Hidden-Role Games: Equilibrium Concepts and Computation

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In this paper, we study the class of games known as *hidden-role games* in which players are assigned *privately* to teams and are faced with the challenge of recognizing and cooperating with teammates. This model includes both popular recreational games such as the *Mafia/Werewolf* family and *The Resistance (Avalon)* and many real-world settings, such as distributed systems where nodes need to work together to accomplish a goal in the face of possible corruptions. There has been little to no formal mathematical grounding of such settings in the literature, and it was previously not even clear what the right solution concepts (notions of equilibria) should be. A suitable notion of equilibrium should take into account the communication channels available to the players (*e.g.*, can they communicate? Can they communicate in private?). Defining such suitable notions turns out to be a nontrivial task with several surprising consequences. In this paper, we provide the first rigorous definition of equilibrium for hidden-role games, which overcomes serious limitations of other solution concepts not designed for hidden-role games. We then show that in certain cases, including the above recreational games, optimal equilibria can be computed efficiently. In most other cases, we show that computing an optimal equilibrium is at least NP-hard or coNP-hard. Lastly, we experimentally validate our approach by computing exact equilibria for complete 5- and 6-player *Avalon* instances whose size in terms of number of information sets is larger than 10^{56}.

A full-text version of the article is available at https://arxiv.org/abs/2308.16017.

CCS Concepts: • **Theory of computation → Solution concepts in game theory**; **Exact and approximate computation of equilibria**; • **Computing methodologies** → *Cooperation and coordination.*

Additional Key Words and Phrases: adversarial team games, imperfect information

ACM Reference Format:
Luca Carminati, Brian Hu Zhang, Gabriele Farina, Nicola Gatti, and Tuomas Sandholm. 2024. Hidden-Role Games: Equilibrium Concepts and Computation. In *The 25th ACM Conference on Economics and Computation (EC '24), July 8–11, 2024, New Haven, CT, USA.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3670865.3673616

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EC '24, July 8–11, 2024, New Haven, CT, USA

ACM ISBN 979-8-4007-0704-9/24/07
https://doi.org/10.1145/3670865.3673616

ACKNOWLEDGMENTS

Prof. Sandholm's group is supported by the Vannevar Bush Faculty Fellowship ONR N00014-23-1-2876, National Science Foundation grants RI-2312342 and RI-1901403, ARO award W911NF2210266, and NIH award A240108S001. The work of Prof. Gatti's research group is funded by the FAIR (Future Artificial Intelligence Research) project, funded by the NextGenerationEU program within the PNRR-PE-AI scheme (M4C2, Investment 1.3, Line on Artificial Intelligence), and by the EU Horizon project ELIAS (European Lighthouse of AI for Sustainability, No. 101120237).