A Profitable Sponsored Search Mechanism

Faria Nassiri-Mofakham
Department of Information Technology Engineering, University of Isfahan, Iran
fnasiri@eng.ui.ac.ir

Samer Hayek
Department of Information Technology Engineering, University of Isfahan, Iran
samer.hayek@yamail.com

Abstract
Nowadays, the Internet has had a rapid expansion and presence in all areas of the individuals, institutions, companies and organizations lives. This has made large extent of data available so that the users need to access their desired information or services through using search engines. To continue and promote providing services, search engines require a source of income. Sponsored search advertising is the main source of revenue for search engines. In sponsored search, limited areas of the search results page are dedicated to display advertising so that the advertiser pays the advertisement cost only per click. To assign advertising areas, an auction is run among advertisers. Several models have been proposed to hold a sponsored search auction. In this study, a new model is proposed to increase the revenue of the search engine. Evaluated using synthetic data, the results of the ad-supported implementation of the search engine model indicate improved revenue in comparison to existing models.

Keywords: search engine, sponsored search, auction mechanism, advertisement

Introduction
Every day, millions of web pages full of information are being explored by millions of Internet users worldwide. Due to the large volume of information and news about goods, music, or anything else which can be easily found online, living in the virtual world would be difficult or impossible without search engines. The increasing use of search engines is not limited to keyword search for finding the products and information; they are also a good place for advertising. More than 50 percent of internet users use search engines at least once a day, so that it reaches over 6 billion searches per month only in America. Above 13 percent of the traffic from search engines comes from commercial sites (Szetela & Kerschbaum, 2010). Search engines create effective opportunities for marketers to attract millions of users towards the manufacturers and service providers’ web sites. Search engines display ads in certain regions of the page which are more likely to attract users’ attention. Sponsored search auction mechanism is used for determining the price of these limited areas and allocating them to advertisers (Jansen & Mullen, 2008).
This paper proposes a new model for determining the winner of the auction and the arbitration price in sponsored search engine. The results show that the model improves the search engine revenue compared to the existing models.

The rest of this paper is organized as follows. Section II introduces sponsored search engine by considering the roles of user, advertiser, and search engine. It also reviews different auction mechanisms in determining the winners and the price to pay. In Section III, the proposed model is presented and sponsored search advertising system is designed and implemented. Section IV presents the simulation results. To assess its effectiveness, revenue of the proposed model is compared with that of other existing models using randomized data. The advertising system is also implemented and evaluated. Finally, Section V concludes and presents the future trends.

**Sponsored Search**

“Sponsored search” relates the process of advertising in Search engines. In this method of advertising, advertisers pay only when their ads are clicked. The cost is determined using sponsored search’s auctions. The behaviour of the Internet users, advertisers and sponsored search engine are dependent and has an important role in the sponsored search process. This section explains the search process, the participants’ behaviour, and the auctions.

A. The concept of sponsored search

Selling the advertising in traditional media (e.g., magazines and television) is generally based on the number of ads or people exposed to the ads. However, the sponsored search cost is calculated based on the number of clicks. The advertisers pay only when a user clicks on their ad. The cost of a large fraction of traditional advertising and even large amount of brand advertising typically is determined through informal assessment and negotiation processes. Nonetheless, sponsored search advertising provides efficient pricing through online auctions to attract advertisers’ genuine desire and to support them over the time. In the industry of sponsored search, different auctions are held for different phrases that are being searched. For example, the queries “Plasma TV” and “three-dimensional television” will be considered in two separate auctions.

Advertiser proposes a list of keywords and suggested prices to the search engine. Suggested price means the highest price the advertiser can pay per click (Szetela & Kerschbaum, 2010). Once a user looks for a keyword, an auction is run among the advertisers’ bids whose corresponding keywords are related to the search. When the user clicks one of the links, the corresponding advertiser will pay to search engine a price per click.

Sponsored search auctions differ from traditional auctions. In the former, only buyers and one auctioneer, which is the seller itself, are playing the roles. However, in sponsored
search auction there are three players:
- Advertisers, who suggest a price per keyword,
- Search engine, who organizes the auction, and
- Users, who search keywords; their behaviors determine the value of each advertising region.

Moreover, the auction is not run only once; it is repeated and the advertisers can change their bids over the time. For example, if the advertiser is a travel agency, it likely will desire to increase its bid when it is close to holidays. Also, it can limit their bids to specific world area as it may be able to present services and products only to that area.

The results provided by a search engine’s search algorithms are called “algorithmic results”. Usually, sponsored search ads are displayed above and on both sides of the algorithmic results. In general, these advertising results explicitly are shown as sponsored links according to recommendation of Federal Trade Commission (FTC) (Jansen & Mullen, 2008). Figure 1 shows the search engine result pages that include algorithmic results and sponsored search advertising.

![Figure 1. Sponsored search advertising (a) Google, (b) Yahoo.](image-url)
B. Participants in sponsored search auction

Players in sponsored search engine auctions are Internet users, advertisers and search engines. Behaviour of each of these three participants can affect the behaviour of other players. In the following sections the behaviour of each of these roles is investigated.

1) Internet users: Internet users play a very important role in the sponsored search auctions. In the advertisers’ point of view, Internet users generate traffic online on their website. The online traffic can lead to a purchase. From the search engine point of view, internet user’s clicks are equal to receiving advertising fees from the advertisers. Studies conducted on the behaviour of Internet users promote a better understanding of the strategies adopted by advertisers and search engine. Internet user performs a search process which consists of the following decisions: First the user decides the keywords and search engine to use to search. After viewing the results, the user must then decide to visit a number of links. After exploring the links, the user should decide for a purchase (http://yahoo.com). These decisions are discussed as follows:

1-1) Selecting search engine and keywords: Similar to in ordinary shopping trip, Internet users must decide about the store to buy the items from. Here, a few questions are raised: Which search engine is better to use? Which search engine will attract more users and why? Does a user prefer to use several search engines? Which keywords are most often used?

Answers of these questions are of great importance in the policies of search engine campaigns and advertisers (Yao & Mela, 2008). These effects are discussed in subsequent sections. However, it may be said briefly that if the Internet users tend to use different search engines and different keywords to search for a product, the advertisers then prefer to participate in auctions held by different search engines and different keywords. Furthermore, the probability of using a particular keyword has an important role in determining the degree of competition by advertisers on this keyword. For example, if the users who want to buy digital camera are often use words “digital camera”, digital camera advertisers also will prefer to use this word in their advertising and then the competition is increased among them. The competition directly affects the search engine income.

1-2) Number of selected web sites to explore: The number of search links that a user clicks on influences the costs that advertisers will pay, the online traffic to the website, the shopping rate, and the search engine revenue. For example, if the user clicks more than one link, despite increasing the click rate of the advertisement it may result in dropping the advertiser’s sales due to very high number of alternatives available for the user. From the search engine’s view, the more number of clicks does not necessarily lead to greater income. It should be noted that the search engine’s income (Equation 1) is derived from the number of clicks (n) and cost-per-click (CPC) (Athey & Nekipelov, 2010).
**revenue = CPC * n**  \hspace{1cm} (1)

So even by increasing the number of clicks, it is possible to reduce the cost per click. Advertisers will decrease their offers due to declining the sales. Therefore, the number of links affects advertising strategies, optimal auction design, and even the design of search results page (Yao & Mela, 2008).

1-3) *Selection of links to click:* Due to the number of links that are displayed on the search results page, user can click the link(s). The page region that is more likely to be clicked is more valuable for both advertisers and search engine. That is, the ranking strategies and the auction revenue depend on the users’ choice.

2) *Advertisers:* The advertiser needs to choose the keywords asking the search engine to advertise on them. To do this, the advertiser must measure the value of each region for each keyword in any search engine. After the decision, she must make a decision about the corresponding bid. She should also pay attention to the advertising design. These issues are referred to in the following parts.

2-1) *Selecting search engine and keywords:* There are various search engines, each one puts up several keywords for auction. Therefore, an advertiser has to select the search engine and the keywords prior to entering the auction. For a selection, the following factors should be considered:

1- The number of Internet users using a search engine and a specific keyword: The volume of users of a search engine for a specific keyword is used to estimate the number of clicks an advertiser sets. So advertisers should choose high traffic search engine and keywords.

2- Characteristics of the Internet users: The level of the user’s impression of the advertisement and her desire to click and purchase affects the online traffic of the advertiser website and shopping rates. Users with very specific goals will be more likely to click and buy. For example, users who search in a more specific keyword such as “hotels in Isfahan” may be more likely to book a hotel with respect to those who just search “Isfahan”.

3- Mechanism Adopted by Search Engines and Competitiveness of the auction: This factor determines the probability of winning and payment value. Low winning probability and high payment price, scare the bidders and cause they avoid participating in the auction (Yao & Mela, 2008).

2-2) *Measuring the value of an advertising region:* To find the value of a place to advertise, there are at least two candidate parameters that can have an influence on advertiser’s sales:

1- Online traffic directed to the advertisers website, and

2- Number of pages displayed in search results.

The value of these two variables cannot be calculated easily because they have an
indirect influence on the advertising process and purchases. After one click, the user may
remain loyal to a store due to a positive feedback even when the click has not resulted in a
purchase. He may return in the future for other purchases. With this assumption, the place
will be underestimated. Since many online retailers offer a variety of products, calculating
the resulting revenue even when a click leads to a purchase is difficult due to difficulty of
predicting the product the customer may purchase. In addition to the number of clicks,
sponsored search advertising can do feedbacks like banner advertising. This feedback will
raise awareness among consumers. Many advertisers bids wrong keywords to also advertise
in the result pages that are potentially unrelated. For example, the eBay.com chooses
grammatically incorrect keywords such as “ebbay”, “ebya”, and “eaby” at Google.com
(Yao & Mela, 2008).
2-3) Designing advertisement: Designing an ad on the search results page affects click
on and feedback. Does the advertiser need to either publish further information on the
search results page or keep that information hoping the consumers will be aware of this
information in visiting his site? Although the first strategy may bring a better feedback, the
second strategy increases the number of clicks.
2-4) Pricing value: The pricing is related to the auction mechanism that the search
engine employs. If the search engine uses general first-price or second-price auction
mechanism, the advertiser’s winning only depends on the value of the bid. He will pay the
price he offered for the region. However, if the search engine employs mechanisms that
consider the quality of advertising and click through rate, then advertisers whose
advertisements have high quality tend to offer lower prices. In contrast, advertisers who
have low quality advertisements would tend to suggest a higher price to compensate the
quality hoping to win a better advertising region which results in gaining more publicity
and quality that in turn can cover decreasing their bids.
3) Search engine: In search engines several complex issues exist which are explained
as follows.
3-1) Optimal auction design: Revenue maximization is the problem that is considered
in designing an auction mechanism for a search engine. This issue is related to several
factors which are considered in the following parts.
1- Winner Determination and Payment: The major problem in designing an auction
mechanism is determining the winner and the price to be paid by the winner. There are
different mechanisms such as first-price and second-price auctions. However, they cannot
be applied directly as sponsored search auction. Revenues expected from advertising
winner depends on the number of expected clicks (α) and the price paid per click (CPC)
(Yao & Mela, 2008).
The other parameters have an impact on these two factors and should be considered in
the design of the mechanism:
- **Which areas the advertiser should win?**

  Better area results in more clicks and then has a higher price. Click through rate of each area is not independent of the identity of the winner. Click through rate varies for different advertisers who advertise on this site.

  - **Advertisers Neighborhood.**

    For example, if ad of a small retailer will be placed next to a large retailer advertisement, users are absorbed to large retailer and so click on the small retailer is decreased.

  - **How many auctions should be held and how many regions should be considered for each auction?**

    Offering more keywords can increase the number of bids. This may get the advertisers to focus on multiple auctions which in turn reduce competition in each auction. Multiple auctions may change the advertiser valuation of each situation causing change of his behaviour in the auction.

2- **Reservation price:** Search engines can determine the minimum possible bid so that any offer lower than the amount will not be accepted. The auction considers this minimum price as “reservation price”. Search engines can take advantage of reservation price as a means to maximize revenue. The basic idea is that all costs in excess of the reservation price is received from the winner. Although this concept can be used in optimization of reservation price in sponsored search engine auctions, a high reservation price decreases the chance of lower bidders for participating the auction. The reduction in the number of bidders could reduce competition and result in lower search engine revenue (Yao & Mela, 2008).

3-2) **Results of search queries:** Search engines are competing to absorb users and advertisers. It is the nature of competition between search engines that advertisers and customers choose the search engine. Due to this, each search engine independently adopts policies to maximize the profit. Such policies include strategies for customers (such as Web page design and search algorithms) and the advertisers’ strategies (such as auction mechanism). Auction mechanisms will be reviewed in part C in Section II. The product of a search engine for users is search results. This free information includes the main results and also sponsored advertisements. Search engine sells users clicks and observations to advertisers in auctions. Advertiser wishes to publish the ad in a more general and popular search engine to propose a higher bid. Hence, the competition for Internet users is investigated. Covering all topics related to a specific keyword on the internet is impossible for a search engine. Search engines should decide about covering the most comprehensive online information or a distinction between the coverage of different search results. More acute in the case of the first strategy, all search engines should present the same results and rankings to different users of the same items. As it is expensive to visit multiple search...
engines, users reasonably are not expected to visit different search engines providing the same information. This situation leads to (1) Search engines compete massively to attract Internet users, (2) fewer advertisers in each search engine and less money they will pay for each advertising region. In contrast, when search engines present different information, they attract different classes of web users. From an advertiser's perspective, this classification makes sponsored search more valuable. She can customize the ads adapting different parts, so there is much difference in price, which in turn leads to increased revenue from the auction.

3-3) Targeted marketing - product differentiation among users: Targeting customers in a virtual environment can be very profitable so that email customization based on customers’ characteristics increases the amount of clicks about 62 percent (Yao & Mela, 2011). The same concept can be taken into consideration in sponsored search auctions. According to past views and clicks, search engine can provide the users with more relevant ads. Such customization of ads with respect to the topic of the user’s query, increases return on investment (RIO). From the advertisers’ point of view, the advertiser might focus on the best profitable customer segment. Especially when the advertisers’ products are different, different sectors will be profitable for them. In the perspective of the search engine, the customized ads help advertisers to increase the amount of their bids for the advertising regions and consequently heighten their profit (Yao & Mela, 2008).

3-4) Click fraud: Click fraud is clicking on the advertisement without any need for the information and going shopping the product. The main objectives of click fraud are: (1) Generating false statistics about the number of advertising views and clicks and/or (2) Eroding funds of competitor companies. Estimations indicate that between 10 to 15 percent of clicks are fraudulent, that the annual cost will be $1 billion. While the advertisers pay the cost, it increases the search engines’ revenue. However, high levels of fraudulent clicks on their ads can shift the advertisers towards the other search engines which will cause a sharp decline in the search engine revenue. In order to support the advertisers, popular search engines, including Google, are doing a lot of efforts to combat fraudulent clicks. Search engines who fully reveal the details of fraudulent clicks will reduce the negative effect on the advertisers (Yao & Mela, 2008).

B. Auction mechanisms

How do search engines rank orders to place at search result page? Calculating costs based on the number of clicks rather than the number of observations has created unusual problems. Instead, the search engine can auction the observations; that is, each region of the result page in a separate auction. Anyway, the number of clicks is auctioned (Feng, Bhargava & Pennock, 2007). It is assumed that a particular region of a page is considered for displaying the sponsored results and the mechanism should select a listing and ranking method to show the results there. A very simple method is to display advertisements in
descending order of the advertisers’ bids. This approach is completely transparent to advertisers demonstrating the amount to offer for any given place. Another option is to consider the probability of click on any ad. Considering click through rate can boost income, although decreases the transparency of auction. Search engines also avoid accepting irrelevant and offensive advertising that reduces the level of quality and causes the loss of income. Hence, the question raised is whether automatically advertising filtering reliable or it has to be controlled manually? Recognizing and preventing clicks by robots or fraudulent clicks are a major management challenge affecting the trust in a search engine. In general, the search engine revenue depends on keeping advertisers and users and preventing their absorption to the other search engines. Therefore, in order to design a sponsored search engine mechanism, keeping users and advertisers as well as the revenue of search engine should be considered.

There are different methods for determining the winner, the advertising place, and payment. In early versions, the sponsored search mechanisms held based on general first-price auctions. Later, the second-price auction was used. These two auctions are strictly based on bid prices. Next, other models proposed considering the number of possible clicks (e.g., $V \times \alpha$ and $\alpha$ Ranking models). These models are described in the following parts. The following parameters are used in studying different models:

- **B** (Bid): Price offered by the advertiser
- **P** (Pay-per-Click): Price paid by the advertiser for each click
- **$\alpha$**: An estimate of the expected number of clicks
- **K**: The number of advertising regions
- **N**: The number of advertisers; $N > K$

1) **Generalized First-Price Auction (GFP)**: In this model, advertisers are arranged descending on the basis of their bids. Advertiser, who has the highest bid, wins the best region and will pay as his bid. The advertiser, who had the second-highest bid, will win the second highest region and will pay as of his own bid, and so on as Equation (2) shows. Payments occur per click. Yahoo marketing found that GFP is not appropriate for this environment.

$$P_i = B_i$$

For example, suppose a specific keyword is worth 10$ and 6$ per click for advertisers A and B, respectively. If B starts with the lowest possible bid (e.g., 1$), advertiser A should bid a little more than B’s (e.g., 1.1$) in order to get the first place. Then B offers 1.2$, and so it is continued until A reaches 6$. Here, B will no longer bid, as it will go beyond its value and cause B’s loss. As a result, B bid 1$ for the second place. Then, it is enough hat A bids 1.1$ for the first place. This causes B to propose $1.2 and thus the cycle continues and will not conclude a stable situation. In 2002, Google introduced a method based on
generalized second-price auction. The method was also welcomed by Yahoo! Inc.

2) Generalized Second-Price Auction\(^1\): In this approach, advertisers are sorted in descending order based on their bid prices. The advertiser offering the highest bid wins the best place and will pay the price proposed by the second highest person plus a very small amount (usually $0.01) per click. The second advertiser wins the second place and will pay as the third highest bid plus the small amount, and so on (Edelman, Ostrovsky, & Schwarz, 2007). The payment is according to Equation (3).

\[
P_i = B_{r(i)} + 0.01
\]  

(3)

The method is less exposed to strategic behaviour of advertisers and brings more income for the organizer. In first-price auctions, advertisers are not motivated to declare their true prices. In fact, they are willing to declare lower price to reduce their losses if they win the advertising region. In the second-price auction, advertisers have no fear of proposing their true prices, as they will pay less than their bid if to be a winner. Afterwards, Google decided to use “quality rate” for ranking. Quality rate is calculated using the advertiser’s bid, click through rate on ad, relativeness degree of keyword, and other factors. It is expected that it brings the search engine more incomes. Search engine income depends not only the cost-per-click, but also very dependent on the click through rate. This method is called \(V \times \alpha\) ranking model.

3) \(V \times \alpha\) Ranking Model: Expected revenue from assigning an advertising area relates the price paid per region and its click rate. The estimated number of clicks on a link depends on the subjective relevance, credibility of web site and its rank in sponsored search engines. Because users naturally like to click on ads with a better ranks. This is based on calculating \(B_\alpha\) and listing top K advertising according to the ranked results. To calculate the price that is paid by the winner, assume \(r(i)\) is the company that won the area \(i\). If \(B_{r(i)} > B_{r(i+1)}\), then the company \(r(i)\) will pay \(B_{r(i)}\) amount. Otherwise, it will pay the amount which is more than the predicted payment of \(r(i+1)\) (see Equations (4) and (5) for more details).

\[
\text{If } B_{r(i)} > B_{r(i+1)}, \quad p_i = B_{r(i+1)}
\]  

(4)

\[
\text{If } B_{r(i)} \leq B_{r(i+1)}, \quad p_i = \frac{B_{r(i+1)} \alpha_{r(i+1)}}{\alpha_{r(i)}}
\]  

(5)

4) \(\alpha\) Ranking Model: In this model, advertisers firstly are arranged according to their bids and K top bids are selected. Next, these K advertisers are sorted based on the expected number of clicks and then the owner of highest expected number of clicks win the first region; the second takes a second place, and so the places are sold (Szetela & Kerschbaum, 2010). Actual price the winners pay per click equals the \((K+1)\)th bid in sorted list of bids, as shown in Equation (6).
The Proposed Model

The goal of the sponsored search is increasing the revenue of search engine. The income is only achieved by clicking on sponsored ads. In determining the winning bid, the bid amount (B) alone is not sufficient. The estimated number of clicks on the link (α) is a very important factor in determining the winning bid. Because, an advertiser might bid high, but receive no or low clicks due to the low ad quality. As a result, search engine expected profit of this advertising will be low and not fulfilled. Similarly, considering the estimated number of clicks alone as a factor in determining the winner of the bid is not a good choice. Because the advertisers avoid proposing true bids for their high quality advertisements and bid lower prices which reduce search engine profit. In this section, we propose a model to rank advertisements and determine winning advertiser by using these two factors. To better understanding the performance of such an engine, Hami, a sponsored search advertising system and interfaces are designed and implemented on top of Hakim² (Hourani, 2011), an ontology-based experimental search engine.

A. Revenue Augmenting Model

Price determination is designed so that search engine can receive the maximum benefit without imposing advertisers any fear of offering their true bid. The winner and payment determination model are as follows. Ranking is similar to V×α ranking model; however the payment is different and increases the expected revenue of sponsored search engine.

1) Winner determination: Advertisers are sorted based on $B_i \alpha_i$ to determine the winner (see part C.3 in Section II) and the advertising regions are allocated to advertisers; the first part is dedicated to the advertiser i with highest $B_i \alpha_i$, and so on.

2) Payment determination: Suppose $r(i)$ is the advertiser who won region i. As Equations (7) and (8), if $B_{r(i)} > B_{r(i+1)}$, advertiser $r(i)$ will pay $B_{r(i+1)}$; Otherwise, he will pay the amount of his bid.

$$\text{If } B_{r(i)} > B_{r(i+1)}, \quad p_i = B_{r(i+1)} \quad \text{(7)}$$

$$\text{If } B_{r(i)} \leq B_{r(i+1)}, \quad p_i = B_{r(i)} \quad \text{(8)}$$

B. Design and implementation of the advertising system

The advertising system is designed in three parts for displaying advertisements, advertiser, and search engine management as follows.

- Display Advertising: This part that is included in search engine displays advertisements and operates in the case of clicking the advertising links.

- Advertisers: This part is for registering advertisers to manage designing their
advertisements and bids.

- Management: This module is for measuring the statistical performance of the system and removing inappropriate advertisements.

1) User and advertiser activities: The activities of the advertiser and user in interaction with the system is described below. User inserts a keyword to search using search engine. Search engine provides organic results and updates its database to generate list of advertisements. After holding the auction, list of advertisements is provided and they are displayed along with organic search results. When user clicks on advertising link, advertisement page is displayed. Then the actual price of the ad is deducted from the total amount introduced by the advertiser and an email containing advertisement date and time in addition to remaining credit and the actual price is sent to the advertiser’ email.

The advertiser registers a new Ad by inserting advertising information including its subject, content, link, bidding price, and a total amount of credit. If the Ad is acceptable (e.g., price is in numbers not alphabets, or bid is less than the total credit, etc.), the Ad information is stored in the database. Otherwise, an error message is displayed.

Advertiser can edit or delete Ads. He can edit an Ad by editing the financial or other information related to the Ad. If the information is correct, the database is updated accordingly. In the case of deleting an Ad, its information will be deleted.

2) Design of advertisement system: The Hami sponsored search advertising is implemented using 3-Layer Architecture (Nozari, 2008) and .NET programming. The model is developed into Hakim search engine.

To overcome the complexity of software systems, particularly in engineering systems, the system is divided into several layers. Each layer receives services from the previous layer and provides the next layer with services. This architecture divides the system into the following three layers:

1- The data layer: The data layer is responsible for storing, retrieving and updating data. The website uses stored procedures to reach a higher program efficiency and transparency.

2- Business logic layer: This layer acts as an intermediate layer that receives information from the presentation layer and sends it to the data layer. Or it receives the query results from data layer and delivers them to the program. All organizational rules and conditions are controlled in this part of the system. Inside the logic layer, there is a data access layer which controls relation with data layer.

3- Presentation layer: This layer is the user interface and forms which users deal with them.

User queries are sent from presentation layer to business logic layer. The business logic layer controls information and if valid, sends the request to the data layer. Data layer also process data according to the user requests delivers the results to business logic layer. This
layer sends the outcome to presentation layer.

This architecture has the following advantages (Nozari, 2008):

1. Other layers and program structure are less vulnerable to any change in data layer.
2. Segmentation of the application in several layers reduces the complexity and volume of programming.
3. Change, development, maintenance and support of software can be readily available in the future.
4. Each layer acts as independently.
5. Classes in each layer are reusable in other projects.
6. Decomposed into several subsystems, making developing a system more easily and quickly.
7. Presentation layer is separated from database commands and queries.
8. Maintains location transparency; no intervention and involvement of layers with each other.

3) Implementation of advertisement system: The three-layered architecture of the advertisement system is implemented as follows:

Layer 1 - Database: SQL Server Express Edition is used for development of the system database. The database can be designed using two methods:

1. Per each keyword one table can be considered containing advertisement information such as the advertiser, Ad content and bid price.
2. Considering a public table that includes all advertises and bids.

The advantage of the first approach is faster search and ranking. However, it doesn’t specify any particular keyword and advertisers can choose any arbitrary word. Therefore, tables will be generated dynamically and in unlimited number. This results in time complexity and the need for more memory for database. Therefore, we use the second method and stored procedures for reducing the search time. Three tables detail the database:

- Auction table: It is the main table of the system database. This table stores ID, Advertiser’s name, Keyword, URL, HeadLine, AdText, Bid, Viewed, Clicked, Payment, and Cost of all the ads from all advertisers.
- Advertiser table: Information about advertisers is stored in the table.
- Log table: This table is used for saving the system log. The table shows the date of each click and the ad displayed per that click.

Layer 2 - Business Logic: This layer is related to data and representation layers. It is divided into two parts. One part (associated with presentation layer) receives the user requests and delivers them to the second part, or vice versa. The second part is related to the data layer through which storage, retrieval, and editing operations are carried out.

Layer 3 - The presentation layer: The system consists of three levels of access for the user, advertiser and managers of the system.
Discussion

The goal of the proposed model is increasing the revenue of the search engine. The search engine revenue depends on the cost of advertising and click through rate. These two factors are dependent on the behaviour of advertiser. That is, theoretical evaluation of the model requires using and accessing the management of a real search engine. Due to this limitation, the performance of the proposed model against other models is evaluated using synthetic data in auction settings under the same conditions. Sponsored search engine is simulated using four auction models for the 3 regions by participating 5 advertisers.

Each advertisement has three factors:
- B Bid,
- P Payment,
- \( \alpha \) Estimation of the expected number of clicks.

It is assumed that each advertisement has been displayed for hundred times. Therefore, the auction revenue is calculated using bid price and estimated percentage of number of clicks multiplied by 100 as shown in Equation (9):

\[
\text{revenue} = 100 \times \sum_{i=1}^{3} P_i \times \alpha_i
\]

For comparing these models, we assume hundred keywords auctioned in the auctions and each one has been searched hundred times. Then, the total revenue of the search engine will be as Equation (10):

\[
\text{revenue} = 100 \times \sum_{j=1}^{100} \sum_{i=1}^{3} P_j \times \alpha_i
\]

A. Simulation Experiments

First, we assume that each advertiser has one ad so that each ad is displayed one hundred times. The comparison is repeated three times using random generated bids – offered by five advertisers A, B, C, D, E— and possibility of click on each ad as shown in Table I. The winners and the payment prices are determined based on related equations in parts C.2 to C.4 in Sections II as well as the proposed Hami model (part A in Section III). The revenue of each auction is calculated using Equation (9). Table II depicts the winners of the auctions. The results show that the proposed model achieves better results than \( V \times \alpha \) Ranking and \( \alpha \) Ranking auctions. It is observed that the winners’ ranking in the proposed Hami model is different from in Second-Price auctions.
Table 1

Advertisers’ Bids

<table>
<thead>
<tr>
<th>Advertiser</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bid</td>
<td>Click Possibility (%)</td>
<td>Bid</td>
</tr>
<tr>
<td>A</td>
<td>81.47</td>
<td>9.75</td>
<td>41.15</td>
</tr>
<tr>
<td>B</td>
<td>90.57</td>
<td>27.84</td>
<td>60.26</td>
</tr>
<tr>
<td>C</td>
<td>12.69</td>
<td>54.68</td>
<td>75.05</td>
</tr>
<tr>
<td>D</td>
<td>91.33</td>
<td>95.75</td>
<td>58.35</td>
</tr>
<tr>
<td>E</td>
<td>63.23</td>
<td>96.48</td>
<td>55.17</td>
</tr>
</tbody>
</table>

B. Overall Results

To generalize, we suppose each participant advertises hundred ads where each will be displayed hundred times. Table III summarizes the revenues of auctions in three runs. It shows that superiority of Hami’s revenue against $V \times \alpha$ ranking, $\alpha$ ranking, and general second-price auction models is 12, 38, and 3 percent in average, respectively.

Table 2

The Winners and Auction Revenue

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Region</th>
<th>Auction Model</th>
<th>(1) Hami</th>
<th>(2) $V \times \alpha$ Ranking</th>
<th>(3) $\alpha$ ranking</th>
<th>(4) Second-Price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Winner&amp;Price</td>
<td>Winner&amp;Price</td>
<td>Winner&amp;Price</td>
<td>Winner&amp;Price</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>D 63.23</td>
<td>D 63.23</td>
<td>D 63.23</td>
<td>D 91.57</td>
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</tr>
<tr>
<td></td>
<td>2</td>
<td>E 63.23</td>
<td>E 26.12</td>
<td>B 63.23</td>
<td>B 82.47</td>
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</tr>
<tr>
<td></td>
<td>3</td>
<td>B 63.23</td>
<td>B 81.53</td>
<td>A 63.23</td>
<td>A 64.23</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Auction Revenue</td>
<td>14400</td>
<td>10800</td>
<td>8430</td>
<td>11600</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>E 55.2</td>
<td>E 42.2</td>
<td>D 55.17</td>
<td>C 61.26</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>D 58.4</td>
<td>D 42.9</td>
<td>B 55.17</td>
<td>B 59.35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>B 41.2</td>
<td>B 41.2</td>
<td>C 55.17</td>
<td>D 56.17</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Auction Revenue</td>
<td>11800</td>
<td>9390</td>
<td>7250</td>
<td>7590</td>
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<tr>
<td>3</td>
<td>1</td>
<td>E 62.4</td>
<td>E 59.8</td>
<td>E 26.90</td>
<td>C 63.37</td>
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<tr>
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<td>2</td>
<td>C 47.7</td>
<td>C 47.7</td>
<td>C 26.90</td>
<td>E 48.74</td>
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<tr>
<td></td>
<td>3</td>
<td>D 22.4</td>
<td>D 22.4</td>
<td>D 26.90</td>
<td>D 27.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Auction Revenue</td>
<td>11500</td>
<td>11300</td>
<td>6800</td>
<td>12000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average</td>
<td>12566.67</td>
<td>10496.67</td>
<td>7493.333</td>
<td>10396.67</td>
</tr>
</tbody>
</table>
Table 3

The Revenue Achieved from Hundred Runs of Auction Models

<table>
<thead>
<tr>
<th>Experiment</th>
<th>(1) Hami</th>
<th>(2) V × α Ranking</th>
<th>(3) α ranking</th>
<th>(4) Second-Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>84400</td>
<td>74000</td>
<td>54000</td>
<td>79100</td>
</tr>
<tr>
<td>2</td>
<td>82400</td>
<td>73200</td>
<td>48100</td>
<td>80700</td>
</tr>
<tr>
<td>3</td>
<td>86200</td>
<td>76500</td>
<td>55400</td>
<td>83200</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>84333</strong></td>
<td><strong>74566</strong></td>
<td><strong>52500</strong></td>
<td><strong>82000</strong></td>
</tr>
</tbody>
</table>

Conclusions and Future works

Search engine compasses the users and is of utmost importance in the Internet. Nowadays a search engine is not limited to searching the web; it has become a useful technology for advertising and E-commerce. By using a sponsored search process, search engine displays ads which are chosen through holding auctions. This study first investigated the role of the Internet users, advertisers and search engine and their interactions in a search process. Different methods such as first-price auction, second-price auction, α ranking model, and α × ν ranking model are used by sponsored search for ranking ad bid prices. The study is then proposed a new model to hold the auction. Comparison of the results gained by the proposed model shows that it always dominates α ranking model, is always better than or equal to α × ν ranking model, and is generally better than second-price auction. Therefore, the proposed model theoretically increases the revenue of search engines. The model was added and implemented as a “Hami” advertising sponsored search system on top of “Hakim” search engine.

The “Hami” advertising system is a prototype of a sponsored search advertising system. The search engine could be developed to display ads based on geographic areas and local time to assess the model based on experimental evaluation. For statistical analysis and inference, data mining can be applied on the information that is provided by the managing part of the model.

Endnotes

1. It should be noted that the Vickrey mechanism is the same method that was developed in 1963 by William Vickrey (Fasli, 2007).

2. Hami and Hakim have Arabian roots and mean “support” and “wise”, respectively. It is worth to mention that the second author is from Syria.
References


