For decades, law enforcement agencies have embraced both **encryption** and deciphering techniques as a means to combat crime, and in 1992, the Federal Bureau of Investigation (FBI) unveiled a plan called *digital telephony*. It proposed requiring every private and public communications system in the country to use software that would make it easier to wiretap data and threatened to fine noncompliant industrialists U.S.$10,000 a day. The plan engendered controversy among communications systems developers, but a version of it eventually was adopted into law in 1994.

The Clipper chip came on the heels of the digital telephony plan. Easier access to communications would prove useless if criminals encrypted communications in unbreakable codes. So the NSA began developing in secret the encryption standard that became famous as the Clipper chip. The chip utilizes the skipjack algorithm and applies to fax transmissions and digital telephone conversations. Computer transmissions, including e-mail, are encoded by another algorithm. The chip can encode any digital communications system. To decode messages, the government unveiled the Escrowed Encryption Standard, which created two keys that could decipher the messages and were held by two agents. Each agent would have a database that consists of a serial number unique to the chip and one-half of the encryption key. For law enforcement officials to decode a message, they would have to get permission from a court and then request the keys from the two agents, each holding half of the encryption key.

Despite protests from civil liberties groups and privacy advocates, the White House approved use of the Clipper chip on a voluntary basis in February 1994. In 1998, the NSA declassified the skipjack and key exchange algorithms to computer security companies in the hope of developing cheaper computer protection methods. The release reflected a willingness of the U.S. government to use security technologies available to the public and paved the way for the Department of Defense to ask companies contracted by the government to employ the algorithm for electronic commerce.

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—*Christina Roache*

Clone

A clone in biology is a perfect replica of a cell or an organism; identical twins, for example, are each other's clone. In the computer industry, a clone is a functional copy of another machine, capable of running exactly the same software and using the same hardware expansion cards. The term became popular with the advent of **personal computer** (PC) clones in the 1980s, although copies of other computers were produced much earlier. A clone does not necessarily look like the original machine, but it is otherwise compatible with it.

Compatibility is different from cloning. The introduction of software compatibility in the computer industry can be attributed to **IBM**. As the leading manufacturer of computers in the 1960s, IBM was faced with the problem of maintaining and developing several lines of incompatible machines. IBM reacted by introducing the IBM 360 series of computers; they differed widely in speed and configuration but were capable of running the same software. IBM kept new machines *downwardly compatible* with obsolete machines; although they usually came with an expanded instruction set, they could still run the legacy software of the older models. Modern **microprocessors** try to preserve downward compatibility, going even to the extreme of including two processors in the same chip, as was done by Intel when the IA-64 architecture was introduced. It was so different from the **Pentium** architecture that the two processors were united in a single chip.

The first computers that were copied were IBM mainframes. **Gene Amdahl** (1922–), a former engineer at IBM, founded the Amdahl Corporation to make IBM-compatible machines. Amdahl Corporation installed its first IBM clone, the Amdahl 470 V/6, in 1975. The company grew steadily because it was able to offer IBM clones only a few months after IBM released the original. In many cases the cloned machines were even faster than the original.

The Soviet Union also had a successful cloning program of IBM mainframes, known as the **Ryad Series.** They were not built with the same components as those used in American machines, but otherwise they were functional copies of IBM 360 and 370 series computers. Their production was allocated among the Soviet bloc members of COMECON, the Council of Mutual Economic Assistance.

Cloning became big business with the advent of IBM's open PC architecture on 12 August 1981. Being a latecomer to the home computer business, IBM decided to release the entire documentation for the machine hardware. This resulted in an explosion of hardware add-ons for the IBM PC and made it the main microcomputer platform in just several months. However, it also made it possible to build copies of the machine, which were cheaper than the original since they were assembled offshore with negligible research and development costs. From being the leading manufacturer of microcomputers, IBM was displaced in the ensuing years by companies such as **Compaq** or **Dell Computer** and by the aggressive Asian "tiger" nations. Dell, with its policy of selling computers only by mail order, was especially able to offer large discounts and grab a large market share.

In the third quarter of 1999, the international market share of Compaq for IBM PC–compatible computers was 13.8 percent of all shipments. Dell, IBM, and **Hewlett-Packard** had 11.6, 8.1, and 6.7 percent, respectively. In the space of 18 years cloning had transformed the vs. industrial landscape and reduced IBM's market share to less than 10 percent. More significant, though, is the fact that no single manufacturer has a clear predominance in the microcomputer market, due to the availability of clones of the clones.

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—*Raúl Rojas*

CMOS

CMOS (complementary metal-oxide semiconductor) is a fabrication technology for **integrated circuits** that allows very high integration density and low power consumption.

Most integrated circuits (ICs) are constructed on the basis of a **silicon** wafer. MOS (metal-oxide semiconductor) circuits are created by superimposing layers of conductors, insulators, and semiconductors in a sandwichlike structure. Generally, photochemical processes are used, such as oxidation of the silicon, diffusion of impurities to affect its conduction behavior, and the placement of connections by a conducting material such as aluminum.

There are two types of **transistors** in MOS technology. In an n-type transistor (nMOS), the silicon contains impurities of materials such as arsenic or phosphorus, which donate additional electrons to the semiconductor. This enables conduction by these negatively charged electrons; p-type transistors, on the other hand, conduct via positively charged holes, which are created by diffusing atoms with an electron deficit, such as boron, into the semiconductor. Both of these two types of transistor can be used to build basic logical switches. However, although they work, they have certain flaws. For example, the output voltage level of an nMOS switch, when in the *on*-state, is a little below the voltage level associated with *on.* This can lead to prob-