



Shaping the Internet's Wireless Future

by Jeremy Reis

*The Internet will enshroud the Earth
in a densely interlaced web of
electronically derived sentience*

It wasn't so long ago that folks communicated with each other across long distances by sending correspondence by foot, horse, and ship. The train and the horseless carriage replaced equestrian mail, and later came the telegraph, the radio, the telephone, the television, and the pager. Today, cellular phones, e-mail, and video-conferencing allow someone from Oslo, Norway to chat with a friend from Sydney, Australia as though they were neighbors gossiping over a backyard fence.

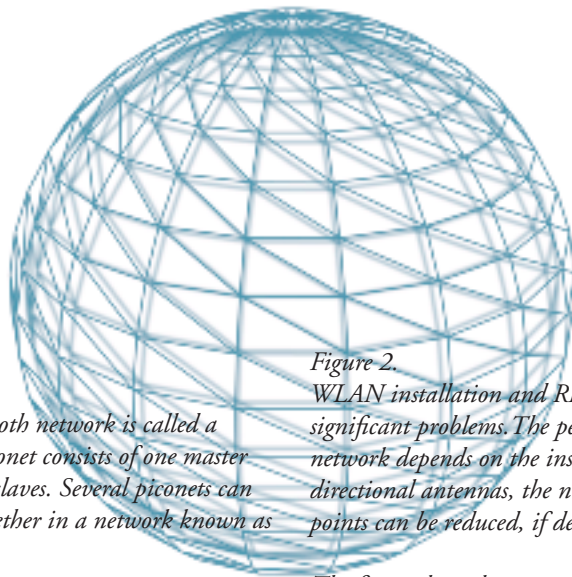
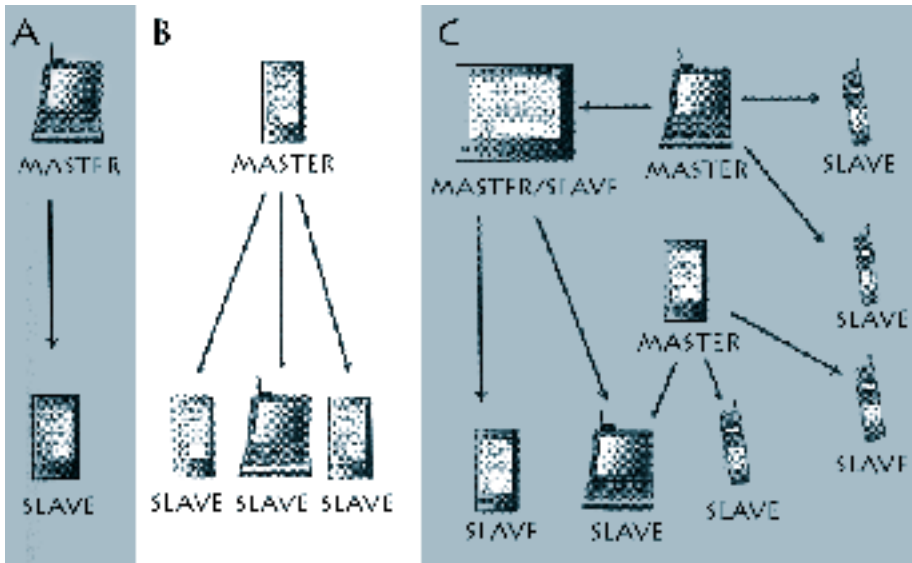


Figure 1. The basic Bluetooth network is called a piconet. One piconet consists of one master and up to seven slaves. Several piconets can be connected together in a network known as scatternet.

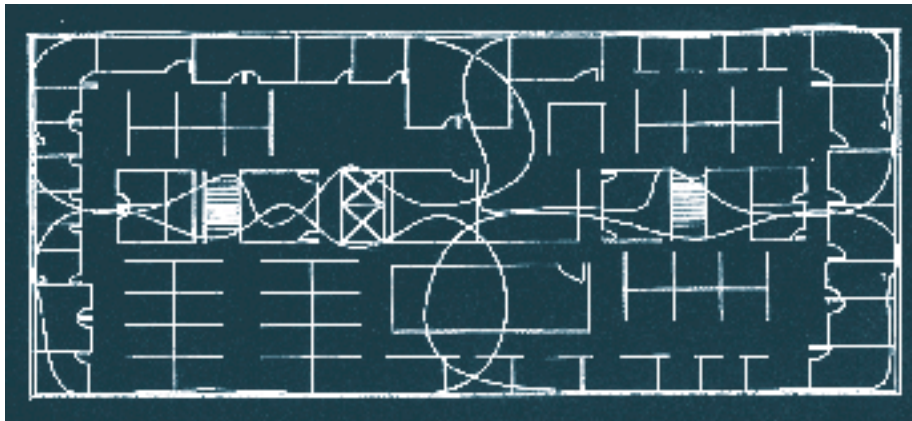
The figure illustrates the various networks, which Bluetooth makes possible.

Figure 2. WLAN installation and RF planning are significant problems. The performance of the network depends on the installation. Using directional antennas, the number of access points can be reduced, if desired.

The figure shows how one floor of an office building can efficiently be covered with four access points employing directional antennas.



1. Topology of a Bluetooth Network
A. Point-to-Point B. Point-to-Multipoint C. Scatternet



2. An installation of WLAN with directional antennas

By 2007 there will be over 2 billion people signed up for cell phone service worldwide. Well over half a billion people already use the Internet around the world. Advancement in the communication industry continues to push what used to be science fiction into tremendously successful businesses. Consequently, the world has become quicker, smarter and smaller.

And soon it will start to grow all-seeing eyes, all-hearing ears, and all-reaching arms. The Internet will enshroud the Earth in a densely interlaced web of electronically derived sentience. And thanks to wireless technology, this network will permeate every corner of the globe; not only on the surface of the planet, but throughout the deep blue sea and the wild, blue yonder, and possibly beyond.

Dr. Todor Cooklev, a professor of electrical engineering at San Francisco State University, is working to establish this vision of a future ‘Super-Net’ by developing the framework to support every wireless device used today and those to be invented tomorrow.

Cooklev earned his Ph.D. from the Tokyo Institute of Technology in Japan and has significantly contributed to wireless technology—exemplified by his twelve patents, four of which are pending. Now he teaches full time and directs his students on projects relating to the development of new, wireless technologies and to the framework upon which they function.

Wireless gadgets, like laptop computers and personal digital assistants, communicate with each other through a network. Like AM and FM radio, broadcast television, and remote control toy race cars, wireless signals are sent and received on radio waves in the electromagnetic spectrum. This network is regulated by wireless standards. “A transmitting device produced by one company must be able to communicate with a receiving device made by another company. In order for this to occur, there must be a set of standards,” says Cooklev. Cooklev has written a book, published by the Institute of Electrical and

Electronics Engineers (IEEE), that discusses the design of the standards for wireless data communications. The IEEE is the authority for this technology, publishing more than 100 of the leading journals in computing, telecommunications, and other disciplines. Specifically, the book answers questions on how these standards work, why they work the way they do, and how they were created. It is the only book devoted to all wireless standards produced by the IEEE. Because the wireless data industry continues to progress faster and faster, he already has the second edition planned for release two years after the first edition is published.

Cooklev supervises nearly 40 students, both graduate and undergraduate, all of them working on many different projects. "I've lost count of the actual number of students," he says. "I've got an open-door policy and don't turn anyone down." One of his graduate students is co-supervised by a senior scientist at Agilent Technologies, an electronic communications company in Palo Alto, California; this research that focuses on the synchronization of network nodes that participate in a wireless network. A network node is a point in a network, such as an individual computer. Industrial manufacturing systems can be complex, requiring robots, computers, sensors and other technologies to work seamlessly together on some task, like assembling cars in a factory. Auto plants, for example use a wired, or physically connected, network to synchronize those processes. This student's goal is to make it easier to synchronize components like these on a wireless network. Shifting a manufacturing plant towards a wireless system could enable workers to report problems and track inventories with much better precision and efficiency than is now possible. "She is doing significant work for the future of the wireless technology industry," says Cooklev, "work that has the capacity to influence not multi-million dollar businesses, but multi-billion dollar businesses."

Another of his graduate students is working in conjunction with the National Aeronautics and Space Administration, in Palo Alto, California, on a chip-based technology designed for use in scientific experiments on the space shuttle. Because space and resources on the shuttle are at a premium during a mission, ways must be found to minimize use of these commodities. The student is helping to develop a novel semiconductor technology to miniaturize biological experiments conducted during missions. Experiments like growing human kidney cells and crystallizing proteins to study their structure will become cheaper and more efficient because of miniaturization on this 'one-chip-lab,' and will eventually be monitored wirelessly via the Internet by the researchers down on Earth.

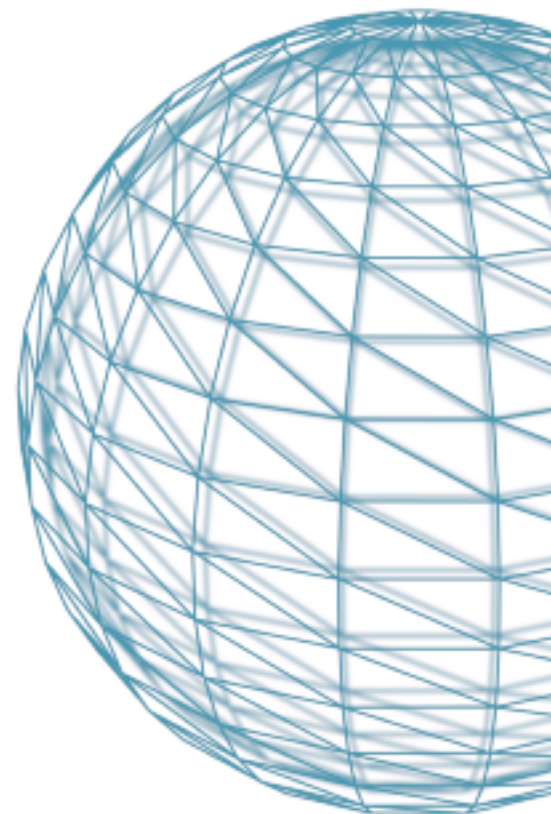
Clearly this vision of a wireless-world must also account for the future. Anyone who has purchased a personal computer is aware that the progress of technology creates a machine that decreases in value the moment the box is taken home. This rapid obsolescence of technology is not isolated to consumers but to the developers of wireless networks as well.

One solution to this problem, will be explored by Cooklev in another book that was first used in both the military and in academia but will likely soon enjoy tremendous consumer attention. It is a union of two well-developed technical industries from the 1990s—digital radio and software development. But this radio will do much more than let a jogger tune into the weekly top 40. Because the wires and transistors have been ripped out and replaced with computer code, the radio's dial will not only display options like AM and FM, but also act as a cell phone with international roaming, a cordless landline telephone, a global positioning satellite receiver to pinpoint the user's location, and a multimedia player that can play downloaded music, to name a few possibilities.

Fusing these separate high-tech gadgets into a single unit will combat that



Todor Cooklev
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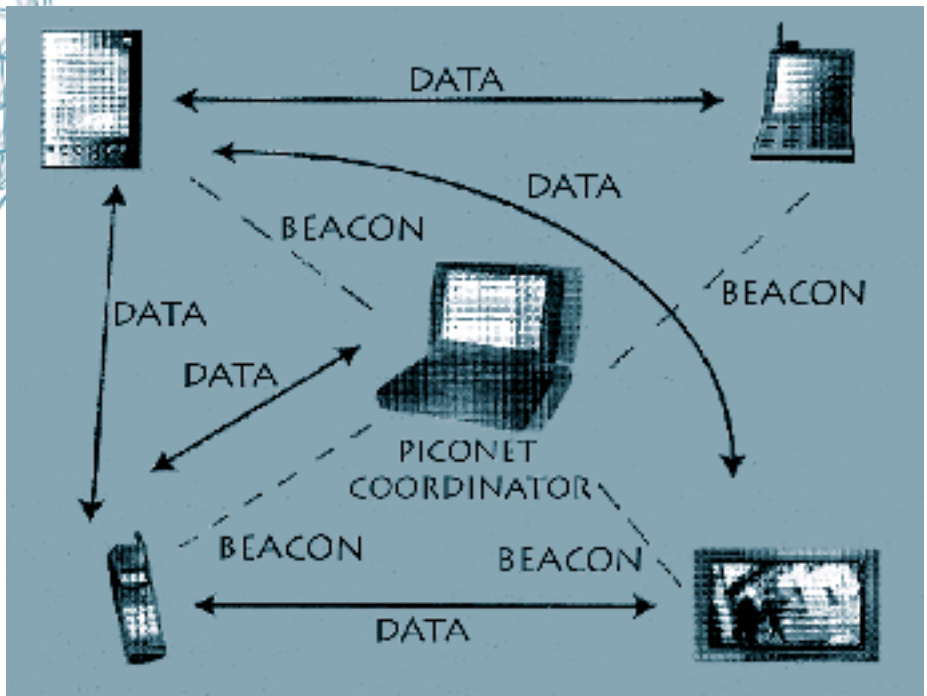




The piconet structure of a high-rate wireless personal area network

3. In wireless personal area networks, the communication is device-to-device and not necessarily computer-to-computer. Many different devices will have wireless connectivity: telephones, consumer electronic devices, and devices that can be called Internet appliances.

The figure illustrates the general architecture of a high data rate wireless personal area network.



inevitable obsolescence, since keeping the unit up-to-date will be as simple as downloading new software. Users of software radios won't have to throw away outdated cell phones and iPods after a year or two of use. Streamlining wireless devices will also solve another limitation of wireless networks. Today, many different wireless devices compete for their own wavelength in the limited range of radio waves in the electromagnetic spectrum, so the signal spectrum is getting overcrowded. Having a single wireless device and a single approved set of standards should reduce the burden on precious wavelength spectra.

Another advance that brings us a step closer to this future 'Super-Net' is known as smart dust. These tiny—mere millimeters in diameter—cordless spies will have their own computing power and will each be connected to the Internet. "They will be deployed by the millions," says Cooklev. Take, for example, a marine biologist who can spread this smart dust in an ocean current and then go back to the lab and observe the migration of an endangered species of fish on her web

browser without having to go back out on a boat every other day to chase blips on a fish-finder.

Others, like The Department of Homeland Security, could find smart dust useful in tracking the comings and goings of suspected terrorists in the remote mountains of Afghanistan, for example. Undoubtedly, the very power of this technology to see, listen, and reach into every nook and cranny will fuel a global debate on where it should—and should not—be used. "The issues of privacy as a result of this technology still need to be worked out," says Cooklev.

But, as is the case with any vision of progress, wireless technology needs to be built up from a solid foundation. For Cooklev and his students that framework is the Electrical Engineering department at SFSU.

"We recently averted a crisis in the Engineering department here at SF State," says Cooklev. Because of California's 2004 budgetary woes, there was serious talk of shutting down the entire Engineering department. But because students, alumni, local companies, industry executives and

even politicians fiercely opposed the elimination of the department, the crisis was prevented.

Given that widespread support, Cooklev remains optimistic that new students will continue to be drawn towards SFSU's engineering programs, and particularly to the future of wireless technology in the Electrical Engineering department. "I hope that the value of engineering is recognized by everybody, because it contributes to the wealth in society," says Cooklev. ✦

Source for U.S. cell phone usage:
(USA Today, 2003)

Source for Worldwide cell phone usage:
(CNET, 2004)

Source for U.S. Internet usage:
(Online Publishing News, 2003)

Source for Worldwide Internet usage:
(Nielsen/Netratings, Aug. 2001)

Diagrams courtesy of Dr. Cooklev