Chapter 6
New Game Paradigm for IoT Systems

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ABSTRACT

Game theory is a mathematical language for describing strategic interactions, in which each player's choice affects the payoff of other players. The impact of game theory in psychology has been limited by the lack of cognitive mechanisms underlying game theoretic predictions. Behavioral game, inference game, inspection game and Markov game are recent approaches linking game theory to cognitive science by adding cognitive details, theories of limits on iterated thinking, and statistical theories of how players learn and influence others. These new directions include the effects of game descriptions on choice, strategic heuristics, and mental representation. These ideas will help root game theory more deeply in cognitive science and extend the scope of both enterprises.

THE COGNITIVE HIERARCHY THINKING BASED POWER CONTROL (CHTPC) SCHEME

The IoT describes a future world of interconnected physical objects, with several applications in the areas of smart environments. To implement the IoT concept, the research in the areas of power controlled circuits, embedded systems design, network protocols and control theory should be required. With the much advancement in these areas, the realization of IoT is becoming increasingly probable. Recently, S. Kim proposed the *Cognitive Hierarchy Thinking based Power Control* (CHTPC) scheme, which is a novel adaptive power control algorithm for IoT systems. Based on the cognitive hierarchy thinking mechanism, the CHTPC scheme is designed as a new behavioral game model to adaptively control the power level. To effectively solve the power control problem in IoT systems, game theory is well-suited and an effective tool.

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Development Motivation

With the rapid development of network technologies over the past decade, IoT becomes an emerging technology for critical services and applications. IoT is a rapidly growing system of physical sensors and connected devices, enabling an advanced information gathering, interpretation and monitoring. In the near future, everything is connected to a common network by an IoT platform while improving human communications and conveniences. Recent research shows more potential applications of IoT in information intensive industrial sectors, and IoT will bring endless opportunities and impact every corner of our world. However, while IoT offers numerous exciting potentials and opportunities, it remains challenging to effectively manage the various heterogeneous components that compose an IoT application in order to achieve seamless integration of the physical world and the virtual one (Singh, 2014; Vermesan, 2011).

Power control has always been recognized as an important issue for multiuser wireless communications. With the appearance of new paradigms such as IoT systems, effective power control algorithms play a critical role in determining overall IoT system performance. According to the adaptively decided power levels, the CHTPC scheme can reduce the interference while effectively improve the system capacity and communication quality. Therefore, the research on power control algorithm in IoT systems is considered an attractive and important topic. However, it is a complex and difficult work under a dynamically changing IoT environment (Ha, 2014).

Usually, there are two different power control algorithms; centralized and distributed power control algorithms. In general, due to heavy control and implementation overheads, centralized control approach is an impractical method. But, a distributed mechanism can transfer the computational burden from a central system to the distributed devices. Therefore, in real world system operations, this distributed power control approach is suitable for ultimate practical implementation. In distributed power control algorithms, individual devices locally make control decisions to maximize their profits. This situation can be seen as a game theory problem (Kim, 2014). In classical game theory, players are assumed to be fully rational, and the rules of the game, payoff functions and rationality of the players are taken as common knowledge. However, in recent decades, there had been many conceptual and empirical critiques toward this justification. Empirical and experimental evidences show that game players are not perfectly rational in many circumstances. These results call for relaxing the strong assumptions of classical game theory about full rationality of players (Camerer, 2003).

In 1997, a game theorist C. Camerer had introduced a new concept of game model, called behavioral game theory, which aimed to predict how game players actually behave by incorporating psychological elements and learning into game theory (Camerer, 1997). Usually, behavioral game theory combines theory and experimental evidence to develop the understanding of strategic behavior needed to analyze economic, political, and social interactions. By using an index of bounded rationality measuring levels of thinking, the behavioral game theory can explain why players behave differently when they are matched together repeatedly (Camerer, 2004a; Camerer, 2004b; Camerer, 2015).

To formulate a power control problem, the CHTPC scheme adopts a non-cooperative behavioral game model. Additionally, the key idea of cognitive hierarchy thinking mechanism is used to improve upon the accuracy of predictions made by standard analytic methods, which can deviate considerably from actual experimental outcomes. Based on the game player's cognitive capability, the CHTPC scheme concentrates on modeling the learning behavior in iterative games, and adjusts the current power level of each IoT device as efficiently as possible.

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