used with a battery-operated device, such as a smart phone, that uses lower voltages to reduce power consumption.

To a programmer, the most important abstractions are the items visible to software: the representations used for data and programs. The next sections consider data representation, and discuss how it is visible to programs; later sections describe how instructions are represented.

### 3.3 Definitions Of Bit And Byte

All data representation builds on digital logic. We use the abstraction *binary digit (bit)* to describe a digital entity that can have two possible values, and assign the mathematical names 0 and 1 for the two values.

Multiple bits are used to represent more complex data items. For example, each computer system defines a *byte* to be the smallest data item larger than a bit that the hardware can manipulate.

How big is a byte? The size of a byte is not standard across all computer systems. Instead, the size is chosen by the architect who designs the computer. Early computer designers experimented with a variety of byte sizes, and some special-purpose computers still use unusual byte sizes. For example, an early computer manufactured by CDC corporation used a six-bit byte, and a computer designed at BB&N used a ten-bit byte. However, most modern computer systems define a byte to contain eight bits — the size has become so widely accepted that engineers usually assume a byte size equal to eight bits, unless told otherwise. The point is:

> Although computers have been designed with other size bytes, current computer industry practice defines a byte to contain eight bits.

### 3.4 Byte Size And Possible Values

The number of bits per byte is especially important to programmers because memory is organized as a sequence of bytes. The size of the byte determines the maximum numerical value that can be stored in one byte. A byte that contains \( k \) bits can represent one of \( 2^k \) values (i.e., exactly \( 2^k \) unique strings of 1s and 0s exist that have length \( k \)). Thus, a six-bit byte can represent 64 possible values, and an eight-bit byte can represent 256 possible values. As an example, consider the eight possible combinations that can be achieved with three bits. Figure 3.1 illustrates the combinations.

\[
\begin{align*}
000 & \quad 010 & \quad 100 & \quad 110 \\
001 & \quad 011 & \quad 101 & \quad 111
\end{align*}
\]

*Figure 3.1* The eight unique combinations that can be assigned to three bits.