and software developers, is working on a formal standardization with a number of standards bodies: the European Computer Manufacturers' Association (ECMA), the European Telecommunications Standards Institute (ETSI), the Internet Engineering Task Force (IETF), the Telecommunications Industry Association (TIA), and the World Wide Web Consortium. WAP will have a large number of users—at least for a couple of years, until more mainstream protocols, such as HTML and Extensible Markup Language (**XML**), can be used effectively with mobile devices.

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—*Neal Leavitt*

Wireless Networks

Wireless networks do not use a cable to convey information from one computer to another — the information is sent using a radio or an infrared link. New problems arise with this type of network, such as the mobility of the users and interference during radio communication. The types of protocols used in the physical layer of wireless networks is therefore very different from those used in cable-based networks.

When messages are transmitted in a wireless **local area network** (LAN) they can collide with messages from other users since the communication medium is shared. One solution, allocating fixed time slots for each computer, cannot be used when the number of computers in the network is changing dynamically. A better solution is to allow all users to send information at the same time but using different frequencies. To avoid blocking one frequency by a single user, the sender hops from one frequency to another in pseudorandom fashion. The receiver knows the **algorithm** used to change frequencies and tracks the sender so that the entire message can be received. This technique, called *frequency hopping spread spectrum* was developed by military agencies to circumvent espionage. When this approach is used within the civil radio band, there are some rules that have to be followed and there are a minimum number of frequencies that have to be used during hopping. The purpose of this is to make a sender appear as random noise in the background in such a way that other senders are not affected.

In the direct sequence spread spectrum approach, each bit (a 1 or a -1) is converted into a pseudorandom sequence of several bits, which can be transmitted over different frequencies. The receiver knows what to expect and can check if the pseudorandom sequence is present. Other participants in the network detect the sequence as random noise and are not affected. Many senders can be active at the same time, since the pseudorandom sequence used by each is different, and the sum of many such messages cancels statistically. There are different wireless LAN adapter cards on the market, operating in frequency ranges that do not require a special license: 902 to 928 megahertz (MHz), and at 2.4 to 2.484 gigahertz (GHz). This range is called the *industrial, scientific, and medical band* (ISM).

Wireless LANs can also be built using microwave senders. However, the main use of microwaves is to interconnect buildings in a restricted geographical area. Since a directed antenna and a line of sight are required, microwaves cannot be used in all circumstances. A similar option is the use of satellites, which are used to relay information at high speed to end users, while the uplink (the information from the user to the network) is transmitted at a slower rate. In some cases, a satellite relays information directly to a user (who has a satellite dish at home) and the information from the user to the network is sent through a conventional modem.

Apple Computer introduced the first personal computers with bundled wireless links in the late 1990s. Using the AirPort, a product developed in a collaboration with Lucent Technologies, it is possible to start a wireless home local area network in which several computers and **laptops** share devices. AirPort runs at a speed of 11 megabits per second (Mbps) and is based in the IEEE 802.11 Direct Sequence Spread Spectrum (DSSS) standard.

The latest development in the field of wireless networks has to do with short-range communication. Bluetooth, a novel wireless interconnection standard developed by Ericsson, will eliminate the cables not only between computers and printers, keyboard, and mouse, but also between portable computers and embedded processors. The sheer explosion in the number of embedded processors used in many appliances and computer equipment has led to a cabling nightmare that the Bluetooth initiative addresses directly. Bluetooth operates in the 2.4 GHz range and communication can be established within 10 meters of each device (100 meters with optional amplifiers).

Harald Bluetooth, a tenth-century Viking king, was selected as patron of the standard because he unified Denmark and Norway, much as the new Bluetooth will unify computer communication. Fittingly, it was Ericsson, a Swedish company, who started investigating the possibility of short-range radio communication in 1994. In 1997, Ericsson representatives approached manufacturers of computer equipment, and in February 1998, five promoters (Ericsson, **IBM**, Nokia, **Toshiba**, and **Intel**) formed a special-interest group to promote the new technology. Lucent, **Microsoft**, **3Com**, and **Motorola** joined the group shortly thereafter. Ericsson expects Bluetooth to become the fastest-growing wireless standard ever. Bluetooth is based on fast frequency hoping with a raw throughput of 1 Mbps and single-chip implementations already exsist.

The first decade of the twenty-first century will witness two main developments in the computer industry: the widespread introduction of embedded processing in all types of appliances, in cars, and at home; and the dominance of wireless networks for the "last mile" of network connectivity at home, in the office, and when traveling. In the world of the future we will have pervasive, seamless, anytime, everywhere wireless networking.

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—*Raúl Rojas*

Wirth, Niklaus

1934–

Swiss Computer Scientist

Niklaus Wirth will be remembered primarily as a prolific and successful designer of imperative programming languages. **Pascal**, **Modula-2**, and **Oberon** were all his creations. He was also a leader in the **structured programming** movement, and his languages helped in the quest for more understandable programs.

After obtaining a degree in electrical engineering from Swiss Federal Institute of Technology (ETH) in Zurich in 1959, Wirth studied at Canada's Laval University and completed an M.Sc. degree in 1960. At the University of California–Berkeley, Wirth worked toward his doctorate, which he obtained in 1963, under the supervision of Harry D. Huskey (1916–), an early computer pioneer. From 1963 to 1967, Wirth taught as an assistant professor at the newly created Computer Science Department at Stanford University, then at the University of Zurich. In 1968 he was appointed full professor of computer science at ETH Zurich.

The first programming languages that Wirth worked on in the 1960s were the PL360 language and, in conjunction with the IFIP Working Group 2.1, a version of **ALGOL** called ALGOL-W. The original and elegant ALGOL 60 programming language, popular in Europe, was developed into the much more complicated ALGOL 68, which was never successful. Disagreements within the ALGOL 68 working group helped lead indirectly to what is probably Wirth's greatest contribution to programming language design: Pascal.

Wirth developed Pascal between 1968 and 1970. The language was designed originally as a teaching tool to promote good programming practice in the structured programming style of **Edsger Dijkstra** (1930–). It, together with its derivatives, have been