and Baeza-Yates [44]. Quicksort was originally invented by Hoare [55] and heapsort by Williams [132]. The taxonomy of sorting algorithms presented in this chapter is based on the one by Azmoodeh [5].

On the functional programming side, Paulson [93] describes most of the sorting algorithms in the strict functional language ML and discusses their performance based on profiling information. He also describes the bottom-up mergesort which was originally devised by O'Keefe [92]. A derivation of quicksort from tree sort through tree deforestation is described by Bird [14].

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Chapter 7

Graph algorithms

This chapter introduces the concept of a graph and describes some of the algorithms that operate on graphs and their applicability to a variety of problems.

7.1 Definitions and terminology

First, we need to introduce some of the terminology associated with graphs. Formally, a graph denoted $G = \langle V, E \rangle$ consists of a finite set of *nodes* (or *vertices*) V and a set of *edges* E, where an edge ij represents a connection between two nodes, i and j. In other words, a graph can be defined as a set and a relation over that set, where every element in the set corresponds to a node in the graph, and where there is a relation between two elements if there is an edge between the corresponding nodes. If the edge has a direction, it is called an *arc* (that is, the relation is not symmetric). In the rest of the chapter, the number of nodes and the number of edges in the graph are respectively denoted as $|V|$ and $|E|$.

Informally, graphs are represented visually as the examples in Figure 7.1 show. The graph on the left is *undirected* (that is, the edges have no direction) and the graph in the