A General Framework for Stable Roommates Problems using Answer Set Programming (Extended Abstract)

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The Stable Roommates (SR) problem (Gale and Shapley 1962) is a matching problem characterized by the preferences of agents over other agents as roommates: each agent ranks all others in strict order of preference. A solution to SR is then a partition of the agents into pairs that are *acceptable* to each other (i.e., they are in the preference lists of each other), such that the matching is *stable* (i.e., there exist no two agents who prefer each other to their roommates, and thus *block* the matching).

SR is an interesting computational problem, not only due to its applications (e.g., for pairing in large-scale chess competitions (Kujansuu, Lindberg, and Makinen 1999), for campus house allocation (Arkin et al. 2009), pairwise kidney exchange (Roth, Sönmez, and Ünver 2005)) but also due to its computational properties described below.

Incomplete preference lists with ties. SR is studied with incomplete preference lists (SRI) (Gusfield and Irving 1989), with preference lists including ties (SRT) (Ronn 1990), and with incomplete preference lists including ties (SRTI) (Irving and Manlove 2002). While SR and SRI are tractable (Irving 1985; Gusfield and Irving 1989), SRT and SRTI are intractable under weak stability (Ronn 1990; Irving, Manlove, and O'Malley 2009).

Stable and more fair solutions. With the motivation of finding more fair stable solutions, optimization variants of SRTI are also studied. For instance, Egalitarian SRTI aims to maximize the total satisfaction of preferences of all agents; it is NP-hard (Feder 1992). Rank Maximal SRTI aims to maximize the number of agents matched with their first preferences, and, subject to this condition, tries to maximize the number of agents matched with their second preferences, and so on; it is NP-hard (Cooper 2020).

Not stable but good-enough solutions. When an SRTI instance does not have a stable solution, Almost SRTI aims to minimize the total number of blocking pairs (i.e., pairs of agents who prefer each other to their roommates); it is NP-hard (Abraham, Biró, and Manlove 2005).

We have introduced a formal framework and its implementation, called SRTI-ASP, that are general enough to provide solutions to all variations of SR mentioned above, including the intractable decision/optimization versions. Having such a flexible framework and implementation is valuable for studies in matching theory.

SRTI-ASP utilizes the knowledge representation and reasoning paradigm Answer Set Programming (ASP) (Niemelä 1999; Marek and Truszczyński 1999; Lifschitz 2002) to declaratively solve the stable roommates problems. The idea is to represent SR and its variations in the expressive logic-based formalism of ASP in an elaboration tolerant way (McCarthy 1998), and to compute models (i.e., answer sets (Gelfond and Lifschitz 1988; Gelfond and Lifschitz 1991)) of these formulations using the ASP solver CLINGO (Gebser et al. 2011).

For each variation of SR, given a problem instance, SRTI-ASP returns a solution (or all solutions) if one exists; otherwise, it returns that the problem does not have a solution. SRTI-ASP is sound and complete (Erdem et al. 2020, Theorem 1).

We have evaluated SRTI-ASP over different sizes of randomly generated SRI instances to understand its scalability for SRI and its intractable variations, as the input size and the degree of completeness of preference lists increase. We have observed that solving the optimization variants of SRI takes significantly more time, compared to solving SRI. We have also observed that as the completeness degree increases, the computation times increases. After developing a method to add ties to these SRI instances, we have empirically analyzed the scalability of SRTI-ASP on SRTI instances as well. We have observed that solving SRTI takes significantly more time, compared to solving SRI.

We have also compared SRTI-ASP with two related approaches over different sizes of randomly generated SRI instances: SRI-CP (Prosser 2014) solves SRI using constraint programming, and SR-AF (Amendola 2018) solves SR using an argumentation framework. We have extended SR-AF to solve SRI for our experiments. We have observed that both SRI-CP and the extended SR-AF perform significantly better than SRTI-ASP for large SRI instances.

Comparisons with SRI-CP and SRI-AF has helped us to better observe the flexibility of SRTI-ASP due to elaboration tolerant ASP representations. It is easier to extend SRTI-ASP to address different variations of SR, while SRI-CP and SRI-AF require further studies in modeling as well as implementation. Note that SRI-CP is overspecialized in the interests of efficiency to solve SRI.

For further information about this study, we refer the reader to our journal paper (Erdem et al. 2020).

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