Designing Sponsored Search Auctions for Federated Domain-Specific Search Engines

(Extended Abstract)

Sofia Ceppi
DEI, Politecnico di Milano, Milano, Italy
ceppi@elet.polimi.it

ABSTRACT

My Ph.D. thesis focuses on the design of economic mechanisms inspired by sponsored search auctions to support new generation search engines. These engines (called integrators) are based on multi-domain queries and on the federation of multiple domain-specific search engines. The problem studied in my thesis is essentially a mechanism design problem where two levels are present: in the first, the advertisers submit bids to the domain-specific search engines; in the second, the domain-specific search engines interact with an integrator in the attempt to produce the best search results.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence—*Intelligent agents*

General Terms

Algorithms

Keywords

Game theory (cooperative and non-cooperative), Auction and mechanism design

1. INTRODUCTION

Sponsored search auctions [9] play a prominent role in the Internet advertising, generating more than ninety per cent of the search engines' revenues. A large number of theoretical/practical works can be found in the very recent literature. Nevertheless, this market is still largely unexplored and a number of problems are currently open. In particular, the recent advancements in the search computing field lead to the definition of novel searching paradigms, based on multi-domain queries and the federation of multiple domain-specific search engines, to which the current sponsored search auctions cannot be applied. The objective of my Ph.D. thesis is the design of economic mechanisms [11] inspired by sponsored search auctions to support the novel searching paradigms.

2. STATE OF THE ART

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2.1 Sponsored Search Auctions

The functioning of sponsored search auctions is simple. When a user enters keywords into a search engine, several sponsored links related to the entered keywords are displayed alongside the search results, e.g., see [2]. The search engine chooses the sponsored links to publish and the ranking over them by using an auction mechanism where the bidders are advertisers and the items of the bids are keywords. The adopted payment scheme is the *pay-per-click*, i.e., the advertiser pays the search engine only when its link is clicked by a user. The most employed auction mechanism in sponsored search auctions is the *generalized second price* (GSP) [6] that is an *ad hoc* extension of the *Vickrey auction* (VA) [8] to the setting where a set of ranked objects is being sold. In the VA, a winner pays the second highest bid, while, in the GSP, each winner pays an amount equal to her next highest bid. However, as shown in [6], in the GSP the truth-telling strategy is not (generally) optimal for the players, as instead it is in the VA. The exact generalization of the VA to the above settings, satisfying the property that the truth-telling strategy is optimal, is similar to the GSP except for the definition of the payments. Although this last mechanism is strategy-proof and should assure a higher degree of the outcome stability, it is not currently adopted in real-world applications.

2.2 Novel Searching Paradigms

The recent advancements in the search computing field lead to the definition of novel searching paradigms to which the available sponsored search auction mechanisms cannot be applied. The main general-purpose search engines crawl the Web and index Web pages, finding the best pages for each specific list of keywords with excellent precision. Anyway, the so-called "deep Web" contains information that is largely more valuable than that contained in single Web pages and the current general-purpose search engines are not able to discover it. The development of new searching paradigms able to address more complex searches than those addressed by the current search engines and to discover deeper information is currently one of the most interesting challenges in the search computing field. In particular, the emerging paradigm is based on the integration of heterogeneous data sources. According to that, a special search engine, called *integrator*, integrates the results produced by multiple search engines, e.g., see [4]. The basic idea is the following. The user's search is composed by multi-domain queries. Each multi-domain query is automatically decomposed by the integrator in multiple single-

domain queries and each single-domain query is addressed to the most appropriate domain-specific search engine. Obviously, when a query addresses a specific domain, domain-specific search engines works better than general-purpose ones. Once the integrator has received the search results form all the domain-specific search engines, it aggregates them in a unique result. This is usually shown by using *ad hoc* interfaces that allows the user to explore the search and refining it, see, e.g., [3].

2.3 Business Models

The search computing field is working exclusively on the searching techniques and is neglecting the business model appropriate for the above scenario (e.g., the kind of contracts that can be drawn by the integrator and the domain-specific search engines). Currently the commercial use of the search results of a search engine is ruled by a contract between the search engine and the publisher prescribing that the publisher must publish the list of sponsored links produced by the search engine, e.g., as in [1]. Once a user clicks on a sponsored link, the search engine receives the payment from the corresponding advertiser and gives part of this to the publisher. The payment ratio of the search engine is defined by a commercial contract and is independently of the specific search. On the one hand, the basic idea behind this business model "naturally" applies to integration-based search computing. On the other hand, the contracts between the publisher (in this case the integrator) and the search engines (in this case the domain-specific search engines) must be reconsidered keeping into account that each search engine plays a role in the generation of the search process. My opinion is that the contracts between the integrator and the search engines should be drawn dynamically, depending on the specific search and, in particular, on the contribution of the specific search engine to the search.

3. THE THESIS OBJECTIVE

The objective of my Ph.D. thesis is the development of economic mechanisms to support the new generation search engines. Essentially, this scenario can be modeled as a two-level auction. The first level is characterized by the interactions between the advertisers, that submit bids for specific keywords, and domain-specific search engines, that produce the list of advertisers most appropriate for a given keyword. The second level is characterized by the interactions between domain-specific search engines, that communicate their lists of sponsored links, and the integrator, that merges the lists of multiple domain-specific search engines and determines the payments for each search engine such that it has the right incentive not to misreport information about its list of sponsored links. In the process of fusion of the lists, the integrator keeps into account the advertisers' bids and the click probabilities related to each domain-specific search engines in order to generate the list of sponsored links that gives the largest expected utility. The integrator being in the position to exploit different data sources, it can produce more fine estimates of the click probabilities related to each single sponsored link. This would lead the integrator to target at best the advertisement and to produce a utility surplus with respect to the situation where the integrator is not present. The objective of my thesis is essentially to model this problem as a mechanism design problem [8] and to provide techniques to solve it.

4. PROGRESS

I focused on the second level of the above scenario. Exactly, I focused on the interaction between the integrator and the domain-specific search engines. I formalized it as an economic mechanism in which the social choice function and the payment functions need to be defined and I studied it by using the automated mechanism design paradigm [10]. Building the mechanism, I imposed several constraints: *incentive compatibility*, *individual rationality*, and *weak budged balance*. A peculiarity of the mechanism is that the valuation functions are *interdependent*. Indeed, the click probability over which the valuation functions are defined depends on the click probabilities of all the domain-specific search engines. At the current state I have defined a basic automated mechanism design tool usable only with small settings; it implements different objective functions with the aim of evaluating how the revenue sharing changes [5]. As next steps of my work I would like to develop analytical mechanisms able to address concrete settings (in particular I will resort to group strategy-proof mechanisms, such as, e.g., the Moulin mechanism and its extensions [7]), I have planned to introduce in the machanism payment rules more appropriated for this kind of auction, I want to study revenue sharing mechanism, and I want to explore two-stage mechanisms to address interdependence valuations.

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