Memory is a collection of hardware elements in a computer into which we store information, as shown in Figure 4.12. For most computers in today's market, each memory cell contains one byte of information, and each byte has a unique and sequential address. The memory is called **byte-addressable** because each byte has a separate address. The address of a memory cell specifies its physical location, and its content is the data. When we **write** to memory, we specify an address and 8, 16, or 32 bits of data, causing that information to be stored into the memory. Typically data flows from processor into memory during a write cycle. When we **read** from memory we specify an address, causing 8, 16, or 32 bits of data to be retrieved from the memory. Typically data flows from memory into the processor during a read cycle. **Read Only Memory**, or ROM, is a type of memory where the information is programmed or burned into the device, and during normal operation it only allows read accesses. **Random Access Memory** (RAM) is used to store temporary information, and during normal operation we can read from or write data into RAM. The information in the ROM is **nonvolatile**, meaning the contents are not lost when power is removed. In contrast, the information in the RAM is **volatile**, meaning the contents are lost when power is removed. The system can quickly and conveniently read data from a ROM. It takes a comparatively long time to program or burn data into a ROM. Writing to Flash ROM is a two-step process. First, the ROM is erased, causing all the bits to become 1. Second, the system writes zeroes into the ROM as needed. Each of these two steps requires around 1 ms to complete. In contrast, it is fast and easy to both read data from and write data into a RAM. Writing to RAM is about 100,000 times faster (on the order of 10 ns). ROM on the other hand is much denser than RAM. This means we can pack more ROM bits into a chip than we can pack RAM bits. Most microcontrollers have much more ROM than RAM.

Help

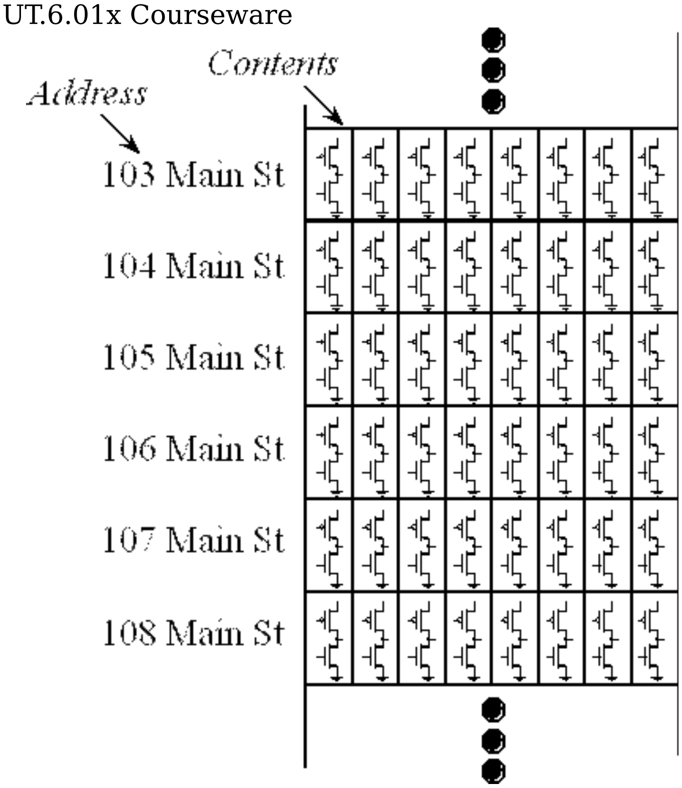

Figure 4.12. Memory is a sequential collection of data storage elements.

Help

In the computer, we can build an 8-bit storage element, shown logically as Figure 4.12, by combining 8 flip-flops. This basic storage element is called a **register**, as shown in Figure 4.13. A **bus** is a collection of wires used to pass data from one place to another. In this circuit, the signals D7–D0 represent the data bus. Registers on the Stellaris® microcontrollers are 32-bits wide, but in this example we show an 8-bit register. We call it storage because as long the circuit remains powered, the digital information represented by the eight voltages Q7–Q0 will be remembered. There are two operations one performs on a register: write and read. To perform a write, one first puts the desired information on the 8 data bus wires (D7–D0). As you can see from Figure 4.13, these data bus signals are present on the D inputs of the 8 flip-flops. Next, the system pulses the **Write** signal high then low. This **Write** pulse will latch or store the desired data into the 8 flip-flops. The read operation will place a copy of the register information onto the data bus. Notice the gate signals of the tristate drivers are negative logic. This means if the **Read*** signal is high, the tristate drivers are off, and this register does not affect signals on the bus. However, the read operation occurs by setting the **Read*** signal low, which will place the register data onto the bus.

CHECKPOINT 4.11

What does negative logic mean?

Hide Answer

With switches it means a closed switch reads as a 0 and open switch reads as a 1;\n\t With LEDs it means writing a 1 turns the LED off and writing a 0 turns it ON. With digital signals, negative logic is defined as the true state having a lower voltage than the false state.

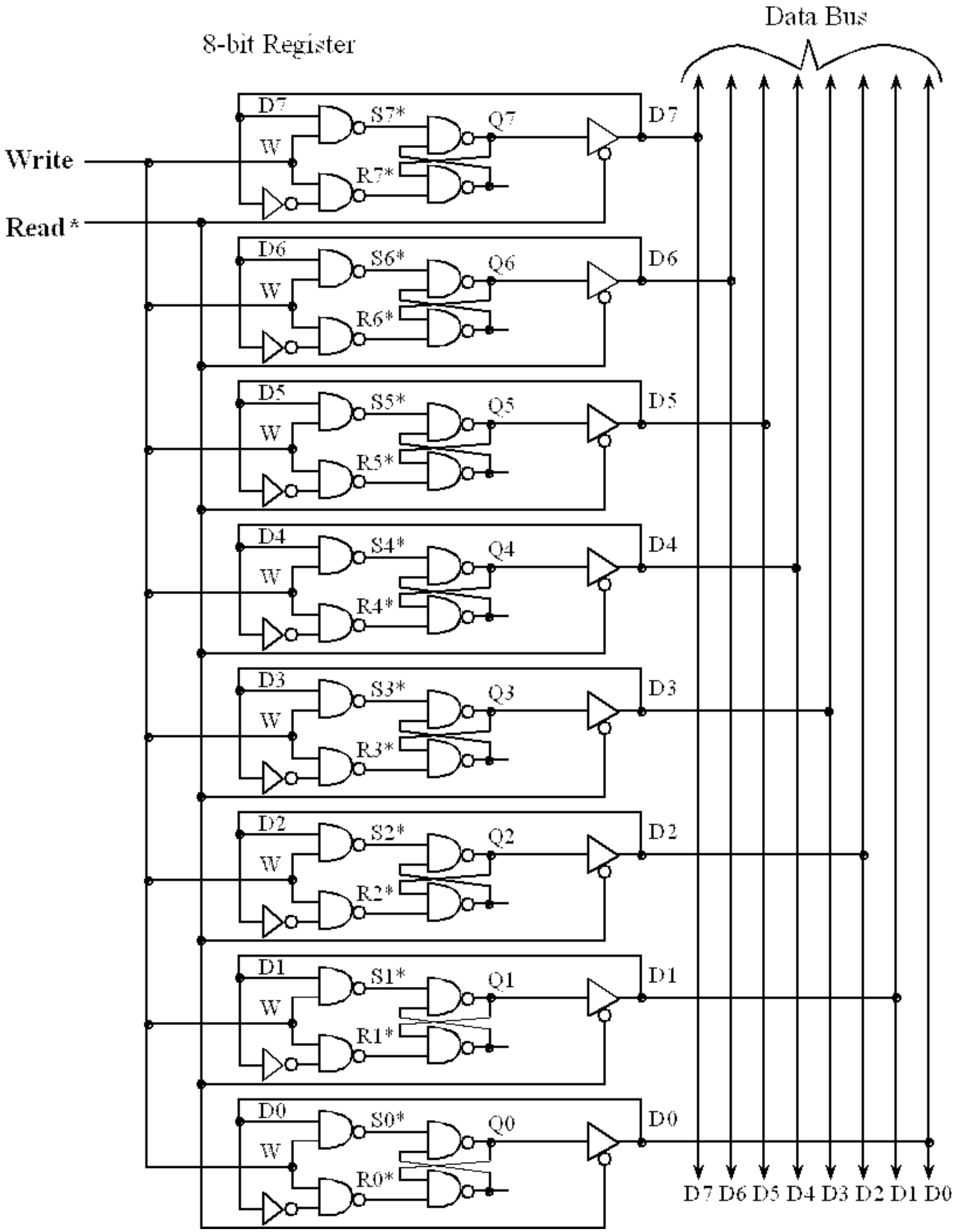

Figure 4.13. Digital logic implementation of a register.

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