

## 1.8 Fallacies and Pitfalls

The purpose of a section on fallacies and pitfalls, which will be found in every chapter, is to explain some commonly held misconceptions that you might encounter. We call such misbeliefs *fallacies*. When discussing a fallacy, we try to give a counterexample. We also discuss *pitfalls*, or easily made mistakes. Often pitfalls are generalizations of principles that are true in a limited context. The purpose of these sections is to help you avoid making these mistakes in the computers you may design or use. Cost/performance fallacies and pitfalls have ensnared many a computer architect, including us. Accordingly, this section suffers no shortage of relevant examples. We start with a pitfall that traps many designers and reveals an important relationship in computer design.

*Pitfall:* Expecting the improvement of one aspect of a computer to increase overall performance by an amount proportional to the size of the improvement.

This pitfall has visited designers of both hardware and software. A simple design problem illustrates it well. Suppose a program runs in 100 seconds on a computer, with multiply operations responsible for 80 seconds of this time. How much do I have to improve the speed of multiplication if I want my program to run five times faster?

The execution time of the program after making the improvement is given by the following simple equation known as **Amdahl's law**:

$$\text{Execution time after improvement} = \frac{\text{Execution time affected by improvement}}{\text{Amount of improvement}} + \text{Execution time unaffected}$$

For this problem:

$$\text{Execution time after improvement} = \frac{80 \text{ seconds}}{n} + (100 - 80 \text{ seconds})$$

Since we want the performance to be five times faster, the new execution time should be 20 seconds, giving

$$20 \text{ seconds} = \frac{80 \text{ seconds}}{n} + 20 \text{ seconds}$$

$$0 = \frac{80 \text{ seconds}}{n}$$

That is, there is *no amount* by which we can enhance-multiply to achieve a fivefold increase in performance, if multiply accounts for only 80% of the workload.

*Science must begin with myths, and the criticism of myths.*

Sir Karl Popper, *The Philosophy of Science*, 1957

**Amdahl's law** A rule stating that the performance enhancement possible with a given improvement is limited by the amount that the improved feature is used. It is a quantitative version of the law of diminishing returns.