as Metcalfe's Law would have it. Even improvements to hardware itself appear to offer diminishing returns, as Wirth's Law decrees.