Chapter 5
Norm-Based Contract Net Protocol for Coordination in Multi-Agent Systems

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Abstract

Contract net protocol (CNP) is often used for coordination in a multi-agent system (MAS). Due to the limitations inherent in the conventional CNP, this chapter proposes a norm-based CNP to improve the efficiency and effectiveness of the coordination processes in a MAS. Firstly, a three-dimensional taxonomy of norms is put forward in terms of the hierarchy, type, and flexibility of norms. Then a coordination process guided by norm-based CNP is developed under the taxonomy framework. The new coordination process consists of two principal stages and five subdivided phases, providing a feasible solution for the optimization of the candidate selection. A case study is finally presented to illustrate the real application of the proposed approach.

5.1 Introduction

Multi-agent systems (MASs) have caught more and more attention in recent years. These systems have been applied in a variety of domains such as manufacturing, electronic commerce, and traffic control. In MAS, an agent is an entity that is situated in some environment and capable of acting autonomously in order to meet its design objectives (Wooldridge 2002). An agent is used to denote a human or computer system software with the

P.-J. Charrel and D. Galarreta (Eds.),
Project Management and Risk Management in Complex Projects, 91–107.
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following properties: bounded autonomy, rationality, social ability, reactivity, and responsibility.

A crucial problem in MAS is the balance between autonomy of individual agents and coordination required between agents to complete efficiently complex tasks. In MAS, one agent cannot solve the complex problem solely since it has no sufficient competence, resources, or information. Agents will influence others to convince them to act in a certain way. Even if agents have common interests to cooperate, they may still have conflicting interests to be coordinated. So cooperation and coordination are critical for managing such inter-agent dependencies and reaching global optimization.

Coordination is a means for members in a system to communicate and compromise to reach mutually beneficial agreements regarding belief, goal, or plan. Coordination is a kind of dynamic glue that binds tasks together into larger meaningful wholes. The complex coordination is achieved by structuring mutually constrained entities into a whole, integrated and harmonious adjustment of individual work efforts towards the accomplishment of a larger goal (Ossowski, 1999). By such process an agent reasons about its local actions and the foreseen actions that other agents may perform, with the aim of making the community behave in a coherent manner. Each agent performs its own tasks and completes jobs for the whole system through communication and coordination with other agents.

The protocols, objectives of coordination, and behaviour mechanism of the agent are essential for coordination. Coordination consists of a set of mechanisms necessary for the effective operation of the MAS in order to get a well-balanced task division while logical coupling and resource dependencies of the agents are reduced.

This work is concerned with the protocol issues for coordination in MASs. Section 2 introduces the Contract Net Protocol (CNP) which is widely used for coordination among agents in MASs. The inherent limitations of conventional CNP are analysed. A taxonomy of norms for the proposed norm-based CNP is studied in Section 3. Section 4 is devoted to the essential procedures of norm-based CNP in coordination process of MAS. A case study is presented to illustrate the application of the proposed approach.

5.2 Contract Net Protocol

A protocol is a set of rules agreed among the members of the system for their interactions and communication. The CNP provided by Smith and Davis is often used for coordination among the nodes in a network system