

# Chapter 3

## Web Search Privacy Evaluation Metrics

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### ABSTRACT

*Privacy quantification methods are used to quantify the knowledge the adverse search engine has obtained with and without privacy protection mechanisms. Thus, these methods calculate privacy exposure. Private web search techniques are based on many methods (e.g., proxy service, query modification, query exchange, and others). This variety of techniques prompted the researchers to evaluate their work differently. This section introduces the metrics used to evaluate user privacy (protection). Moreover, this section also introduces the metrics used to evaluate the performance of privacy attacks and theoretical evaluation approaches.*

### INTRODUCTION

Web search is the most dominant online activity due to the sheer abundance of information on the Web over the last two decades (El-Ansari, Beni-Hssane, Saadi, & El Fissaoui, 2021; Khan & Ali, 2013; Khan, Ullah, Khan, Uddin, & Al-Yahya, 2021; Preibusch, 2015). This abundance of information exceeds human processing abilities and prevent them from finding their desired contents (such as information, product, services and others) (Khan, 2020; Khan et al., 2021; Ullah, Islam, Khan, Aleem, & Iqbal, 2019). Web search engines provide the most relevant web content to the users based on their query, location, history (user profile) and other parameters (Khan et al., 2020; Khan & Islam, 2017; Ullah et al., 2021; Ullah et al., 2022). Usually, web search service providers claim that they offer their service free of cost and make

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a profit with the advertisements displayed alongside query results (Khan & Islam, 2017; Khan, Islam, Ullah, Aleem, & Iqbal, 2019; Preibusch, 2015). However, maintaining user profiles may cause serious privacy breach concerns as these profiles may contain private and sensitive queries about users (Khan, 2020; Preibusch, 2015; Ullah et al., 2019). Eurobarometer reported in 2016 that 82% of European web users say that user activity monitoring tools should only be used with their permission (Monteleone, 2017; Zuiderveen Borgesius, Kruikemeier, Boerman, & Helberger, 2017).

Private web search and private information retrieval are the techniques for retrieving the desired information from web search engines or a database without disclosing the user's identity, intentions and other tracking information (Saint-Jean, 2005). These techniques are proposed to tackle the user privacy infringement problem (Khan et al., 2021). There are numerous techniques available to counter privacy infringement, such as proxy networks (Berthold, Federrath, & Köpsell, 2001; Mokhtar et al., 2017), profile obfuscation techniques (Nissenbaum & Daniel, 2009), query scrambling techniques (Arampatzis, Drosatos, & Efraimidis, 2015; Arampatzis, Efraimidis, & Drosatos, 2013), private information retrieval protocols (Reiter & Rubin, 1998; Romero-Tris, Castella-Roca, & Viejo, 2011; Romero-Tris, Viejo, & Castellà-Roca, 2015; Ullah et al., 2019; Ullah et al., 2021; Ullah, Khan, & Islam, 2016a, 2016b; Ullah et al., 2022; Viejo, Castella-Roca, Bernadó, & Mateo-Sanz, 2012) and others (Chen, Bai, Shou, Chen, & Gao, 2011; Mokhtar, Berthou, Diarra, Quéma, & Shoker, 2013; Mokhtar et al., 2017; Petit, Cerqueus, Mokhtar, Brunie, & Kosch, 2015; Shapira, Elovici, Meshiach, & Kuflik, 2005).

Performance evaluation metrics are vital tools to measure the effectiveness of the proposed procedures or methodologies and compare their performance against their state-of-the-art counterparts. The evaluation metrics are usually based on mathematical or statistical methods designed to simulate some events in a simulator or a mathematical model and collect the response values of these events. In computing, the usual metrics are algorithmic time and space complexity; however, different metrics are developed for different problems to evaluate the effectiveness of the tools proposed for the specific problems (Aslanpour, Gill, & Toosi, 2020). It is essential to select the right metric for evaluating the proposed techniques as it gives a sound idea about the behaviour and success of the technique on the field. Performance evaluation provides a systematic method to study a technique, practice, intervention or initiative to understand how well the proposed technique will achieve its goals. It also helps to determine which area of the proposed technique works fine and what could be improved. With the selection of appropriate metrics, one can demonstrate the impact of Research, suggest improvements, continue research efforts, and use used in other potential domains.

In private web searches and private information retrieval domains, various performance evaluation metrics are available to evaluate the performance of proposed techniques. Most researchers use statistical and mathematical functions, while some use simulation results and theoretical analysis of the mechanism. This chapter overviews the most prominent metrics used to evaluate privacy web search and private information retrieval techniques.

The rest of the chapter is organized as follows: Section 2 briefly presents the metrics proposed and used for private web search techniques evaluation. In section 3, we present a conclusive summary of all the attacks, and in section 4, we discuss the relative future directions.

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