Multi-Agent systems (MAS) are typical KBS and intelligent agents are viewed as extensions of KBS. Originating from the field of Distributed Artificial Intelligence (DAI), agent and Multi-Agent (MA) technology has been at the forefront of research in the last decade (Nilsson, 1998). Since the late 1980s, researchers have applied agent technology to perform tasks, and it is considered a promising paradigm for intelligent manufacturing (Shen & Norrie, 2001). In the 21st century especially, the manufacturing industry has become more and more competitive in a market that is frequently changing. Manufacturing systems should therefore move to support product innovation, global competitiveness and rapid market responsiveness. Recent new developments in agent and MA technology have brought new and interesting possibilities (Jennings & Wooldridge, 1998), researchers have been trying to develop and apply agent technology for supporting intelligent manufacturing, and there have been many projects in agent-based intelligent manufacturing. The basic theory and applications of agent and MAS are introduced in this chapter. The recent development of agent and MAS is reviewed, and the current research level of MAS is also summarized. Finally, the fundamentals of agent technology including communication and interaction, collaboration and behavior coordination, are presented.

INTELLIGENT AGENTS

‘Intelligent’ can be utilized as both a noun and an adjective. If considered as a noun, it refers to all the mental activities human beings are capable of, such as feeling, cognition, memorization, relating, calculating, reasoning, judging, decision-making, and summarization. If used as an adjective, it carries the meaning of being human-like, smart, flexible, self-learning, self-organizing, self-adaptive, and autonomous.

The research with regard to the theory of intelligence is divided into two aspects. The first is to conduct direct research for the forming and working mechanisms of intelligence, which is classified as natural “intelligent” theory and has mainly been researched by physiologists and psychologists. The second aspect is to explore methods to stimu-
late and expand intelligence artificially, which is classified as artificial “intelligent” theory and has mainly been used by engineers. In the first aspect, ‘intelligent’ is often used as a noun because it mainly explores the mechanisms of mental activity. ‘intelligent’ is used as an adjective in the second aspect because what we really care about is whether functions of AI are better than functions of natural intelligence.

Definition and Properties

The development of Intelligent Agents are a natural result of the development of distributed AI technology and network technology. Intelligent agent and MA have been hot topics in the area of network-based distributed AI. References even claim that agent technology has been a significant breakthrough in network software.

The concept of agent can be traced back to the year of 1977 when Hewitt published the article ‘Viewing Control Structures as Patterns of Passing Messages’. In this paper, an object was first defined as self-compatible, interactive and capable of parallel processing. The object has closed internal states and is able to conduct message-exchange and feedback with other similar objects (Hewitt, 1977). The term ‘Agent’ can first be found in the book ‘Society of Mind’, published by Minsky in 1986. In this book, Minsky introduced the concepts of ‘Society’ and ‘Society Behavior’. Every individual is a part of the society, but different individuals can solve problems through coordination and competition despite the contradictions between them (Minsky, 1986). In 1994, Minsky elaborated his ideas on agent. From his perspective, agent is an entity that possesses unique skills. For computers, agent is referred to as a machine that can accomplish certain tasks and operators do not have to know its working mechanisms. This machine is treated as a functional black box. In this way, Minsky revealed two important attributes that are essential to an agent, namely, sociality and intelligence (Minsky, 1994). In 1996, Franklin and Graesser presented a paper at the third international workshop on agent theories, architectures and languages called ‘Is it an Agent, or just a program?: a taxonomy for autonomous agents’. In this paper, the authors collected a variety of definitions on the intelligent agent, and drew out their own definition. They defined an autonomous agent as a system situated within a part of an environment that senses the environment and acts accordingly, over time, in pursuit of its own agenda, which affects what it senses in the future (Franklin & Graesser, 1996).

Intelligent agent is an abstract noun that can represent all intelligent entities whether they are of natural intelligence or artificial intelligence. It is therefore used to describe a wide range of entities, such as human beings, robots, intelligent devices, and intelligent software. In a certain environment, an intelligent agent can sense the environment through sensors and affect the environment through effectors. The working mechanisms of intelligent agents are shown in Figure 1. It is worth mentioning that an intelligent agent cannot exist alone in an environment, but rather works coordinate with many other agents through communications and message-exchanging. Nevertheless, every individual agent can function actively and autonomously, which makes distributed AI possible, and has enormous practical value in such areas as parallel programming, computer communications, network management and control.

Agent research is currently extremely popular in many areas, such as in AI and in computer science (Jennings, 2000). The theory of agent and MAS, the architecture of agent, communications and message-exchanging between agents in a MAS, and the language of agent have all been key areas of interest. Scientists even put forward a new definition for AI based on intelligent agent. It is defined as a branch of computer science and its goal is to create agents that are capable of undertaking certain intelligent behaviors. In a special report at IJCAI’95, Hayes-Roth from