Talk is cheap in the city

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Telecommunications companies have paid a heavy price for their share of the radio spectrum. So they have been quick to exploit ‘multiple antennas’ that can increase transmission rates in urban areas.

Because we love to talk, and because modern microchips have brought down the cost, cellular (mobile) phones have become a ubiquitous feature of Western society since their introduction in the early 1980s. This demand has made the wireless-communications industry a leading part of the high-tech economy. But growth depends on attracting new subscribers, and the market is already reaching saturation in some areas—Finland leads the world in this respect, with 71 cellphones per 100 people. So, in order to keep growing, the industry must find new applications for the public to buy into.

The wireless industry sees data services, particularly e-mail and Internet links, as the solution. Unfortunately, compared with wired networks, wireless connections generally suffer from a low rate of data transmission, which results in unacceptable delays when downloading a typical web page. Three solutions to this problem have been proposed, and in this issue M. R. Andrews, P. P. Mitra and R. deCarvalho describe how they are working towards the most ambitious of the three (Nature 409, 316–318; 2001).

One solution developed by a consortium of large companies is to slim down the content of data-rich web pages so they work with the low data rates of cellular networks and the small screens of palm-sized devices. This approach is embodied by the wireless application protocol (WAP), which incorporates a lightweight version of the mark-up language used to format documents on the web.

A second solution limits the length of the radio transmission to short distances, over which relatively high data rates are possible. Wireless versions of local-area networks (LANs) take this approach, but require that the wireless device is within a few tens of metres from a connection to a wired network. So public areas must be dotted with these wired access points, or the user will be restricted to a small area, thereby losing all the benefits of a portable technology.

The most ambitious approach, and the one that will benefit from the ideas of Andrews and colleagues, seeks to increase the data transmission rate of the radio channel, even for the much longer distances covered by cellphones.

Radio signals from a base station or wired access point are often scattered by objects such as buildings (Fig. 1a). This scattering provides multiple paths between the base station and the wireless device, and allows them to communicate even when they are not in sight of each other. When cellular networks were first introduced, this multipath scattering gave rise to destructive interference, echoing and other problems that limited signal quality. Various approaches were taken to overcome these problems, one of which is to use multiple antennas to take advantage of the multiple communication channels created by scattering.

In view of the difficulties caused by multipath scattering for ordinary cellular networks, it came as a surprise when communications engineers suggested that multiple antennas could be used to increase the rate of data transmission in a scattering environment, such as a dense urban area. By using a group of N antennas for transmission and N for reception, and with a signal-processing system in the receiver, they were able to transmit data at N times the rate that could be achieved using single-transmit and single-receive antennas. This improvement is made possible by the unique ‘echo signature’ of each of the transmitting antennas, which is detected by the signal-processing system. Such gains are not possible when the antennas are in a non-scattering environment, because N independent signals have to be transmitted in order to take advantage of the increased capacity.

The type of multiplicative scaling offered by multiple antennas has already had a big impact on the wireless industry, in which much smaller gains can generate excitement. But there is one disadvantage with this approach. As originally conceived, the multiple antennas within a group have to be...