Chapter 4

AUTOMATA

INTRODUCTION

In addition to the study of problems of the design and analysis of algorithms and circuits, as well as of the computational complexity of algorithmic problems, another main method of theoretical computing to get an insight into the power of computational resources is to study models of quantum computing devices and the corresponding complexity classes. This will be done in this chapter for three most basic models of quantum automata: quantum versions of finite automata, Turing machines and cellular automata.

Quantum finite automata are perhaps the most elementary model of quantum automata. They are in addition the only model so far for which it has been fully proved that they have larger power than their classical counterparts.

Quantum Turing machines are the main model to study the most fundamental questions concerning the power of quantum computing itself and the power of quantum versus classical computing. Quantum cellular automata are of a special interest. They seem to be a model much closer to the physical reality than quantum Turing machines. In addition, it is still a major open problem whether quantum cellular automata are more powerful than quantum Turing machines.

LEARNING OBJECTIVES

The aim of the chapter is to learn:

1. the basic models of one-way and two-way quantum finite automata as well as their computational power and space efficiency in comparison with classical finite automata;
2. the basic models of quantum Turing machines and methods of implementing the main classical programming primitives in a reversible way;
3. the types and precision of amplitudes needed to ensure sufficient accuracy of computation on quantum Turing machines;
4. the basic models of quantum cellular automata and partitioned quantum cellular automata, as well as simulations between quantum cellular automata and quantum Turing machines.