OPRFs: notes and more

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1 Introduction

From [NT22]:
"An oblivious pseudorandom function (OPRF) [FIPR05, JL09] allows a client holding a private input x and a server holding a key for a PRF f to engage in a protocol to *obliviously* evaluate f on x. The client learns (and optionally verifies) the evaluation $f_(x)$ while the server learns nothing."

OPRFS are used in many privacy-preserving protocols:

- Anti-Fraud systems [DGS+18], such Privacy Pass,

- Private set-intersecction for compromised credentials [LPA+19, TPY+19],

- Password-authenticated key exchange [JKX18, JKK14],

- De-identified authenticated logging [HIJ+21],

- Private click measurement (PCM) in the W3C [WTKW20],

- Private ad click or visualization [ZeQ19],

- Collecting user data [DSQ+21] [AD22].

They are used to provide proof between sessions that a positive action took place.

2 Limitations

Some know limitations:

- Key management: the server often has to maintain a single main key, or a set of keys per client/user. This is prone to leakage or to problems with key rotation.

- Double spending protection: servers have to keep a large database of spent tokens per client. Each request for spending a token has to be checked with the database so tokens are not double-spent. Maintaining this database is cumbersome. Is there a better solution?

- Hoarding attacks: individual users (or groups of users) gather tokens over a long period of time and redeeming them all at once, e.g., in an attempt to overwhelm a service.

- Hoarding cookies: A successful token redemption could be exchanged for single-origin cookies. These cookies allow clients to avoid future challenges for a particular domain without using more tokens. In the case of a hoarding attack, an attacker could trade in their hoarded number of tokens for a number of cookies:

  - Cookies are bound to the domain they are issued, the IP address they are issued to, and have a fixed lifetime. Traded by tokens, they are not bounded anymore.
  - Mount a layer 7 DDoS attack with the "hoarded" cookies.

- No post-quantum efficient proposal.

2.1 New applications?

- Token Theft: Session credentials for authenticated users are traditionally stored as cookies in the browser. "These are easily extracted by malware. Services traditionally defend against this by associating certain invariant client properties (screen size, webGL renderer, etc) with a user's cookie, and rejecting the session credential (forcing the use to re-authenticate) if it appears that the cookie is used on a new device" [W3C22]. Do we still have to use cookies for this?

- Fake engagement: "Fake engagements may be simulated (i.e. generated by something other than the honest platform), automated or hijacked (i.e. generated on the claimed platform, but without genuine user intent), or incentivized (i.e. generated by a human in exchange for an undisclosed incentive)." [W3C22]. Can we use anonymous tokens for this?

- Linking to private windows in a "private way".

2.2 What can we achieve?

- A SoK for the different needs for OPRFs.

- A potential list of applications.

- A survey of fraud attacks and how anonymous tokens can help.

- Working group to explore these cases.

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