

used that protocol in Protocol 4, that compares the cost of a CPA, which is shared between two agents, to the upper bound which is held by only one of them.

One research direction that we plan to pursue is improving the computational cost of Protocol 5. Other research directions include the extension of this work to other search-based algorithms for DCOP solving, such as AFB [6] or NCBB [2], and to other privacy types. Finally, we plan to compare our approach to the one that was recently presented in [16].

7. ACKNOWLEDGMENTS

The authors would like to thank Benny Lutati and Vadim Levit for their help with the AgentZero simulator.

8. REFERENCES

- [1] J. Benaloh. Secret sharing homomorphisms: Keeping shares of a secret secret. In *Crypto*, pages 251–260, 1986.
- [2] A. Chechetka and K. Sycara. No-commitment branch and bound search for distributed constraint optimization. In *AAMAS*, pages 1427–1429, 2006.
- [3] P. Doshi, T. Matsui, M. C. Silaghi, M. Yokoo, and M. Zanker. Distributed private constraint optimization. In *WI-IAT*, pages 277–281, 2008.
- [4] S. Even, O. Goldreich, and A. Lempel. A randomized protocol for signing contracts. *Communications of the ACM*, 28:637–647, 1985.
- [5] B. Faltings, T. Léauté, and A. Petcu. Privacy guarantees through distributed constraint satisfaction. In *WI-IAT*, pages 350–358, 2008.
- [6] A. Gershman, A. Meisels, and R. Zivan. Asynchronous forward bounding. *JAIR*, 34:25–46, 2009.
- [7] A. Gershman, R. Zivan, T. Grinshpoun, A. Grubshtein, and A. Meisels. Measuring distributed constraint optimization algorithms. In *DCR Workshops*, pages 17–24, 2008.
- [8] R. Greenstadt, B. Grosz, and M. D. Smith. SSDPOP: improving the privacy of DCOP with secret sharing. In *AAMAS*, pages 171:1–171:3, 2007.
- [9] R. Greenstadt, J. Pearce, and M. Tambe. Analysis of privacy loss in distributed constraint optimization. In *AAAI*, pages 647–653, 2006.
- [10] T. Grinshpoun. When you say (DCOP) privacy, what do you mean? – categorization of DCOP privacy and insights on internal constraint privacy. In *ICAART*, pages 380–386, 2012.
- [11] T. Grinshpoun, A. Grubshtein, R. Zivan, A. Netzer, and A. Meisels. Asymmetric distributed constraint optimization problems. *JAIR*, 47:613–647, 2013.
- [12] T. Grinshpoun and A. Meisels. Completeness and performance of the APO algorithm. *JAIR*, 33:223–258, 2008.
- [13] K. Hirayama and M. Yokoo. Distributed partial constraint satisfaction problem. In *CP*, pages 222–236, 1997.
- [14] M. Kantarcioglu and C. Clifton. Privacy-preserving distributed mining of association rules on horizontally partitioned data. *TKDE*, 16:1026–1037, 2004.
- [15] T. Léauté and B. Faltings. Distributed constraint optimization under stochastic uncertainty. In *AAAI*, pages 68–73, 2011.
- [16] T. Léauté and B. Faltings. Protecting privacy through distributed computation in multi-agent decision making. *JAIR*, 47:649–695, 2013.
- [17] R. T. Maheswaran, J. P. Pearce, E. Bowring, P. Varakantham, and M. Tambe. Privacy loss in distributed constraint reasoning: a quantitative framework for analysis and its applications. *JAAMAS*, 13:27–60, 2006.
- [18] R. T. Maheswaran, M. Tambe, E. Bowring, J. P. Pearce, and P. Varakantham. Taking DCOP to the real world: Efficient complete solutions for distributed multi-event scheduling. In *AAMAS*, pages 310–317, 2004.
- [19] R. Mailler and V. R. Lesser. Solving distributed constraint optimization problems using cooperative mediation. In *AAMAS*, pages 438–445, 2004.
- [20] J. Modi and M. Veloso. Multiagent meeting scheduling with rescheduling. In *DCR Workshops*, 2004.
- [21] P. J. Modi, W. Shen, M. Tambe, and M. Yokoo. ADOPT: asynchronous distributed constraints optimization with quality guarantees. *Artificial Intelligence*, 161:149–180, 2005.
- [22] K. Nissim and R. Zivan. Secure DisCSP protocols – from centralized towards distributed solutions. In *DCR Workshops*, 2005.
- [23] A. Petcu and B. Faltings. A scalable method for multiagent constraint optimization. In *IJCAI*, pages 266–271, 2005.
- [24] M. C. Silaghi, B. Faltings, and A. Petcu. Secure combinatorial optimization simulating DFS tree-based variable elimination. In *ISAAC*, 2006.
- [25] M. C. Silaghi and D. Mitra. Distributed constraint satisfaction and optimization with privacy enforcement. In *WI-IAT*, pages 531–535, 2004.
- [26] T. Tassa and E. Gudes. Secure distributed computation of anonymized views of shared databases. *TODS*, 37, Article 11, 2012.
- [27] J. Vaidya and C. Clifton. Privacy preserving association rule mining in vertically partitioned data. In *KDD*, pages 639–644, 2002.
- [28] A. Yao. Protocols for secure computation. In *FOCS*, pages 160–164, 1982.
- [29] W. Yeoh, A. Felner, and S. Koenig. BnB-ADOPT: An asynchronous branch-and-bound DCOP algorithm. *JAIR*, 38:85–133, 2010.
- [30] M. Yokoo, K. Suzuki, and K. Hirayama. Secure distributed constraints satisfaction: Reaching agreement without revealing private information. *Artificial Intelligence*, 161:229–246, 2005.
- [31] W. Zhang, Z. Xing, G. Wang, and L. Wittenburg. Distributed stochastic search and distributed breakout: properties, comparison and applications to constraints optimization problems in sensor networks. *Artificial Intelligence*, 161:55–87, 2005.
- [32] S. Zhong, Z. Yang, and R. Wright. Privacy-enhancing k -anonymization of customer data. In *PODS*, pages 139–147, 2005.
- [33] R. Zivan and A. Meisels. Message delay and DisCSP search algorithms. *MAAI*, 46(4):415–439, 2006.