Available online at www.sciencedirect.com
ScienceDirect
Journal of Economic Theory 156 (2015) 103–143
JOURNAL OF Economic Theory
www.elsevier.com/locate/jet

Envy freedom and prior-free mechanism design

Nikhil R. Devanur [a], Jason D. Hartline [b,*], Qiqi Yan [c]

[a] *Microsoft Research, One Microsoft way, Redmond, WA 98052, USA*
[b] *Electrical Engineering and Computer Science Department, Northwestern University, 2133 Sheridan Rd., Evanston, IL 60208, USA*
[c] *Google Inc., 1600 Amphitheatre Pkway, Mountain View, CA 94043, USA*

Available online 7 August 2014

Abstract

We consider the provision of an abstract service to single-dimensional agents. Our model includes position auctions, single-minded combinatorial auctions, and constrained matching markets. When the agents' values are drawn independently from a distribution, the Bayesian optimal mechanism is given by Myerson [1] as a virtual-surplus optimizer. We develop a framework for prior-free mechanism design and analysis. A good mechanism in our framework approximates the optimal mechanism for the distribution if there is a distribution; moreover, when there is no distribution this mechanism still provably performs well.

We define and characterize optimal envy-free outcomes in symmetric single-dimensional environments. Our characterization mirrors Myerson's theory. Furthermore, unlike in mechanism design where there is no point-wise optimal mechanism, there is always a point-wise optimal envy-free outcome.

Envy-free outcomes and incentive-compatible mechanisms are similar in structure and performance. We therefore use the optimal envy-free revenue as a benchmark for measuring the performance of a prior-free mechanism. A good mechanism is one that approximates the envy-free benchmark on any profile of agent values. We show that good mechanisms exist, and in particular, a natural generalization of the random sampling auction of Goldberg et al. [2] is a constant approximation.
© 2014 Elsevier Inc. All rights reserved.

JEL classification: C7

Keywords: Envy freedom; Incentive compatibility; Myerson; Prior-free; Mechanism design

* Corresponding author.

http://dx.doi.org/10.1016/j.jet.2014.08.001
0022-0531/© 2014 Elsevier Inc. All rights reserved.

1. Introduction

The theories of optimal mechanism design for revenue maximization and social surplus maximization are fundamentally different. The revenue-optimal mechanism of Myerson [1] depends on the prior distribution from which the values of the agents are drawn whereas the surplus-optimal mechanism of Vickrey [3], Clarke [4], and Groves [5] is prior free. In fact, the latter result is singular in this regard. Incentive constraints bind across the possible misreports of each agent; therefore, an optimal mechanism must generally trade off performance on one input (i.e., profile of agent valuations) for another. This paper gives and justifies a formal methodology for prior-free mechanism design and employs this methodology to design good prior-free mechanisms for the revenue objective in complex environments.

Prior-free mechanisms have a number of advantages over Bayesian mechanisms. By design their performance is guaranteed on any input. In particular, they do not rely on randomization of or knowledge of the agents' preferences. Moreover, they do not rely on the common prior assumption, i.e., that the agents themselves have distributional knowledge of each other's preferences. Therefore the guarantees obtained in prior-free mechanism design are very robust. While implementation of the Bayesian optimal mechanism requires a market analysis which may be error prone, costly, or infeasible; a prior-free mechanism can be implemented without any additional knowledge.

The literature on prior-free mechanism design since Goldberg et al. [2,6] has primarily explored the benevolent environment of digital goods, i.e., where each agent wishes to buy a unit and serving an agent imposes no constraint on whether other agents can or cannot be served. This paper extends this study to structurally rich environments with complex feasibility constraints over the sets of agents that can be simultaneously served. To do so, we give (a) a non-trivial generalization of the prior-free design and analysis framework codified by Goldberg et al. [6] and extended by Hartline and Roughgarden [7] and (b) novel methods for analysis of prior-free mechanisms in complex environments.

In this framework for the design and analysis of prior-free mechanisms we analyze a generalization the *random sampling mechanism* proposed by Goldberg et al. [2,6] and Baliga and Vohra [8]. A random sampling mechanism, as it is run, performs a market analysis on a random subset of the agents and uses this market analysis to optimize the mechanism for the remaining agents. The advantage of incorporating the market analysis in the mechanism is that the mechanism's analysis then accounts for both the incentives and the statistical inaccuracies inherent in performing the market analysis. Our work extends the analysis of the random sampling mechanism to structurally rich environments. Our main theorem gives a very strong guarantee on such a mechanism's revenue which holds pointwise over all valuation profiles. A corollary of this pointwise guarantee is that, in expectation for agents with values from an i.i.d. but unknown distribution that satisfies a mild regularity condition, the mechanism's revenue approximates the Bayesian optimal mechanism's revenue.

A running example of an environment for single-dimensional agents is that of the *position auction* which models the problem of allocating advertisements on Internet search engines, cf. Edelman et al. [9] and Varian [10]. A position auction allocates clicks to advertisers by ordering their advertisements on a search results page under the assumption that the probability that an advertisement is clicked on is given exogenously by the position of the advertisement in the ordering. Denote this vector of click rates (a.k.a., *weights*) for n possible positions (in the non-increasing order) by $\mathbf{w} = (w_1, \ldots, w_n)$. An advertiser is considered *served* if her ad is clicked on. A position auction can assign the advertisers to positions deterministically or

متن کامل مقاله

دریافت فوری

ISIArticles
مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات