with each other (both have an action which deletes a condition that the other agent needs).

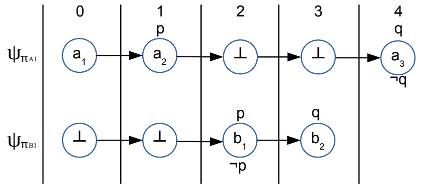

Figure 2: Schedule example

Table 3 represents the game in normal-form of problem 2 shown in Table 1. In this case, we find three different equilibria: (π_{A1}, π_{B2}) with payoffs (15,14) and delays (3,2) for agent A and B, respectively; another NE is (π_{A2}, π_{B1}), with payoffs (14,15) and a delay of (2,3) time steps, respectively; the last NE is a mixed strategy with probabilities 0.001 and 0.999 for π_{A1} and π_{A2} of agent A, and probabilities 0.001 and 0.999 for strategies π_{B1} and π_{B2} of agent B. In this problem we have a cell with $-\infty$ as payoff of the two agents. This payoff represents that there does not exist a valid joint schedule for the plans due to an unsolvable conflict as the one shown in Figure 3.

	π_{B1}	π_{B2}	π_{B3}	π_{B4}
π_{A1}	$-\infty,-\infty$	15,14 (3,2)	18,7 (0,2)	17,9 (1,0)
π_{A2}	14,15 (2,3)	14,14 (2,2)	16,6 (0,3)	16,9 (0,0)
π_{A3}	8,16 (0,2)	8,16 (0,0)	8,7 (0,2)	8,8 (0,1)
π_{A4}	7,18 (2,0)	6,16 (3,0)	9,9 (0,0)	8,9 (1,0)

Table 3: Problem 2

The game in Table 4 is the same game as the one in Table 3 but, in this case, the agents suffer a delay penalty of 3.5 (instead of 1) per each action delayed in their plan schedules. Under this new evaluation, we can see how this affects the general game. In this situation, the only NE solution is (π_{A2}, π_{B2}) with utility values (9,9) and a delay of two time steps for each agent. Note that this solution is neither Pareto-optimal (solution (16,9) is Pareto-optimal) nor it maximizes the social welfare. However, these two solution concepts can be applied in case of multiple NE.

In conclusion, our approach simulates how agents behave with several strategies and it returns an equilibrium solution that is stable for all of the agents. All agents participate in the schedule profile solution and their utilities are dependent on the strategies of the other agents regarding the conflicts that appear in the problem.

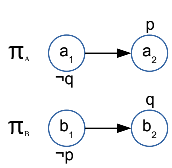

Figure 3: Unsolvable conflict

	π_{B1}	π_{B2}	π_{B3}	π_{B4}
π_{A1}	$-\infty,-\infty$	7.5,9 (3,2)	18,2 (0,2)	14.5,9 (1,0)
π_{A2}	9,7.5 (2,3)	9,9 (2,2)	16,-1.5 (0,3)	16,9 (0,0)
π_{A3}	8,11 (0,2)	8,16 (0,0)	8,2 (0,2)	8,5.5 (0,1)
π_{A4}	2,18 (2,0)	-1.5,16 (3,0)	9,9 (0,0)	5.5,9 (1,0)

Table 4: Problem 2b, more delay penalty to the utility

Conclusions and future work

In this paper, we have presented a complete game-theoretic approximation for non-cooperative agents. The strategies of the agents are determined by the different ways of solving mutex actions at a time instant and the loss of utility of the solutions in the plan schedules. We also present some experiments carried out in a particular planning domain. The results show that the SPE solution of the extensive-form game in combination with the NE of the general game return a stable solution that responds to the strategic behavior of all of the agents.

As for future work, we intend to explore two different lines of investigation. The exponential cost of this approach represents a major limitation for being used as a general MAP method for self-interested agents. Our combination of a general+internal game can be successively applied in subproblems of the agents. Considering that this approach solves a subset of goals of an agent, the agent could get engaged in a new game to solve the rest of his goals, and likewise for the rest of agents. Then, a MAP problem can be viewed as solving a subset of goals in each repetition of the whole game. In this line, the utility functions of the agents can be modeled not only to consider the benefit of the current schedule profile but also to predict the impact of this strategy profile in the resolution of the future goals. That is, we can define payoffs as a combination of the utility gained in the current game plus an estimate of how the joint plan schedule would impact in the resolution of the remaining goals. Another line of investigation is to extend this approach to cooperative games, allowing the formation of coalitions of agents if the coalition represents a more advantageous strategy than playing *alone*.

Acknowledgments

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Minima architecto inventore ullam vel ipsa fugit fugiat sequi, tenetur nobis quia nihil ducimus aperiam quibusdam porro et nesciunt in.Mollitia vel architecto ipsa temporibus maiores eligendi rem laudantium minima at voluptatibus, praesentium quisquam nulla unde sequi quod nostrum eos autem voluptatem incidunt, iure porro molestiae odio, temporibus quo explicabo consequuntur?Explicabo non accusamus suscipit eligendi perspiciatis quasi blanditiis omnis recusandae vel aliquam, hic iste eaque voluptatibus alias suscipit minus nihil, ullam totam recusandae repellat aperiam, eius omnis repellendus ut facere repudiandae consectetur illo rem.Recusandae corporis harum quo omnis alias tempora porro, libero quos numquam ipsa voluptas, delectus iusto odit labore ducimus cumque quia sint aut enim tenetur corporis.