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Search Engine Marketing and Click Fraud

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Preface of the Authors

Since its introduction the Internet began a rapid advance into all areas of life and changed the working world as well as daily life. The Internet provides a vast amount of information for almost every topic. Since the end of the 20th century, so called search engines established oneself to retrieve information online. After inserting one or several search terms, the searcher receives a list of search results ordered by certain relevance criteria of the search engine algorithm.

Development of the information society

The individual search terms indicate an interest of the searcher for a certain topic. The selective approach at a point in time when the potential target audience is already thematically activated and involved represents an attractive opportunity for advertisers and led to the inclusion of advertisements besides the search results of a conducted search.

This search engine advertising has become a dominant form of online advertising and is the predominant business model of search engines. The world-wide leading search engine *Google* earned 16 billion US \$ with search engine advertisement in the fiscal year 2007. The advertiser does not usually pay for the impression of the ad, but for a click on the advertisement.

Relevance of search engine advertising

Fraudulent clicks present an inherent problem of this so called pay-per-click model. Click fraud represent any procedure that illegally exploits pay-per-click markets. In particular, click fraud resolves around intentional clicks without intent to interact with the advertiser.

Click fraud challenges online advertising

In this context, a class action against several search engine providers in 2005 attracted attention (DELANEY 2005). To what extend, search engine providers are liable for the manipulation of clicks and click rates, was not finally judicially clarified. Google settled the class action by agreeing to pay its advertisers 90 million US \$.¹

Click fraud represents a general threat for the pay-per-click model as well as a more specific threat for the business model of search engines. Search

Aim of the study

¹ For more details on the settlement see Danny Sullivan's comment online at <http://blog.searchenginewatch.com/blog/060308-152034>.

engine providers need to ascertain the reliability and correctness of the pay-per-click model to preserve the trust of advertisers. Advertisers likewise need to consider click fraud in their decision process for the future configuration of advertising campaigns. In this contribution, we illustrate the main consequences of fraudulent clicks on frequently used measures of search engine advertising. Thereby, we support the early detection of and defense against click fraud.

Hagen, June 2008

Univ.-Prof. Dr. Rainer Olbrich

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Overview of the research results

- I. *The pay-per-click model is the predominant payment system in the context of search engine advertising. The cost of advertising are not calculated upon the number of ad impressions, but upon the number of clicked advertisements. Fraudulent clicks endanger this business model. Click fraud refers to the illegal behavior of intentionally clicking an advertisement without the intent to interact with the advertiser (chapter 1.).*
- II. *Search engine marketing, defined as a group of means to increase the number of visits to a certain Website, can be divided into search engine optimization and search engine advertising. Search engine advertising tries to achieve this aim by paid advertisements. Depending on the payment system, search engine advertising is subject to the problem of click fraud (chapter 2.)*
- III. *Click fraud can be divided into four types according to the motivation and the form of the conducted fraud. Damnification of an ad campaign and enrichment in case of commission models are two different motivational roots of click fraud. The form to produce fraudulent clicks can be distinguished into manual and automated procedures (section 3.1.).*
- IV. *Comprehensive information are necessary to detect fraudulent clicks. Log data collected while using the Website serve as a data basis. A simple rule-based approach can for example be employed to automatically detect suspicious clicks.*

A comprehensive click fraud detection system should structure the processes according to the complexity, the arithmetic performance, as well as the integration of additional information, in order to guarantee the prompt identification of fraudulent clicks. These information can be used on the one hand to avoid continuous click attacks and on the other hand for claim for compensation (section 3.2.).
- V. *Based on a cost-revenue-comparison, a simple decision rule can be utilized to decide upon the continuation or discontinuation of a search engine advertising campaign. The presented rule can be applied upon a complete advertising campaign as well as a single transaction. To apply this decision rule, it is necessary to assign a value to the measured goal.*

The cost per conversion and the conversion rate are two suitable indicators for the identification of click fraud. A conversion measures whether a contact through the advertisement commits a certain action. This action can for example be a visit to a target Website, a request of information material, a registration of a new user, or a buying transaction (chapter 4.).

1. Introduction

1.1. Aim of the Study

The digital networked environment provides a variety of new possibilities to communicate, to interact, and to learn. Covering nearly every topic, a vast amount of information is accessible through the Internet. To find the most relevant information, news, and products, many people rely on search engines to retrieve the links to available information and services (GANDAL, 2001; NICHOLSON et al., 2006). Since searchers actively have used search engines to seek information (GANDAL 2001, SEN et al., 1998), marketers have been interested in addressing these prospective customers due to the existing involvement. The inclusion of advertisements besides search results has evolved as the prevalent business model for search engines (IMMORLICA et al., 2005, JANSEN/RESNICK, 2006).

In comparison to traditional media, advertisers are generally not charged for the number of displayed advertisements (impressions), but for the number of clicked advertisements. This pay-per-click model is the predominant payment system in search engine advertising (FENG et al., 2007; SEDA, 2004). The prospective revenues also induced the development and employment of countermeasures to deal with search engine spamming (JANSEN, 2006). Search engine spamming revolves around the malicious and methodical manipulation of a Website's relevancy to increase the Website's ranking for specific search queries. An overview of search engine spamming methods is e. g. provided by GYÖNGYI/GARCIA-MOLINA (2005). Another form of adversarial behavior, that search engines face, is the deliberate clicking on advertisements without intending to transact with the advertiser (KITTS et al., 2006). In general, this behavior is referred to as click fraud. Click fraud poses a crucial threat to the pay-per-click business model (KITTS et al., 2005; JANSEN, 2006; SEN, 2005).

If search engine providers cannot restrain fraudulent click behavior, advertisers have to reconsider the allocation of advertising budgets. For advertisers, click fraud imperils the advertising effectiveness of search engines. Click fraud must be addressed by search engine providers and advertisers alike. Search engine providers need to proof the reliability and accuracy of the pay-per-click system to maintain advertiser's trust. In addition, advertisers have to account for click fraud when deciding on future advertising campaigns. An informed decision on a search engine

Pay-per-click model

Search engine spamming

Click fraud

Advertising effectiveness

advertising campaign has to be based on the estimated degree of fraudulent click behavior.

Research outline This paper addresses the impact of click fraud on traditional performance measures in case of search engine advertising. The discussion presented here supports advertisers with the evaluation of search engine advertising campaigns under consideration of fraudulent clicks. After the related literature is presented in paragraph 1.2., the perspective of search engine marketing taken on in this paper is introduced in part 2. Chapter 3. introduces four distinguishable click fraud types and points out various methods to detect fraudulent clicks based on log file data. The impact of click fraud on the performance of search engine advertising is discussed in paragraph 4. The paper concludes with a summary and directions for future research.

1.2. Theoretical Background

Research state The search engine literature is founded in the area of information retrieval. The vast amount of data available online has initiated extensive research on algorithms and the architecture of search engines (e. g. ARASU et al., 2001; BRIN/PAGE, 1998; LIDDY, 2001). In turn, research focused on search engine performance over time and across search engines (e. g. BAR-ILAN, 2002; BAR-ILAN et al., 2006; METTROP/NIEUWENHUYSEN, 2001), the bidding strategy of search engine advertising (e. g. CHAKRABARTY et al., 2007; EDELMAN/OSTROVSKY, 2007; KITTS/LEBLANC, 2004; LIM/TANG, 2006) and pricing strategy of search engine advertising (BHARGAVA/FENG, 2002; FENG et al. 2007; LIU/CHEN, 2006), the search engine market structure (TELANG et al., 2004), as well as the social, political, and moral implications of search engines (INTRONA/NISSENBAUM, 2000).

Research objectives Another line of research investigates online search behavior. JANSEN/SPINK (2006) point out three categories of online search studies based on transaction log data, laboratory experiments, and studies related to and affecting online search behavior. Besides the general body of literature on search engines and search engine advertising, researchers have reported few studies on the click fraud problem. For example, KITTS et al. (2006) and JANSEN (2006) elaborate on the general issue of fraudulent click behavior, whereas other studies (e. g. IMMORLICA et al., 2005; KITTS et al., 2005 and ZHOU/LUKOSE 2006) discussed properties of the auctioning algorithm utilized by search engines. This paper extends the body on adversarial

information retrieval in the domain of search engine advertising by addressing the consequences of click fraud on the advertising effectiveness of search engine advertising campaigns. The discussion on the effect of click fraud on traditional performance measures contributes to the body of literature on click fraud and adversarial information retrieval as well as the decision rule supports advertisers in case of fraudulent clicks whether a search engine campaign should be continued or not.

2. Search Engine Marketing

Most search engines list two types of results for any submitted search query. Alongside the organic listings, the output of the search algorithms, search engines also display sponsored links (JANSEN/RESNICK, 2006; NICHOLSON et al., 2006). Sponsored links are advertisements matched to the search query by a set of provided keywords. The keywords are generally associated with the contents, services, or products of the advertised Website. Search engine marketing addresses both result types. Search engine marketing can be defined as a set of marketing methods to increase the chance of receiving quality traffic through search engines.

Search engine marketing

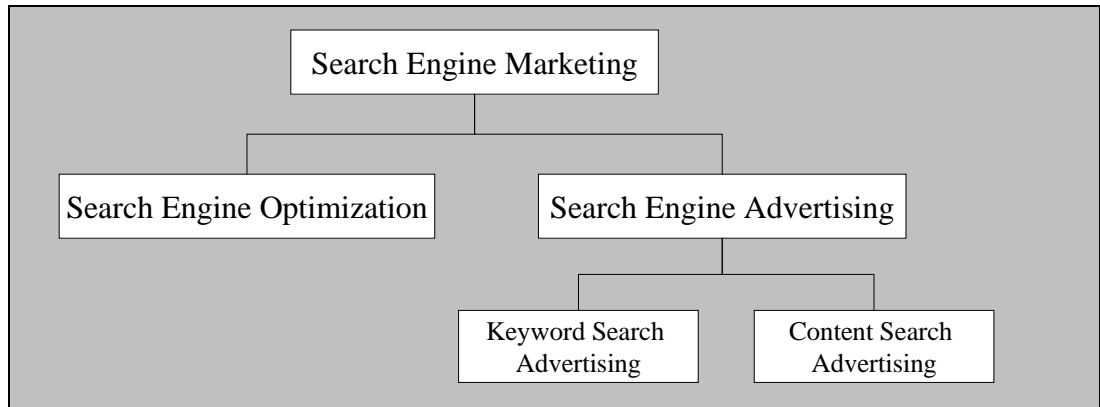
Search engine optimization attempts to improve the ranking of a Website in organic listings by adjusting the Websites structure, content, and programming towards certain search terms. This optimization is usually limited to few keywords due to the high effort and expense as well as technical restrictions.

Search engine optimization

Search engine advertising tries to increase traffic by approaching prospective customers through advertisement. In the literature, it is also sometimes interchangeably called keyword advertising (e. g. LIU/CHEN, 2006), sponsored search (e. g. FENG et al., 2007), sponsored links (e. g. JANSEN, 2007; JANSEN/ RESNICK, 2006), paid placement (e. g. BHARGAVA/ FENG, 2002; NICHOLSON et al., 2006; SEN, 2005), paid results (e. g. MORAN/HUNT, 2006) or paid search (e. g. KITTS et al., 2005). Search engine advertising can be further distinguished in keyword search advertising and content search advertising. Keyword search advertising relates to any ad placement triggered by search queries. The advertisements can thus appear on a search engine's Website or on a partner Website featuring the search engine capabilities. In contrast, content search advertising places advertisements on a partner Website due to the specific content of the site and not due to a search request.

Search engine advertising

Figure 1: Search Engine Marketing



In search engine advertising, the keywords provided by advertisers indicate an interest for a target audience as well as a relation to the advertised contents, services, or products. Advertisers value regularly keywords differently, so if multiple advertisers bid on the same term (EDELMAN/OSTROVSKY, 2007; KITTS/LEBLANC, 2004; LIM/TANG, 2006), an electronic auction takes place to determine the rank of the advertisements (FENG et al. 2007; LIU/CHEN, 2006). The advertisements can be exclusively positioned according to the bid amount. Search engines may also consider additional indicators, such as the Website content of the advertiser according to the query or the number of clicks an advertisement has received, to present the searcher with the most relevant search results. An extensive body of literature based on auction theory discusses the optimal design of auctions in the context of search engine advertising (e. g. BHARGAYA/FENG 2002, CHAKRABARTY et al. 2007, EDELMAN/OSTROVSKY 2007, FENG et al. 2007, KITTS/LEBLANC 2004, LIM/TANG 2006 und LIU/CHEN 2006). However, the concrete auction procedure remains often intransparent for the advertiser.

Auctioning

Payment systems

Three accounting systems are generally distinguished for search engine advertising: pay-per-impression, pay-per-click, and pay-per-conversion (e. g. MORAN/HUNT, 2006; SEDA, 2004). In case of pay-per-impression, the advertiser is charged for every ad appearance. Similar to traditional media, the cost per mille metric is often used for the pay-per-impression system. If the advertiser is charged whenever the advertisement is clicked, the pay-per-click system is employed. Pay-per-click systems allow an improved measurement of successful advertising contacts compared to traditional media. A further acknowledgment of advertisers' objectives is the pay-per-conversion system. In the literature, the term pay-per-conversion is also, partial synonymously called: pay-per-action (e. g. JANSEN, 2006), pay-per-purchase (e. g. KITTS et al., 2006), and pay-per-acquisition (e. g.

IMMORLICA et al. 2005). Here, advertisers are only charged if a click on an advertisement leads to a predefined action, such as engaging in an e-commerce transaction. Since search engines, as advertising medium, cannot reliably monitor a conversion without intruding into the advertiser's Website, the majority search engine advertising programs are based on pay-per-click systems (FENG et al., 2007; SEDA, 2004). As introduced, pay-per-click systems are however vulnerable to click fraud.

3. Click Fraud

3.1. Click Fraud Types

In this paper, click fraud is considered to represent any kind of fraud that exploits pay-per-click markets. Any intentional click on a pay-per-click advertisement is conceived as fraudulent if no intention of a conversion exists (JANSEN, 2006; KITTS et al., 2006). In other words, the perpetrator is not interested in the products, services, or the content of the advertised Website. A conversion is generally referred to a click on an advertisement that leads to a predefined action. In the view of an advertiser, this positive result can be the visit of a Website, the request of information material, the registration of a new customer, or the conclusion of an e-commerce transaction. Based on this definition of click fraud, a classification of click fraud types is presented according to the motivation and the form of the click fraud conducted.

Click fraud

Conversion

Click fraud motivation can be differentiated into damnification and enrichment. Damnification refers to a perpetrator aiming to harm the company by assaulting the advertising campaign. In contrast, enrichment is click fraud directed towards a personal gain. An example of this case is a partner of the search engine provider causing click fraud in order to increase advertising compensation.

Click fraud motivation

Additionally, click fraud can be distinguished according to its form. Click fraud can be conducted manually by individuals clicking on an ad or automatically by computer programs. Figure 2 provides an overview of four general distinguishable click fraud situations.

Click fraud form

Figure 2: Classification of Click Fraud Types

		Click Fraud Motivation	
		damnification	enrichment
Click Fraud Form	manual	①	③
	automatic	②	④

The first situation of click fraud is characterized by individual human actions damnifying a certain advertising campaign. In most cases, this type of click fraud is induced by advertising competitors or in some cases

First click fraud situation

irritated employees. The degree of fraudulent clicks may range from a small percentage caused by an individual or few persons to a considerable extent produced by organized click farms (VIDYASAGAR, 2004). The perpetrator aims at exhausting the budget of the attacked advertising campaign. A general purpose of the click fraud attack is to financially harm the business attacked by increasing the advertising expenditures. Another purpose of this action is to decrease competition for advertising space, so that for example the advertisement of a competitor receives better (higher) placement at lower costs. If the click through rate is part of the search engine's relevance algorithm, this fraud attack also benefits the advertisement attacked by receiving higher positions for lesser expenses in the future due to the increased click through rate (EROSHENKO, 2004). However, the ratio of the number of conversions to the number of clicks, the so called conversion rate decreases.

Second click fraud situation

The second situation of click fraud is also motivated by aggrieving a target advertising campaign. Here the perpetrator utilizes automatic tools to generate false clicks. Employing a software application into the fraud process enables the perpetrator to create a vast number of fraudulent clicks over a short period of time. The capabilities of any click fraud detection system need to address these automatic attacks and provide counter measures preferably in real time. Furthermore, the search engine as advertising media ought to anticipate future developments in automated click fraud applications and consider these click fraud trends while refining their systems.

A characteristic for both aforementioned situations is the short term damnification of the advertiser. The search engine provider actually gains short term revenues. If click fraud as a problem however persists, the aggrieved advertisers are likely to spend the marketing budget elsewhere choosing an advertising medium that attends to the advertisers' interests. For the two situations of click fraud motivated enrichment, the same rationale can be made. Additionally, a direct beneficiary can however be identified in these two situations. In contextual search engine advertising, the partner of the search engine profits from every click by receiving a fraction of the price paid.

Third click fraud situation

In situation three, few individuals or organized groups cause the occurrence of fraudulent clicks. In addition to the above presented purposes, another intention is the enrichment of for example an affiliate partner. Since the

search engine provider does not possess the data of the advertiser, proofing an intention and tracking the click fraud source is a challenging task.

Situation four completes the classification of click fraud types. The situation is characterized by automated click fraud trying and enrichment of an involved party.

Fourth click fraud situation

3.2. Click Fraud Detection

Detecting click fraud requires certain data. The aggrieved party can generally use data collected from log files which Web servers automatically create and maintain. Internet log files record requests of files for a certain domain. Four types of log files can in general be distinguished: access log, agent log, error log, and referrer log (BERTOT et al., 1997; SEN et al., 1998).

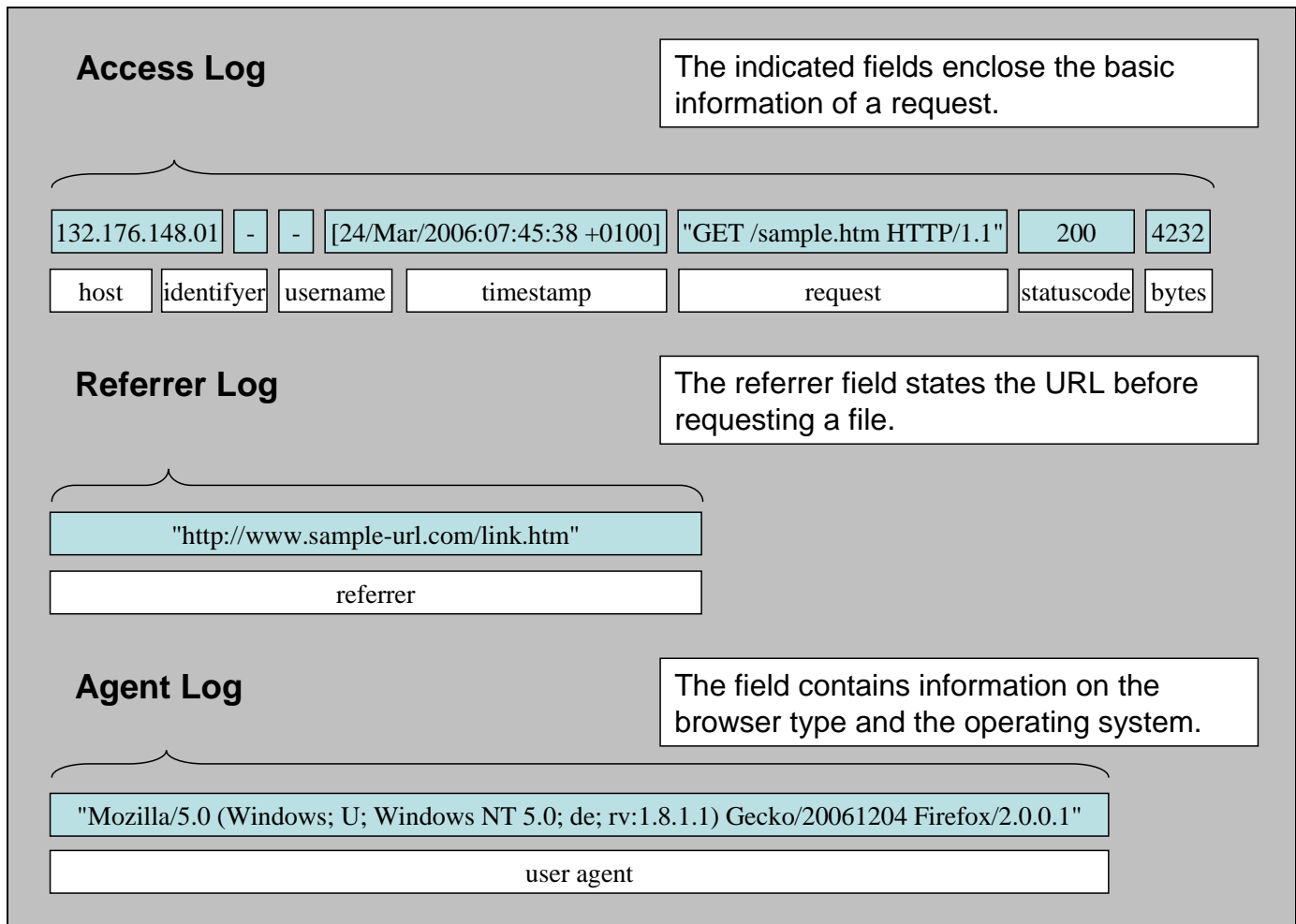
Log file and log file data

- Access logs list all requests for an individual file. The entries include the remote hostname of the request, the date and time of the request, the request line from the client, the status code returned to the client, and the transferred bytes of the transferred document. The hostname refers to the name of the requesting machine. In the Internet, this corresponds in many cases to the IP address assigned to the computer.
- Agent log provide data on the name and version of the requesting browser.
- Error logs note all error occurrences during a transaction.
- Referrer logs record the origin of the request in form of a uniform resource locator.

The exact constitution of the log file depends on the employed server protocol. The combined log form standard of the National Center for Supercomputing Applications (NCSA) for instance embraces fields of an access log, an agent log, and a referrer log. The following figure provides an example for such a combined log file entry:

Log file structure

Figure 3: Example of a NCSA Combined Log File Entry



Forensic nature and rule-based approach

The click fraud detection systems based on the outlined data pool are categorized by two characteristics: The click fraud detection systems are of forensic nature and follow a rule-based approach. Log file analysis generally examines the data pool in order to discover anomalous patterns. Anomalous patterns are a deviation from the individually defined rule set for the search engine campaign. The rule set is based on historic data of the campaign or according bench marks. One typical benchmark is the behavior of an unadvertised user in comparison to the behavior of a user whose attention is drawn to the advertised site.

Furthermore, the forensic examination can improve the assessment of the search engine advertising performance measures by identifying fraudulent clicks. The identification of fraudulent clicks might serve as a potential claim for the aggrieved party. To source click fraud is however a challenging task. Another complex task is the design of a click fraud detection system. The following paragraph outlines some properties of the data pool to build the rule set on.

The hostname of the request provides some information about the origin of the requesting client. For example, the analysis may infer from the IP address the country of origin of the request. If the country does not fit the advertised offer or the country is generally suspected of manual click fraud (GROW et al., 2006; VIDYASAGAR, 2004), the clicks might be fraudulent. Also under investigation are click patterns stemming from IP ranges of open proxy servers. Open proxy servers are e. g. operated for anonymous Internet surfing. In this case, the hostname recorded by the Web server equals the IP address of the open proxy server and does not relate to the IP address of the request's origin. An unusual number of clicks over a time interval from a single source might as well be an indication of click fraud.

Hostname

The time stamp of a request might also yield further information for detecting click fraud. In most cases, date and time of the request are combined with additional properties to narrow down specific click patterns. An indication warranting a more extensive examination is the atypical occurrence of a significant number of clicks, for example diverging from a historically outstanding day time or weekday. Time stamps also enable the analysis of the interval of consecutive clicks. If the click density increases without any notable market change, the suspected pattern should be further investigated. The steps discussed in this paper serve this further investigation.

Time stamp

In some cases, the addition of the browser information is justified. If anomalous patterns are discovered, but cannot confidently be associated as fraudulent, a conclusion might be made consulting browser information.

Browser information

The referrer log adds the reference page to the analysis. If a certain threshold over time is reached for a single reference source, the click pattern is declared as potentially fraudulent. For search engine advertising, the listed reference generally includes the search terms entered. In search engine marketing, the entered search terms trigger the relevant advertisement based on the keywords provided by the advertiser for the advertisement. If a single keyword commences to induce an unusual amount of clicks, a fraudulent action can be suspected.

Referrer log

The aforementioned properties of the data set are in general utilizable by the search engine as well as the advertiser. These properties generally revolve around the combination of a single request. A second class of characteristics however concludes from the stream of requests. From the so called click stream, analysts can examine the retention period on a single

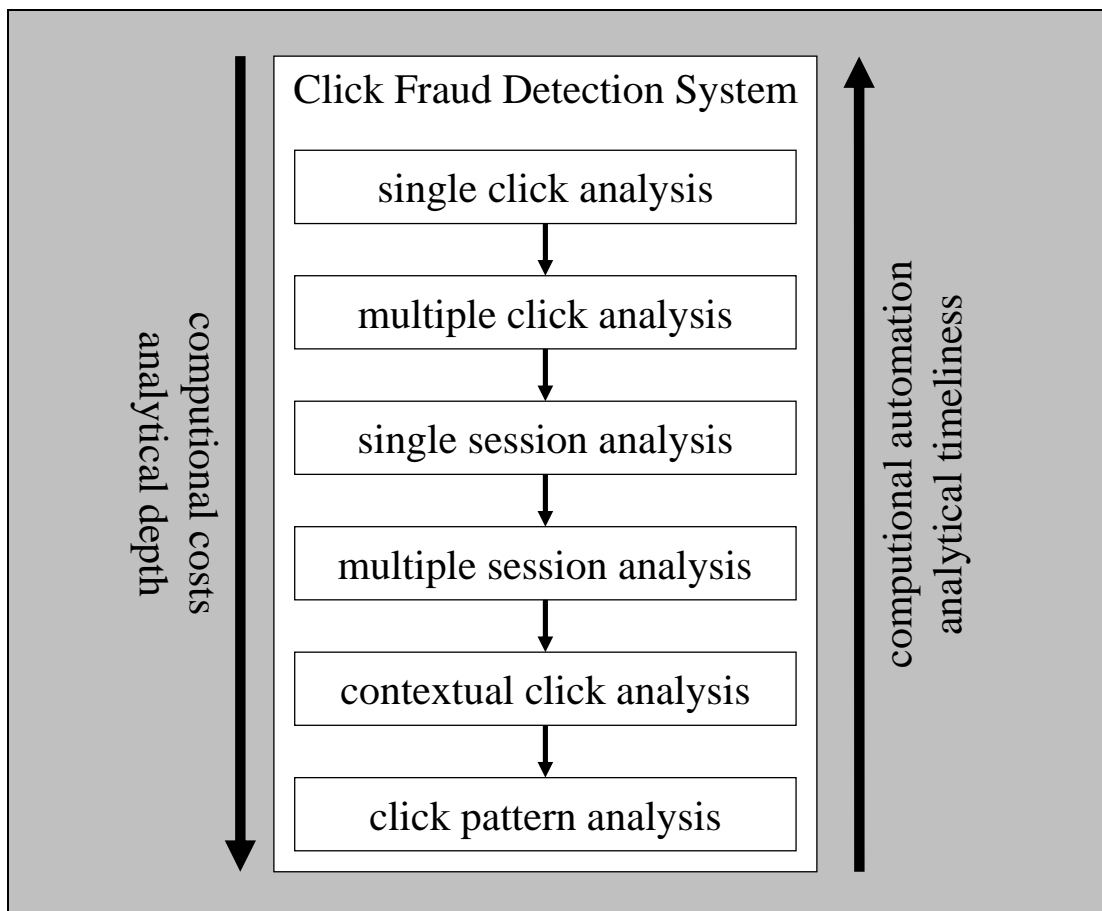
Click stream analysis

Website or over the entire Website visit. The click stream also enables the click fraud detection system to determine an indicator for the depths of each visit. For example, an occurrence of a significant click number that indicate searchers visit only the single advertised Website as well as spend a short time period on the site might indicate fraudulent clicks.

Contextual
information

So far, the presented properties of the data pool have not included additional contextual information. By integrating a profit oriented perspective into the analysis, the click fraud detection system may be improved further. Monitoring the conversion rate is another central aspect of any click fraud detection system. Fraudulent clicks tend to decrease the conversion rate. So if the conversion rate drops significantly while the number of clicks changes only in usual ranges or remains constant as in case of a historically exhausted budget, the data should be inspected for anomalous patterns.

Figure 4: Levels of a Click Fraud Detection System



An extension of the rule-based approach is the integration of additional pattern recognition methods such as automated cluster analysis. Data mining methods are primarily employed to discover reoccurring patterns.

On one hand, these methods can confirm certain click streams as usual behavior. On the other hand, an identical or a frequently close match of patterns raises suspicion of potential automatic click fraud.

Figure 4 displays the successive levels of click fraud detection.

As pointed out, the various levels are prioritized according to the degree of potential automation. The initial levels of a click fraud detection system are characterized by simple automated operations on a small set of data performed repetitively. Furthermore, the analysts do not have to add supplementary expertise to the system. As the click fraud detection system advances towards more sophisticated analyses, the complexity of the data analysis increases and the timeliness of the data analysis decreases. Also, additional expertise is needed to evaluate anomalous patterns.

Levels of a click fraud protection system

For the performance of the various analysis steps, advertisers require a coherent and complete data set. An important point to note is that the parties involved in search engine advertising usually possess varying data bases of the transaction. For example, the search engine provider possesses data on the search history of an individual, and the advertiser may track the behavior after the click occurred.

Problem of varying data bases

4. Consequences of Click Fraud for Search Engine Advertising

As click fraud challenges online advertising, marketers need to evaluate the advertising campaigns. In a situation of fraudulent click occurrence, a possible way to determine a campaign's economic relevance is to ignore the existence of click fraud in the data set. So, the decision whether to continue or discontinue a search engine advertising campaign may be based on the cost c , the number of clicks cli , and the number of conversions con of the campaign. Assuming that advertisers can assess the return of a conversion r , for example by employing a customer lifetime value (see e. g. BAUER/HAMMERSCHMIDT, 2005; JONKER et al., 2004; VENKATESAN/KUMAR, 2004), the costs c of the campaign should generally not exceed the expected return $r \cdot con$:

Economic relevance of a search engine advertising campaign

$$c \leq r \cdot con. \quad (1a)$$

The division by the number of conversions con transforms expression (1a) into the following equation. This transformation shifts the focus from a campaign point of view to a view of a single conversion. The formulation (1b) describes that the costs per conversion c / con should not exceed the expected return per conversion r .

$$\frac{c}{con} \leq r. \quad (1b)$$

If the expression (1a) is extended to focus on the average costs, the costs per click con / cli , the constraint (2) represents the cost-return-ratio regarding a single transaction. The constraint (2) postulates that the costs per click should not exceed the return of a single click.

Cost-return-ratio of a transaction

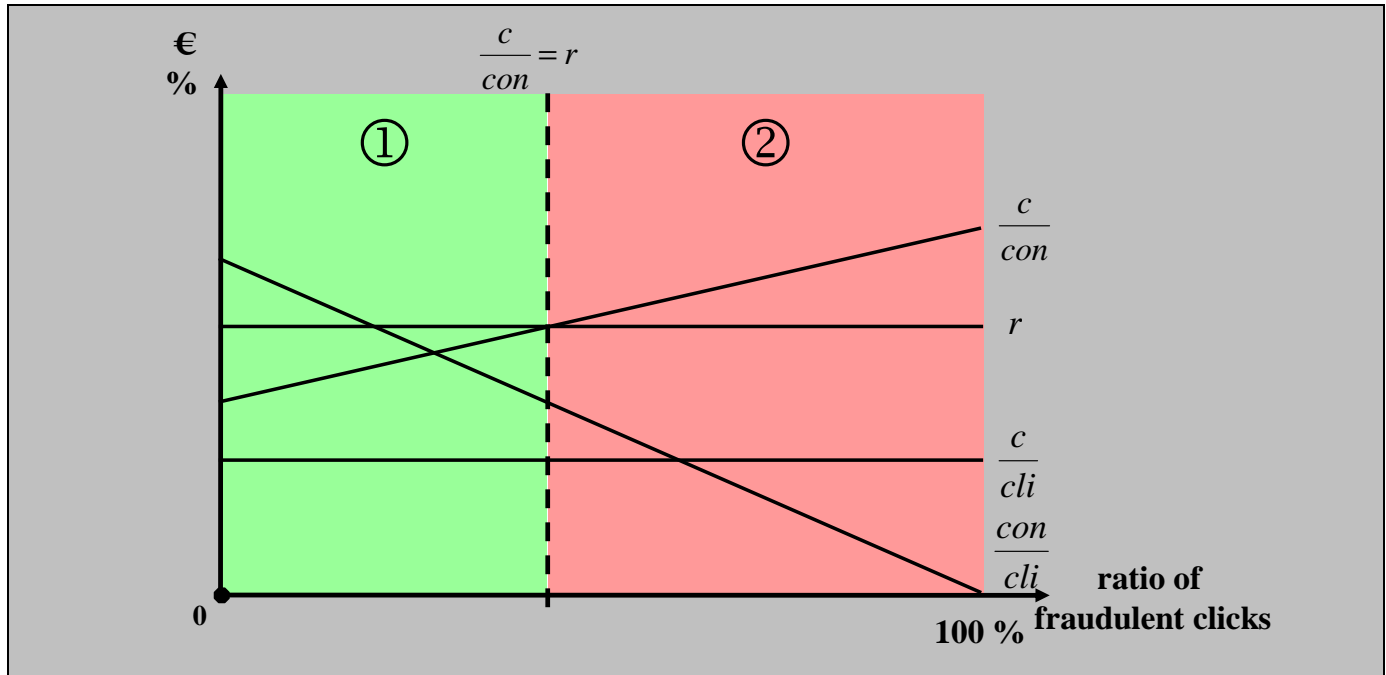
$$\frac{c}{cli} \leq r \cdot \frac{con}{cli}. \quad (2)$$

Both equations include an important indicator to detect fraudulent clicks. Expression (1b) incorporates the costs per conversion c / con and formula (2) compares the conversion rate con / cli with the expected return of a conversion r . As discussed shortly, the trends of traditional performance measures can be predicted for search engine advertising campaigns influenced by click fraud.

Conversion oriented advertising campaign

As long as the advertising campaign objective is purely conversion oriented, the presented constraints are applicable. If the campaign concerns additional or different objectives, such as traffic generation or brand establishment, advertisers have to consider the degree of fraudulent clicks in their decision process. The following illustration outlines the two indicators as a function of the click fraud degree.

Figure 5: Profitability in Consideration of Click Fraud



In the illustration, it is assumed that the advertising campaign is profitable without click fraud. In consequence, there exists a certain degree of fraudulent clicks when a profitable campaign (field 1, with: $c / con \leq r$) becomes unprofitable (field 2, with: $c / con > r$). Furthermore, the constant costs per click presume the absence of relevance factors in the ranking algorithm of the search engine. This restriction is relaxed to some extent in the following discussion on search engine campaign performance measures. Likewise, the distinction between exhausted and not exhausted advertising budgets is accounted for in the following analysis.

Number of impressions

In case of click fraud, the number of advertisement impressions increases considering a limitless budget. The fraudulent click behavior occurs in addition to the market behavior. Considering a budget constraint, the number of impressions needed for a fraudulent click, is assumed in most cases to be less than the number of impressions without click fraud. The reasoning is grounded on the intention of click fraud. In case of click fraud, a single impression generally leads to a click, whereas it requires 50

impressions for a single click considering an exemplary click through rate of 2 percent. Thus, click fraud generally creates a higher click through rate than actual search behavior as well as a decrease of advertisement impressions for a stable exhausted budget.

However, it could also be argued against this reasoning by pointing out the possibility to reproduce a specific click through rate by employing an elaborate automated click fraud method. An example is repetitively conducted searching for the targeted search terms, thus increasing the number of advertising impressions. This approach would create more interactions between the perpetrator and the advertising media. Thus, extra data on the click fraud operation is collected, so the chance of counter measuring as well as tracing the source improves. Considering the click rate as a potential relevance criteria, this elaborated approach will also influence related advertisements by creating additional impressions for those ads. In turn, this may harm related advertisements due to a reduced click through rate. This phenomena is referred to impression fraud and in contrast to click fraud exploits such factors of relevance and causes a high number of ad impressions.

Automated click fraud

Impression fraud

Additionally assuming a fixed and exhausted budget, the number of clicks can be rationalized to be stable over time if market competition is constant and the auctioning algorithm does not include any performance-related relevance factors, such as the click through rate of an advertisement. Whilst the budget was not exhausted in the past, the click number increases in case of click fraud, since the fraudulent clicks occur in addition to the search behavior. In consequence, the click through rate also increases as previously discussed. If the auctioning algorithm does include any click-related relevance factors, the number of clicks may even increase due to the intentional nature of click fraud. The advertisement will be considered as more relevant for a subsequent search query. Considering a relevance factor, such as the click through rate, the costs per click may drop, since the advertiser has to pay less for an identical positioning of the advertisement. If the costs saved by the increased relevance factor are higher than the additional costs caused by click fraud, a relevance factor increased by fraudulent clicks can even lower the costs of a campaign. In case of an exhausted advertising budget, an increased relevance factor caused by fraudulent clicks can generate an increased number of clicks at the same costs, whereby the number of fraudulent clicks is however without value for the advertiser.

Number of clicks considering advertising budget

Number of clicks considering relevance factors

Number of conversions As click fraudsters do not intent to engage in an e-commerce transaction with the advertiser, the number of conversions is constant for a limitless budget. Considering a stable and exhausted budget, the number of conversions is more likely to decline, because a portion of the budget is claimed by the fraudulent click behavior and therefore not available for subsequent search queries. Hence, fewer searchers become aware of the advertised content, products, and services.

For advertisers, an important point to note is to carefully define a conversion and thoroughly select an appropriate method to track the number of successful advertising contacts. This for example implies to trace a prospective customer over multiple sessions as well as across various communication channels.

A prospective customer may download or request further information concerning a service offered by the advertiser. In this case, it is important to follow the customer from clicking the advertisement, to inspecting further information, and to eventually signing a contract to determine the success (conversion) of the advertising campaign. Since the number of conversions decreases in a situation of click fraud and the number of clicks generally rises, the conversion rate declines indicating a decreased advertising efficiency.

Figure 6: Performance Measure Trends in case of Click Fraud

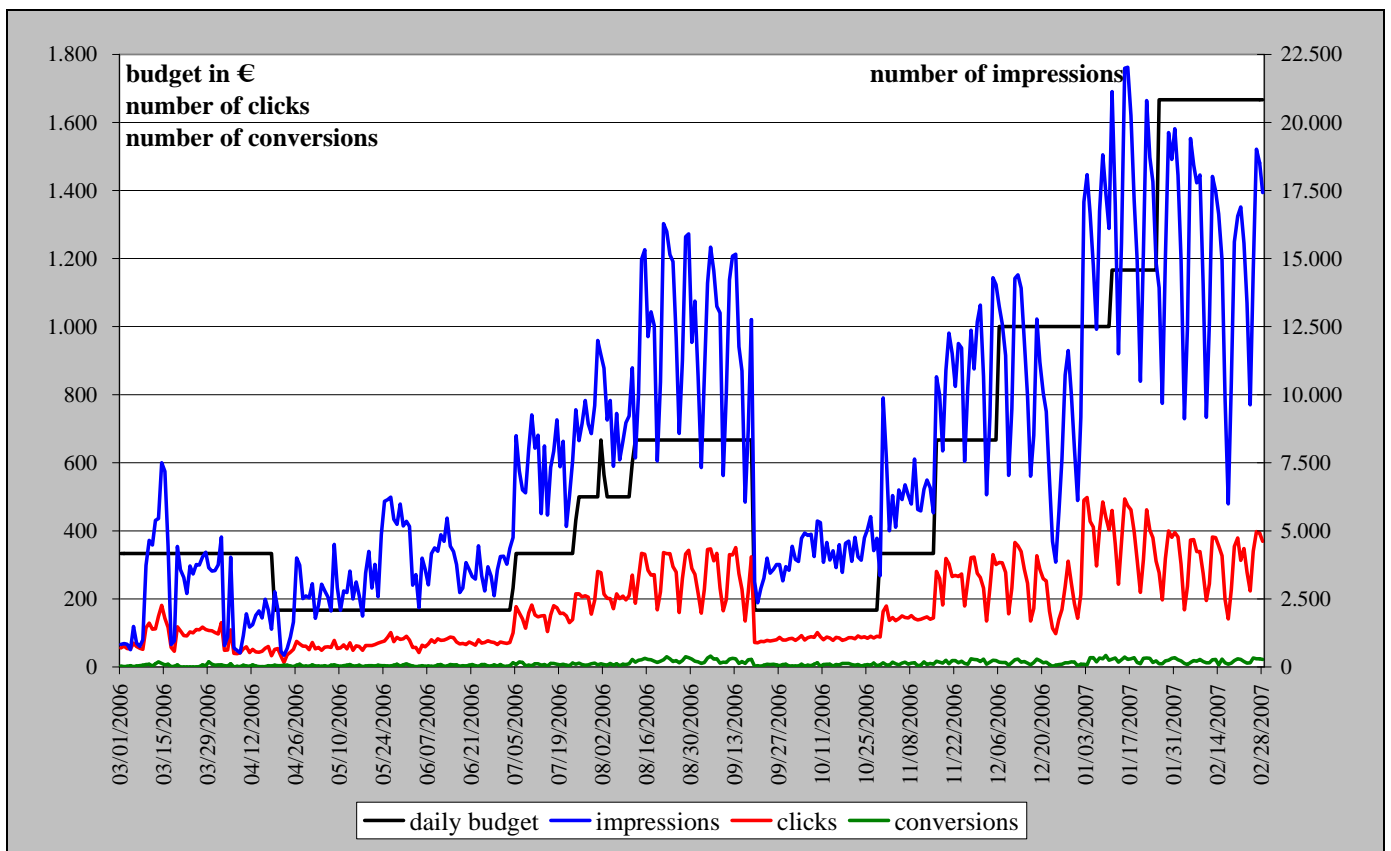
Performance Measure	no Budget Constraint	Budget exhausted	
		ranking without relevance factor	ranking with relevance factor
number of impressions	↑	↓	↓
click through rate	↑	↑	↑
number of clicks	↑	↔	↑ / ↔
conversion rate	↓	↓	↓
number of conversions	↔	↓	↓

Click fraud influences traditional performance measures of search engine advertising campaigns. The trend of the various performance measures depends on the degree of the budget exhaustion as well as employed relevance factors, such as the click through rate, in the ranking algorithm.

Based on an earlier version by Olbrich and Schultz (2008), figure 6 summarizes the effect of click fraud on these performance measures.

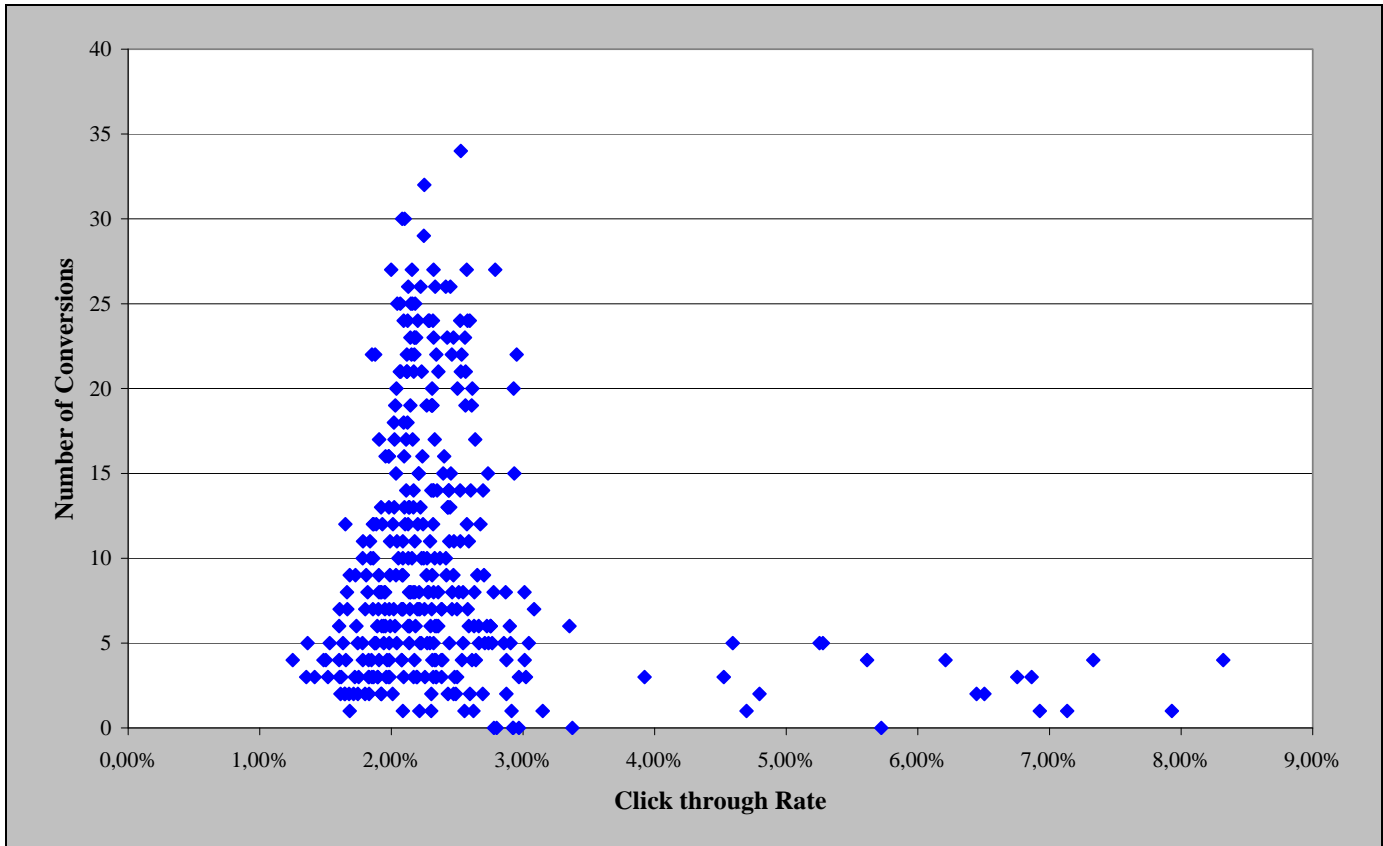
The following illustration 7 reports the course of a single real search engine advertising campaign for a one year time period from March, the 1st 2006 to February, the 28th 2007. In total, this search advertisement accounted for 2.863.981 impressions, 63.989 clicks, and 3.685 conversions. The advertising spending summed up to €153.623,10, so the daily budget was not always exhausted.

Figure 7: Course of a Search Engine Advertisement (Aggregated per Day)



The number of conversions as a function of the click through rate may provide a starting point for a deeper analysis. The following figure displays the according scatter plot of the search engine advertising campaign presented above depending on the number of conversions and on the click through rate.

Figure 8: Number of Conversions Depending on the Click through Rate (Aggregated per Day)



Graphical analysis The relevant variations can graphically be found in the lower right hand corner of figure 8, which represents days of the search engine advertisement with a high click through rate and low number of conversions. The inappropriate level of deviation can simply be determined by statistical hypothesis testing. However, even for this simple method, the advertiser needs to remember to either include the absolute amount of clicks or the conversion rate to exclude for example the influence of a budget decision. As such, the figure indicates click fraud only under a constant budget.

The proposed equation depends on the expected return of a conversion r and represents the acquisition price deemed acceptable for a conversion. Thus, advertisers are required to explicitly define a conversion as well as determine an acceptable conversion price that should not be exceeded. Defining a conversion is a challenging task, since the definition has to be in line with the marketing objectives and has to be operationalized by tracing a distinct event on the Website.

Effect of the advertising objectives

For some objectives, such as increasing brand awareness, a single Website event is not apparent. However, as an indication of increased brand

awareness, advertisers may draw on click stream data to determine a conversion according to the retention period or retention depths of a visit (CHATTERJEE et al., 2003; VAN DEN POEL/BUCKINX, 2005). Advertisers also need to price the conversion which in case of brand awareness represents an expense factor without immediate revenues.

In contrast to increasing brand awareness, increasing online sales is a marketing objective that can be identified by a single Website event, for example confirming a shopping transaction by pressing an ‘order now’ button. Further, the profit margin of the recent transaction can be calculated. According to the formulated equations, the profit contribution accounted to the advertising campaign should be at least equal to the advertising spending. A question marketers have to consider is whether the conversion return r should include profit contribution of future transactions. A difficulty in determining r is its volatility over time. For example, r can be subject to market fluctuations regarding competitors and prices of raw and supply materials.

Measuring the return of a conversion

Two general directions are conceivable for advertisers to address click fraud: abandoning the campaign or elevating the campaign’s profitability through detecting fraudulent clicks. Search engine advertisers will require search engine providers to deal with the problem of click fraud by for example implementing proactive click fraud detection systems.

Also conceivable is the adjustment of the business model from the pay-per-click system to the pay-per-conversion paradigm. However, a comprehensible and binding measurement of a conversion is problematic as well as the paradigm shift does not resolve the short term decision process. As such, the advertiser aims to lower the costs of the advertising campaign or increase the revenues of the ad campaign. A revision of the advertising campaign as well as the Website may deem the advertisement more relevant for a certain search query.

Paradigm shift

Advertisers may for example adjust the number and selection of keywords associated with a campaign to narrow or broaden the range of the keywords. If additional options by search engines are provided, advertisers might for instance constrain the campaign to specific countries or to a certain time of day. Decreasing the bidding amount is another possibility for adjustment. However, a lowered bid will only counter a single level of click fraud requiring continual adjustment of the advertising campaign and may also have been the aim of the perpetrator.

Keyword adjustment

5. Conclusion and Future Research

The paper addressed the issue of click fraud in the domain of search engine marketing from an advertiser's perspective. While the analysis centers on the search engine domain and the advertiser's perspective, the insights provided here are in many cases transferable to the problem of click fraud in general (as for example the perspective of the search engine provider).

Threat potential Click fraud is defined as the exploit of pay-per-click markets without the intention to transact with an advertiser. Four different types of click fraud situations were presented according to the click fraud form and motivation. Even though intention is a fundamental characteristic of click fraud, the different click fraud types do not incorporate further criminal intent as in case of blackmailing for example. Future research needs to be conducted to investigate the threat potential of this line of thought.

Proactive click fraud detection systems The paper also described various methods of detecting click fraud based on log file data. As pointed out in section 3, click fraud detection systems need to be organized in different layers depending on the computational costs, the computational automation, the analytical depth, and the analytical timeliness. Further research can extend on this outline to process in real time vast amount of data generated. Another direction of research concerns the proactive capacity of click fraud detection systems.

Early indicator Section 4 discussed the effect of click fraud on five frequently used performance measures and presented a decision rule to continue or discontinue a search engine advertising campaign. The tendencies of the five performance measures were analyzed and discussed considering an exhausted as well as a not exhausted budget. The costs per conversion and the conversion rate are particularly suited for the identification of click fraud, because both ratios possess opposing directed numerators and denominators in case of fraudulent clicks. In addition, both ratios compared tend in different directions: the costs per conversion generally increase and the conversion rate generally decreases in case of click fraud. However, both measures are only suited as indicators of click fraud if a conversion can be defined and priced by the advertiser. Future research may focus on the question, which early indicators are appropriate for conversions that are hard to define or hard to price.

<p>Another open research question concerns the comparison of online and traditional (not online) advertising media: Which consistent databases can be utilized to compare these different advertising media?</p>	<p>Comparison of different advertising media</p>
<p>The paper focused on the perspective of an advertiser in case of click fraud in search engine advertising. Thus, future research needs to concentrate on the search engine perspective. An interesting and challenging question for future studies is how search engine providers should communicate, establish, and maintain trustworthiness in the eyes of the searcher and the advertiser.</p>	<p>Multiple perspectives Trustworthiness of search engine advertisement</p>

References

- ARASU, A./CHO, J.; GARCIA-MOLINA, H./PAEPCKE, A./RAGHAVAN, S. 2001: Searching the Web, *ACM Transactions on Internet Technology*, Vol. 1, 2001, No. 1, 2-43.
- BAR-ILAN, J. 2002: Methods for Measuring Search Engine Performance over Time, *Journal of the American Society for Information Science and Technology*, Vol. 53, 2002, No. 4, 308-319.
- BAR-ILAN, J./MAT-HASSAN, M./LEVENE, M. 2006: Methods for comparing rankings of search engine results, *Computer Networks*, Vol. 50, 2006, No. 10, 1448-1463.
- BAUER, H. H./HAMMERSCHMIDT, M. 2005: Customer-Based Corporate Valuation – Integrating the Concepts of Customer Equity and Shareholder Value, *Management Decision*, Vol. 43, 2005, No. 3, 331-348.
- BERTOT, J. C./MCCLURE, C. R./MOEN, W. E./RUBIN, J. 1997: Web Usage Statistics: Measurement Issues and Analytical Techniques, *Government Information Quarterly*, Vol. 14, 1997, No. 4, 373-395.
- BHARGAVA, H. K./FENG, J. 2002: Paid Placement Strategies for Internet Search Engines, *Proceedings of the 11th International Conference on World Wide Web*, WWW '02, Honolulu, Hawaii, USA, 2002, 117-123.
- BRIN, S./PAGE, L. 1998: The anatomy of a large-scale hypertextual Web search engine, *Computer Networks and ISDN Systems*, Vol. 30, 1998, No. 1-7, 107-117.
- CHAKRABARTY, D./ZHOU, Y./LUKOSE, R. 2007: Budget Constrained Bidding in Keyword Auctions and Online Knapsack Problems, 16th International World Wide Web Conference WWW 2007, Banff, Canada, 2007.
- CHATTERJEE, P./HOFFMANN, D. L./NOVAK, T. P. 2003: Modeling the Clickstream: Implications for Web-Based Advertising Efforts, *Marketing Science*, Vol. 22, 2003, No. 4, 520-541.
- DELANEY, K. J. 2005: Internet Firms Face Legal Test On Advertising Fees, *The Wall Street Journal*, 04-05-2005, http://online.wsj.com/public/article/SB111265034532297608-TEcjJA8V_mnuukWG0MzcHcBc_f4_20050505.html?mod=tff_main_tff_top, 21.07.2008.
- EDELMAN, B./OSTROVSKY, M. 2007: Strategic bidder behavior in sponsored search auctions, *Decision Support Systems*, Vol. 43, 2007, No. 1, 192-198.

- EROSHENKO, D. 2004: Click fraud. The state of the industry, *Pay per Click Analyst*, 10-19-2004, <http://www.payperclickanalyst.com/content/templates/article.aspx?articleid=68&zoneid=1>, 21.07.2008.
- FENG, J./BHARGAVA, H. K./PENNOCK, D. M. 2007: Implementing Sponsored Search in Web Search Engines: Computational Evaluation of Alternative Mechanisms, *Inform's Journal on Computing*, Vol. 19, 2007, No. 1, 137-148.
- GANDAL, N. 2001: The dynamics of competition in the Internet search engine market, *International Journal of Industrial Organization*, Vol. 19, 2001, No.7, 1103-1117.
- GYÖNGYI, Z./GARCIA-MOLINA, H. 2005: Web Spam Taxonomy, *Proceedings of the First Workshop on Adversarial Information Retrieval on the Web*, AIRWeb 2005, Chiba, Japan, 2005, 39-47.
- GROW, B./ELGIN, B./HERBST, M. 2006 Click Fraud – The dark side of online advertising, *BusinessWeek online*, 10.02.2006.
- IMMORLICA, N./JAIN, K./MAHDIAN, M./TALWAR, K. 2005: Click Fraud Resistant Methods for Learning Click-Through Rates, in: Deng, X. and Ye, Y. (eds.): *Internet and Network Economics*, First International Workshop, WINE 2005, Springer, Hong Kong, China, 2005, 34-45.
- INTRONA, L. D./NISSENBAUM, H. 2000: Shaping the Web: Why the Politics of Search Engines Matter, *The Information Society*, Vol. 16, 2000, No. 3, 169-185.
- JANSEN, B. J. 2007: The Comparative Effectiveness of Sponsored and Non-Sponsored Links for Web Ecommerce Queries, *ACM Transactions on the Web*, Vol. 1, 2007, No. 1.
- JANSEN, B. J. 2006: Adversarial Information Retrieval Aspects of Sponsored Search, *Proceedings of the Second Workshop on Adversarial Information Retrieval on the Web*, AIRWeb 2006, Seattle, Washington, USA, 2006, 33-37.
- JANSEN, B. J./RESNICK, M. 2006: An Examination of Searcher's Perception of Nonsponsored and Sponsored Links during E-Commerce Web Searching, *Journal of the American Society for Information Science and Technology*, Vol. 57, 2006, No. 14, 1949-1961.
- JANSEN, B. J./SPINK, A. 2006: How are we searching the World Wide Web? A comparison of nine search engine transaction logs, *Information Processing and Management*, Vol. 42, 2006, No. 1, 248-263.

- JONKER, J. J./PIERSMA, N./VAN DEN POEL, D. 2004: Joint Optimization of Customer Segmentation and Marketing Policy to Maximize Long-Term Profitability, *Expert Systems with Applications*, Vol. 27, 2004, No. 2, 159-165.
- KITTS, B./LEBLANC, B. 2004: Optimal Bidding on Keyword Auctions, *Electronic Markets*, Vol. 14, 2004, No. 3, 186-201.
- KITTS, B./LEBLANC, B./MEECH, R./LAXIMINARAYAN, P. 2006: Click Fraud, *Bulletin of the American Society of Information Science and Technology*, Vol. 32, 2006, No. 2, 20-23.
- KITTS, B./LAXIMINARAYAN, P./LEBLANC, B./MEECH, R. 2005: A Formal Analysis of Search Auctions Including Predictions on Click Fraud and Bidding Tactics”, *Proceedings of the ACM Conference on E-Commerce*, EC 2005, Workshop on Sponsored Search, Vancouver, Canada, 2005, <http://research.yahoo.com/workshops/ssa2005/papers/kitts-ssa2005.doc>, 21.07.2008.
- LIDDY, E. 2001: How a Search Engine Works, *Searcher*, Vol. 9, 2001, No. 5, 38-43.
- LIM, W. S./TANG, C. S. 2006: An auction model arising from an Internet search service provider, *European Journal of Operational Research*, Vol. 172, 2006, No. 3, 956-970.
- LIU, D./CHEN, J. 2006: Designing online auctions with past performance information”, *Decision Support Systems*, Vol. 42, 2006, No. 3, 1307-1320.
- METTROP, W./NIEUWNHUYSEN, P. 2001: Internet Search Engines – Fluctuations in Document Accessibility, *Journal of Documentation*, Vol. 57, 2001, No. 5, 623-651.
- MORAN, M./HUNT, B. 2006: Search Engine Marketing, Inc – Driving Search Traffic to Your Company’s Web Site, IBM Press, Upper Sadle River 2006.
- NICHOLSON, S./SIERRA, T./ESERYEL, U. Y./PARK, J.-H./BARKOW, P./POZO, E. J./WARD, J. 2006: How Much of It is Real? Analysis of Paid Placement in Web Search Engine Results, *Journal of the American Society for Information Science and Technology*, Vol. 57, 2006, No. 4, 448-461.
- OLBRICH, R./SCHULTZ, C. D. 2008: Suchmaschinenmarketing und Klickbetrug, in: BORTFELDT, A./HOMBERGER, J./KOPFER, H./PANKRATZ, G./STRANGMEIER, R. (Hrsg.): *Intelligente Entscheidungsunterstützung – Aktuelle Herausforderungen und Lösungsansätze*, Festschrift für Hermann Gehring, Wiesbaden 2008, 255-271.
- SEDA, C. 2004: Search Engine Advertising – Buying Your Way to the Top to Increase Sales, New Riders, Indianapolis 2004.

- SEN, R. 2005: Optimal Search Engine Marketing Strategy, *International Journal of Electronic Commerce*, Vol. 10, 2005, No. 1, 9-25.
- SEN, S./PADMANABHAN, B./TUZHILIN, A./WHITE, N./STEIN, R. 1998: The identification and satisfaction of consumer analysis-driven information needs of marketers on the WWW, *European Journal of Marketing: Special Issue on Marketing in Cyberspace*, Vol. 32, 1998, No. 7/8, 688-702.
- TELANG, R./RAJAN, U./MUKHOPDAHYAY, T. 2004: The Market Structure for Internet Search Engines, *Journal of Management Information Systems*, Vol. 21, 2004, No. 2, 137-160.
- VAN DEN POEL, D./BUCKINX, W. 2005: Predicting online-purchasing behavior, *European Journal of Operational Research*, Vol. 166, 2005, No. 2, 557-575.
- VENKATESAN, R./KUMAR, V. 2004: A Customer Lifetime Value Framework for Customer Selection and Resource Allocation Strategy, *Journal of Marketing*, Vol. 68, 2004, No. 4, 106-125.
- VIDYASAGAR, N. 2004: India's secret army of online ad 'clickers', *The Times of India*, 03.05.2004.
- Zhou, Y./Lukose, R. 2006: Vindictive Bidding in Keyword Auctions, *ACM Conference on Electronic Commerce (EC '06)*, Second Workshop on Sponsored Search Auctions, Ann Arbor, Michigan, USA, 2006.

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Forschungsbericht Nr. 3:

OLBRICH, R./BATTENFELD, D. 2000: Komplexität aus Sicht des Marketing und der Kostenrechnung, FernUniversität in Hagen.

Forschungsbericht Nr. 4:

OLBRICH, R. 2001: Ursachen, Entwicklung und Auswirkungen der Abhängigkeitsverhältnisse zwischen Markenartikelindustrie und Handel, FernUniversität in Hagen.

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Forschungsbericht Nr. 7:

OLBRICH, R./WINDBERGS, T. 2002: Marktbezogene Wirtschaftlichkeitsaspekte von Biogasanlagen nach der Verabschiedung des „Erneuerbare-Energien-Gesetz (EEG)“ – Konsequenzen für die deutsche Energie- und Entsorgungswirtschaft, FernUniversität in Hagen.

Forschungsbericht Nr. 8:

OLBRICH, R./GRÜNBLATT, M. 2003: – Projekt SCAFO – Stand der Nutzung von Scanningdaten in der Deutschen Konsumgüterwirtschaft – Ergebnisse einer empirischen Untersuchung, FernUniversität in Hagen.

Forschungsbericht Nr. 9:

OLBRICH, R./BUHR, C.-C. 2003: – Projekt SCAFO – Sortimentscontrolling im filialisierenden Handel – dargestellt am Beispiel von Frischwaren, FernUniversität in Hagen.

Forschungsbericht Nr. 10:

PEISERT, R. 2004: Die Wahl internationaler Standorte durch europäische Handelsunternehmen – Internationalisierungspfade, Strategiemuster, empirische Befunde und Handlungsempfehlungen, FernUniversität in Hagen.

Forschungsbericht Nr. 11:

OLBRICH, R./BUHR, C.-C./GREWE, G./SCHÄFER, T. 2005: Die Folgen der zunehmenden Verbreitung von Handelsmarken für den Wettbewerb und den Verbraucher, FernUniversität in Hagen.

Forschungsbericht Nr. 12:

OLBRICH, R./WINDBERGS, T. 2005: – Projekt SCAFO – Zur Beziehung zwischen Markentreue, Einkaufsstättentreue und Erfolg im Lebensmittelhandel – Eine kausalanalytische Betrachtung am Beispiel von Premiumhandelsmarken, FernUniversität in Hagen.

Forschungsbericht Nr. 13:

OLBRICH, R./VOERSTE, A. 2006: – Projekt SCAFO – Determinanten des Konsumverhaltens nach einer Lebensmittelkrise – Ergebnisse einer empirischen Analyse zum Konsum rindfleischhaltiger Lebensmittel nach einer BSE-Krise in Deutschland, FernUniversität in Hagen.

Forschungsbericht Nr. 14:

OLBRICH, R./TAUBERGER, J. 2006: – Projekt SCAFO – Verkaufsförderung – Ziele und Formen der Wirkungsmessung am POS, FernUniversität in Hagen.

Forschungsbericht Nr. 15:

OLBRICH, R./GREWE, G. 2007: – Projekt SCAFO – Folgen der zunehmenden Verbreitung von Handelsmarken – geringere Artikelvielfalt und Anstieg der Preise, FernUniversität in Hagen.

Forschungsbericht Nr. 16:

OLBRICH, R./SCHULTZ, C. D. 2008: Suchmaschinenmarketing und Klickbetrug, FernUniversität in Hagen.

In English**Research Paper No. 1:**

OLBRICH, R./BUHR, C.-C. (2005): The impact of private labels on welfare and competition – how retailers take advantage of the prohibition of resale price maintenance in European competition law, FernUniversität in Hagen.

Research Paper No. 2:

BUHR, C.-C. (2005): Regularities in aggregated consumer behavior and prevention of stock-outs in retailing, FernUniversität in Hagen.

Research Paper No. 3:

BUHR, C.-C. (2005): Quantifying knowledge on consumers' payment behavior in retailing, FernUniversität in Hagen.

Research Paper No. 4:

OLBRICH, R./WINDBERGS, TH. (2006): The Relationship between Brand Loyalty, Store Loyalty and Performance in the Retail Food Sector: A causal-analytical Analysis using the Example of Premium Store Brands, FernUniversität in Hagen.

Research Paper No. 5:

OLBRICH, R./SCHULTZ, C. D. (2007): Search Engine Advertising and Click Fraud, FernUniversität in Hagen.