Report on the outcomes of a Short-Term Scientific Mission[1]

Action number: CA16228

Grantee name: Artem Tsikiridis

Details of the STSM

Title: On Budget-Feasible Mechanism Design

Start and end date: 17/03/2022 to 31/03/2022

Description of the work carried out during the STSM

Description of the activities carried out during the STSM. Any deviations from the initial working plan shall also be described in this section.

During the STSM, I, the grantee, worked with my host at University of Essex, Dr. Georgios Amanatidis, on problems in the area of budget-feasible mechanism design. As per the submitted Working Plan, we initially focused on budget-feasible mechanism design beyond the common single-parameter model (Objective no. 1 of the initial working plan) and analyzed the limits of such extensions. We considered a formulation in which the private information, which commonly includes only the private cost of each agent participating in the procurement auction, is enriched with an additional "supply" parameter, as per the work of [Lehmann et al. 01]. Our preliminary studies during the STSM suggest that there may be inherent impossibility results of significant theoretical interest. Regarding the study of auction environments in which strategic agents are willing to offer the auctioneer multiple-levels of service (Objective no. 2 of the initial working plan), we identified cases of theoretical and practical interest, established structural properties of this generalization of the problem and, at the same time, managed to obtain non-trivial preliminary results (see paragraph below for a detailed description). En route, during the STSM we revisited the well-known tools and frameworks which have been used in the proofs of the known state-of-the-art results and literature in the area. This process is a critical preliminary step in our attempt to implement Objective no. 3: that is, understanding the optimal deterministic mechanisms that are incentive-compatible, budget-feasible and can be implemented in polynomial-time when the utility function of the auctioneer is an additive function of the agents, a fundamental open problem in the area. By continuing the study of the multi-level extension of Objective 2, we expect to arrive at useful synergies which may lead us to the answer to this question.

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[1] This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the GH for payment of the Grant.

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Description of the STSM main achievements and planned follow-up activities

Description and assessment of whether the STSM achieved its planned goals and expected outcomes, including specific contribution to Action objective and deliverables, or publications resulting from the STSM. Agreed plans for future follow-up collaborations shall also be described in this section.

To the best of our knowledge, we are the first to study the problem of budget-feasible mechanism design when agents are willing to provide the auctioneer multiple levels of service. In this model the auctioneer has a particular budget, a publicly known concave utility function and faces bidders each of which has a private cost. The goal of the auctioneer is to maximize the total utility obtained by bidders using an economic auction mechanism that is incentive compatible (bidders have no incentive to lie about their cost) and can be implemented in polynomial time. Additional combinatorial constraints which further refine the space of feasible solutions may be present (e.g., polymatroid constraints). During the STSM and in line with my proposed working plan, we accomplished the following goals:

1. We chartered the frontier of tractability for the problem: our initial result implies that, under the assumption that the budget is such that each bidder is guaranteed to be paid on their own, the performance of the best mechanism with the above properties crucially depends on the maximum number of levels of service that is offered (lower bound). Note that this assumption is common in the literature of budget-feasible mechanism design.
2. We obtained appropriate generalizations of known mechanisms which turned out to be optimal for the special case of an additive utility function and multiple levels of service.
3. We determined that such approaches are not effective for the problem when the auctioneer has a general concave utility function (note that additive functions are merely a particular special case of concave functions). We concluded that new tools need to be developed to tackle this problem for the more general cases. On that front, we discovered a prototype of a mechanism which is more effective when handling concave utility functions, although we believe that there is still significant room for improvement.

As can be derived from the above, my STSM to the university of Essex accomplished several objectives that are listed to the action's Memorandum of Understanding. To highlight a few:

1. Novel theory and methodology was developed on problems of truthful and budget-feasible mechanism design, an area naturally connected to the study of incentives and game theory in general, a core objective of this COST action.
2. It is due to this STSM that me and my host started this interdisciplinary research agenda with our main goal being the dissemination of our results to leading publishing venues in the area.
3. A new link is now in place between the department of Informatics at AUEB and the department of Mathematics of University of Essex.
4. The grantee, a junior researcher from the European Union, was exposed to an international research environment. This experience may prove to be quite useful during my next steps (e.g. a postdoctoral researcher position).