
Abstract of PhD Thesis

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Abstract

The analysis of the computational aspects of strategic situations is a basic field in Computer Sciences. Two main topics related to strategic games have been developed. First, introduction and analysis of a class of games (so called angel/daemon games) designed to asses web applications, have been considered. Second, the problem of isomorphism between strategic games has been analysed. Both parts have been separately considered.

Part I: Angel-Daemon Games. A service is a computational method that is made available for general use through a wide area network. The performance of web-services may fluctuate; at times of stress the performance of some services may be degraded (in extreme cases, to the point of failure). In this thesis *uncertainty profiles* and *Angel-Daemon* games are used to analyse service-based behaviours in situations where probabilistic reasoning may not be appropriate.

In such a game, an *angel* player acts on a bounded number of “angelic” services in a beneficial way while a *daemon* player acts on a bounded number of “daemonic” services in a negative way. Examples are used to illustrate how game theory can be used to analyse service-based scenarios in a realistic way that lies between over-optimism and over-pessimism. The resilience of an orchestration to service failure has been analysed - here angels and daemons are used to model services which can fail when placed under stress. The Nash equilibria of a corresponding *Angel-Daemon* game may be used to assign a “robustness” value to an orchestration.

Finally, the complexity of equilibria problems for *Angel-Daemon* games has been analysed. It turns out that *Angel-Daemon* games are, at the best of our knowledge, the first natural example of zero-sum succinct games. Deciding the existence of a pure Nash equilibrium or a dominant strategy for a given player is Σ_2^P -complete. Furthermore, computing the value of an *Angel-Daemon* game

is EXP-complete. Thus, matching the already known complexity results of the corresponding problems for the generic families of succinctly represented games with exponential number of actions.

Part II: Game Isomorphism. The question of whether two multi-player strategic games are equivalent and the computational complexity of deciding such a property has been addressed. Three notions of isomorphisms, *strong*, *weak* and *local* have been considered. Each one of these isomorphisms preserves a different structure of the game. *Strong* isomorphism is defined to preserve the utility functions and Nash equilibria. *Weak* isomorphism preserves only the player preference relations and thus pure Nash equilibria. *Local* isomorphism preserves preferences defined only on “close” neighbourhood of strategy profiles.

The problem of the computational complexity of game isomorphism, which depends on the level of succinctness of the description of the input games but it is independent of the isomorphism to consider, has been shown. Utilities in games can be given succinctly by Turing machines, boolean circuits or boolean formulas, or explicitly by tables. Actions can be given also explicitly or succinctly. When the games are given in *general form*, an explicit description of actions and a succinct description of utilities have been assumed. It is has been established that the game isomorphism problem for general form games is equivalent to the circuit isomorphism when utilities are described by Turing Machines; and to the boolean formula isomorphism problem when utilities are described by formulas. When the game is given in explicit form, it is has been proven that the game isomorphism problem is equivalent to the graph isomorphism problem.

Finally, an equivalence classes of *small* games and their graphical representation have been also examined.

Table of Contents

- 1 Algorithmic Game Theory and Isomorphisms 1**
 - 1.1 Algorithmic Game Theory and Isomorphisms 1
 - 1.2 Isomorphisms on Game Theory 3
 - 1.3 Angel-Daemon Games and Web Orchestrations 4
 - 1.4 Overview of this thesis 6
 - 1.5 Thesis outline 8
 - 1.6 Notes 9
- 2 Preliminaries on games 11**
 - 2.1 Strategic and Extensive Games 11

2.2 Definitions and Preliminaries 15
2.3 Notes 20

Part I: Angel-Daemon Games

3 Preliminaries on Web Orchestrations 25
3.1 Web-services and Orchestration versus Choreography 25
3.2 Orchestration and Game Theory 31
3.3 Notes 31

**4 Bounded Site Failures:
an Approach to Unreliable Web Environments.....33**
4.1 Unreliable Environments and Risk Management 33
4.2 Assessing Orchestrations 38
4.3 Two Player Games: The Angel-Daemon Case 39
4.4 Maximisation and Minimisation Approaches 43
4.5 Properties of Uncertainty Profiles and Assesments 45
4.6 Notes 51

**5 On the Complexity of Equilibria Problems
in Angel-Daemon Games53**
5.1 Angel-Daemon Games 53
5.2 Strategic Games and Succinct Representations 54
5.3 Orc and Angel-Daemon Games 56
5.4 The Complexity of the EPN Problem 56
5.5 Computing the Value of Angel-Daemon Game 60
5.6 Deciding the Existence of Dominant Strategies 64
5.7 Notes 64

Part II: Computations Issues of Game Isomorphism

6 Preliminaries on Game Isomorphisms 69
6.1 Strong, Weak and Local Game Isomorphism 71

6.2 Classical Complexity’s Problems 73
 6.3 Notes 75
7 The Complexity of Game Isomorphism 77
 7.1 The IsISO and ISO Problems 77
 7.2 Complexity Results for Strong Isomorphisms 79
 7.3 Weak Isomorphisms 99
 7.4 Notes 110
8 On the Hardness of Game Equivalence under Local Isomorphism 111
 8.1 The Isomorphism Problem 111
 8.2 From Strong Isomorphism to Local Isomorphism 114
 8.3 From General Games to Binary Actions Games 118
 8.4 From Local Isomorphism on Binary Action Games
 to Strong Isomorphism 126
 8.5 The Complexity of Local Isomorphism 127
 8.6 Notes ?129

Conclusions and Future Work

9 Conclusions and Future Work 133

Appendices

A Arranging a Meeting using Reputation 141
B IT System Example 145
C Small Games. Graphic Representation 153

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