4.16 Write a multithreaded program that calculates various statistical values for a list of numbers. This program will be passed a series of numbers on the command line and will then create three separate worker threads. One thread will determine the average of the numbers, the second will determine the maximum value, and the third will determine the minimum value. For example, suppose your program is passed the integers

90 81 78 95 79 72 85

The program will report

```
The average value is 82
The minimum value is 72
The maximum value is 95
```

The variables representing the average, minimum, and maximum values will be stored globally. The worker threads will set these values, and the parent thread will output the values once the workers have exited. (We could obviously expand this program by creating additional threads that determine other statistical values, such as median and standard deviation.)
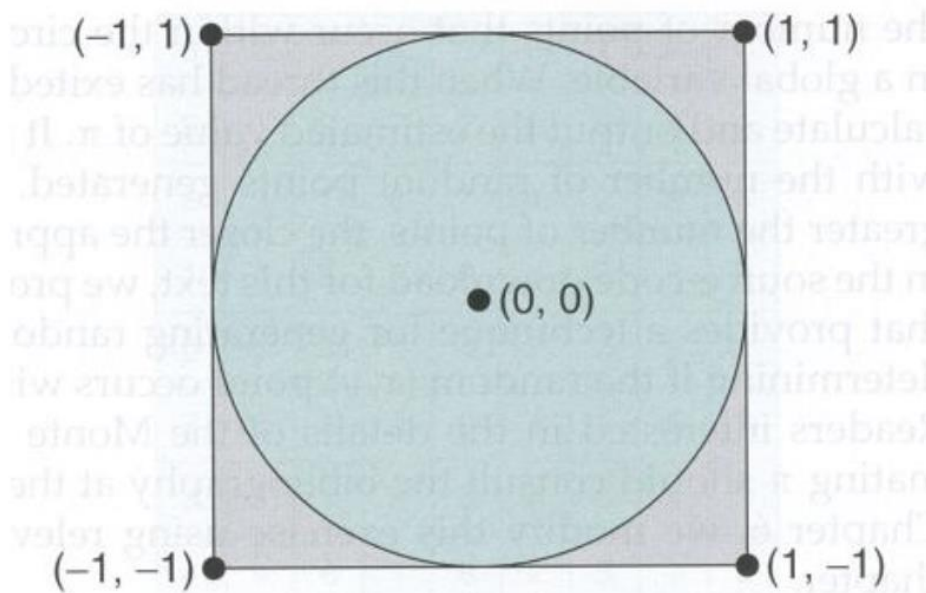
Figure 4.18 Monte Carlo technique for calculating pi.

4.17 An interesting way of calculating π is to use a technique known as *Monte Carlo*, which involves randomization. This technique works as follows: Suppose you have a circle inscribed within a square, as shown in Figure 4.18. (Assume that the radius of this circle is 1.) First, generate a series of random points as simple (x, y) coordinates. These points must fall within the Cartesian coordinates that bound the square. Of the total number of random points that are generated, some will occur within the circle. Next, estimate π by performing the following calculation:

$$\pi = 4 \times \textit{(number of points in circle)} \,/\, \textit{(total number of points)}$$

Write a multithreaded version of this algorithm that creates a separate thread to generate a number of random points. The thread will count the number of points that occur within the circle and store that result in a global variable. When this thread has exited, the parent thread will calculate and output the estimated value of π. It is worth experimenting with the number of random points generated. As a general rule, the greater the number of points, the closer the approximation to π.

In the source-code download for this text, we provide a sample program that provides a technique for generating random numbers, as well as determining if the random (x, y) point occurs within the circle.

Readers interested in the details of the Monte Carlo method for estimating π should consult the bibliography at the end of this chapter. In Chapter 6, we modify this exercise using relevant material from that chapter.

Reference (the Monte Carlo method):

http://mathfaculty.fullerton.edu/mathews//n2003/montecarlopimod.html