# 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 $\Sigma_2^p$-complete. Furthermore, computing the value of an *Angel-Daemon* game



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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.

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