Private Blocklist Lookups with Checklist

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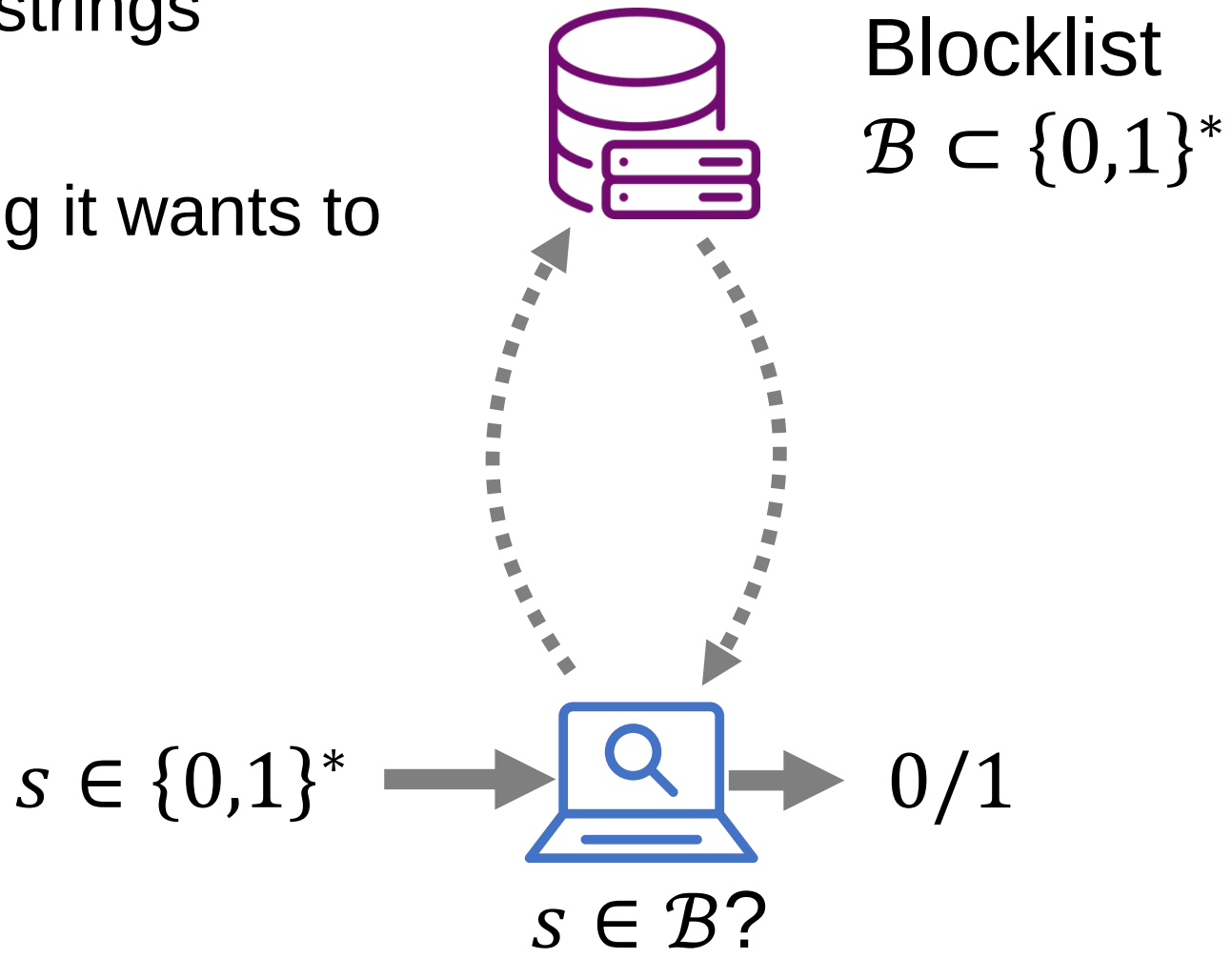
Blocklist lookup

Server holds a blocklist of strings

Client holds a **private** string it wants to check against the blocklist

Examples:

- Certificate revocation
- Password checkup
- Safe Browsing



Safe Browsing

Leaks information about user's browsing history
[GKL16,Per19,BK20]

Firefox browser

uyghuracademy.com/

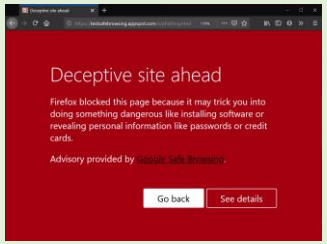
Partial hashes

0x104
0x130
0x1F3
0x1FF
0x24C
0x2B2
...

Lookup
0x24C

Full hash
0x24C1A8…

Warn



Google Safe Browsing

Hashes of ~3M dangerous URLs

0x104A158413B9…
0x130CA8F45BE3…
0x1F346FFD10DA…
0x1FF60910E4BF1…
0x24CC8335003A…
0x2B26ED8D140B…
…

This work

Checklist – a system for private blocklist lookups

Builds on offline/online private information retrieval [CK20]

- Allows for sublinear online server time

Contributions:

- New offline/online PIR (reduces server computation by >100x)
- A technique to efficiently support database updates
- Implementation & evaluation of a private Safe Browsing system

Requirements

Correctness

Client learns whether $s \in \mathcal{B}$ (with overwhelming prob.)

Privacy for the client

Non-goal: privacy for the server

(see paper for discussion of this extension)

(Malicious) server “learns nothing” about client’s string

Efficiency

Minimize latency, communication, computation, storage

Two-server private information retrieval [CGKS95,…]

Server computation is large
Servers needs to do $\Omega(n)$ work [BIM04]

$x \in \{0,1\}^n$

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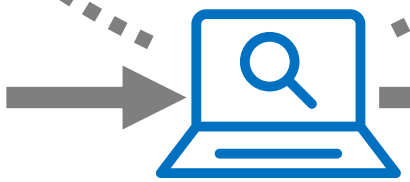
Communication is small
$O(\log n)$ from DPFs [GI14, BGI15]
(Distributed Point Functions)

Security
Each server **on its own** learns nothing about i

Index
$i \in [n]$



$x_i \in \{0,1\}$

$[n] = \{1, \dots, n\}$

Offline/Online PIR [CK20]

Step 1: Offline phase

$x \in \{0,1\}^n$

$x \in \{0,1\}^n$

$O(n)$ time

Hint $\approx \lambda\sqrt{n}$ bits

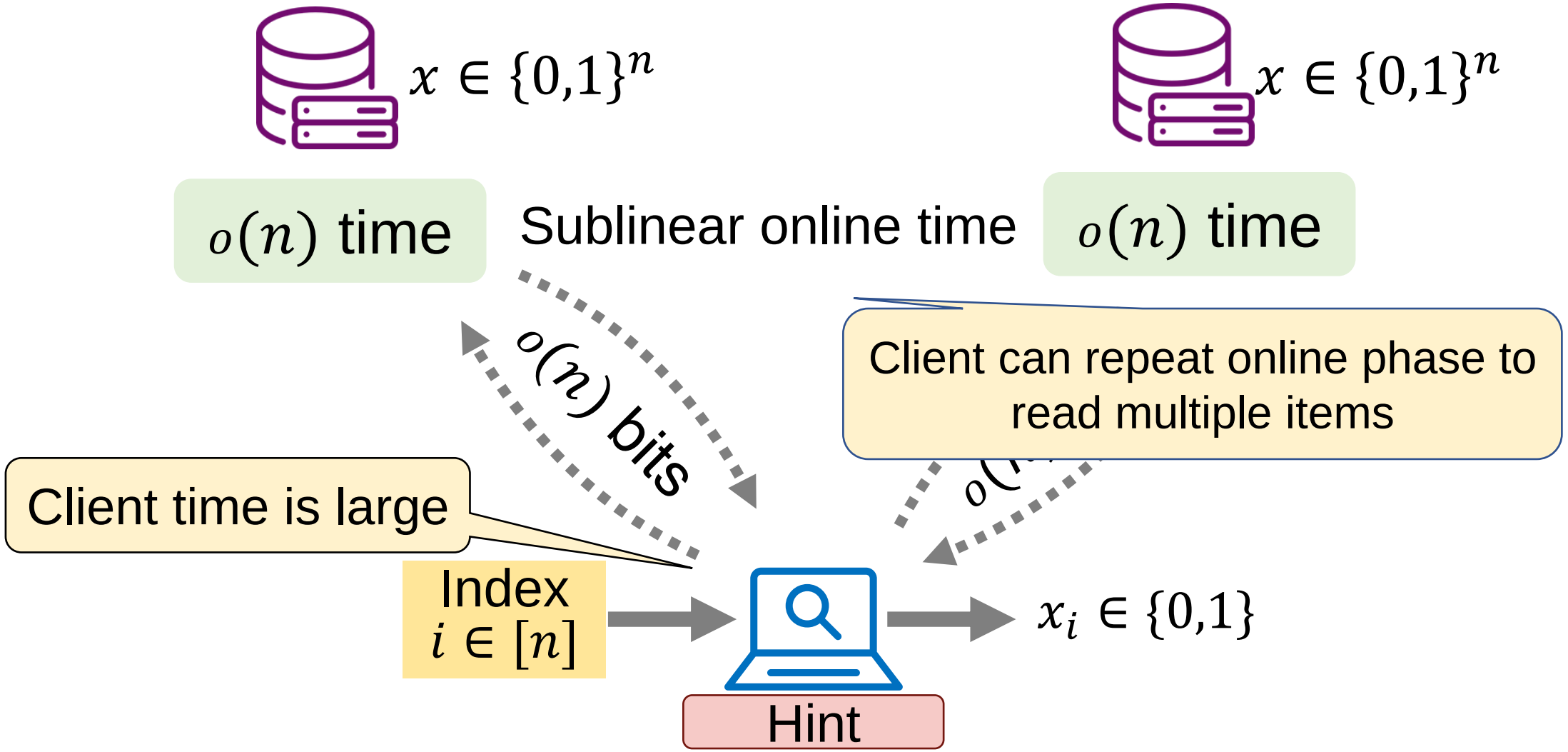
$\lambda\sqrt{n}$ bits

- The left server runs in linear time.
- But only once per client.

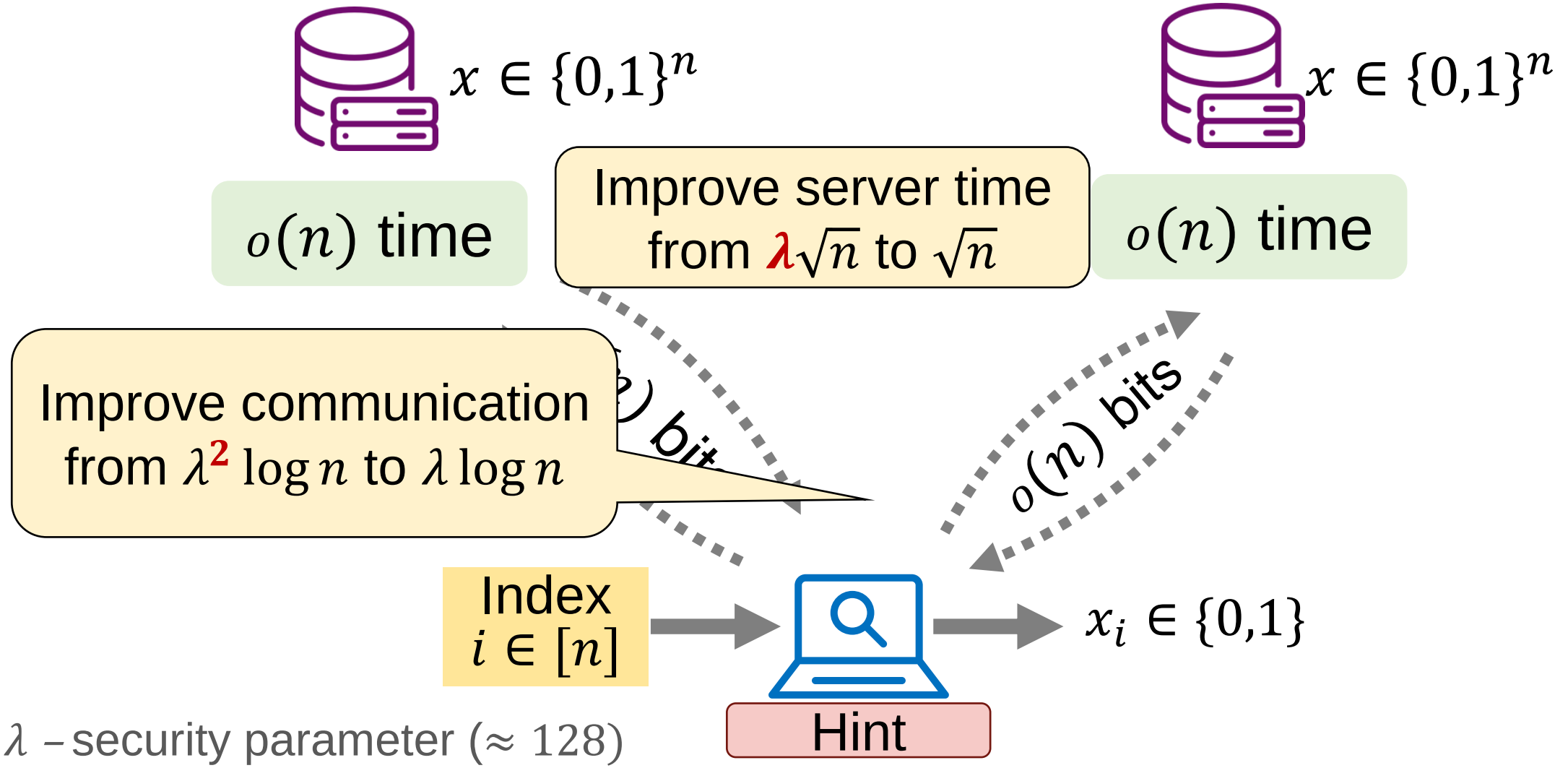
λ – security parameter (≈ 128)

Offline/Online PIR [CK20]

Step 2: Online phase – reading x_i



Our first contribution:
$\lambda\times$ faster offline/online PIR



λ – security parameter (≈ 128)

Our second contribution:
Offline-online PIR with DB updates

When the database changes, client needs a new hint

Naïve approach: rerun the offline phase after each change

- Linear amount of server work on each change

Refined approach: incremental preprocessing

- Use “buckets” of exponentially increasing size
- Logarithmic amount of server work on each change

Static-to-dynamic data structures [BS80,GO96,CKO90,SSP13,SPS14,PT16]

Our third contribution:
Private Safe Browsing

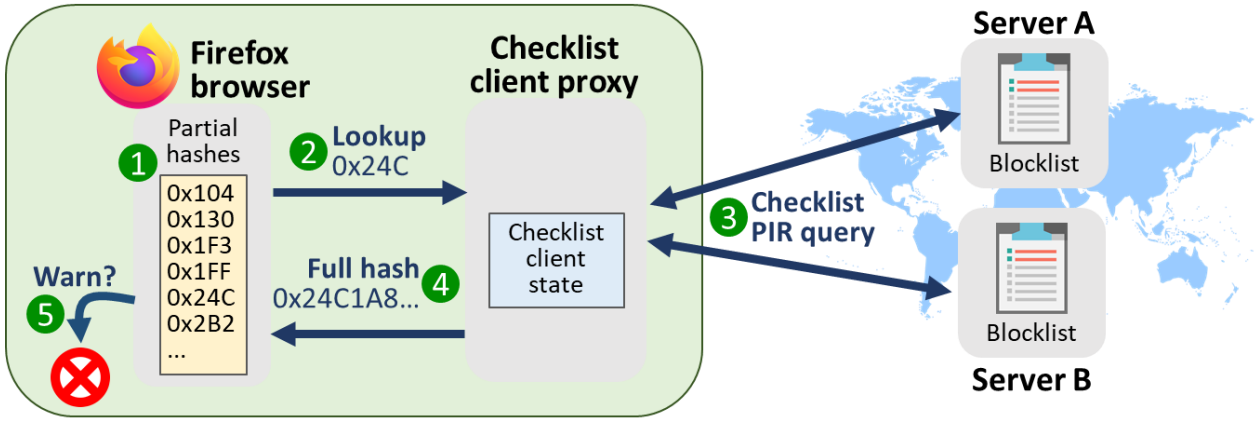
Checklist: a system for private Safe Browsing queries, integrated and evaluated with Firefox browser

Implementation

Roughly 2500 lines of Go + 500 lines of C

Support offline/online and DPF-based PIR

Browser integration: local proxy + browser config change



Estimating the Safe Browsing parameters

Monitor a week of Safe Browsing requests and responses

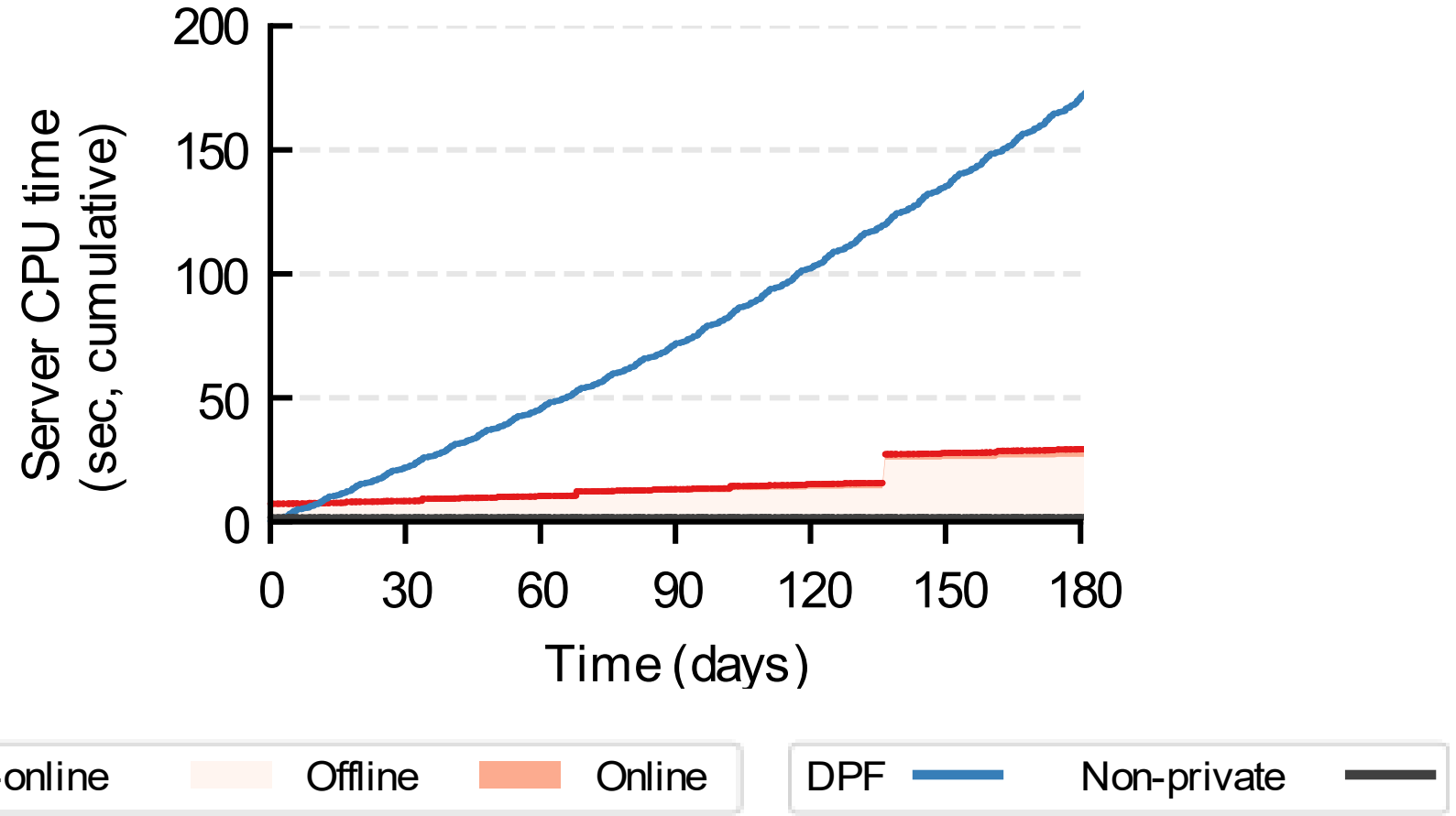
Local proxy forwards requests to the real Safe Browsing service

Deduce:

- Frequency of lookups
- Frequency of updates
- Database growth

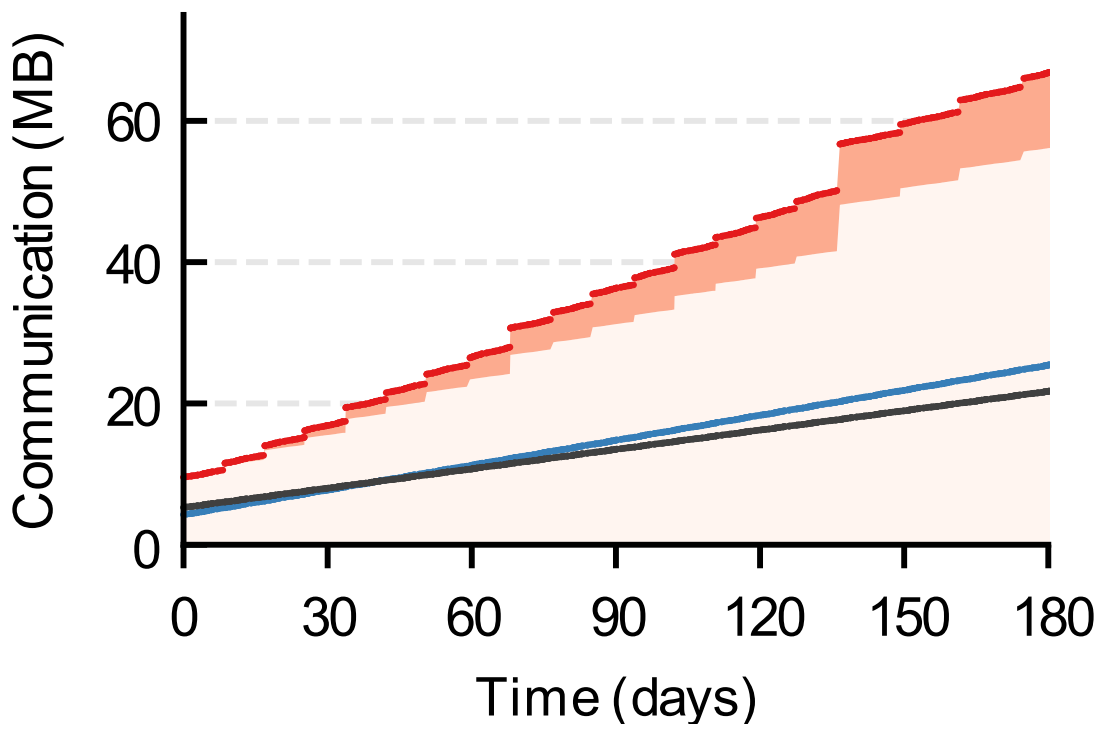
Checklist with offline/online PIR is more efficient for the server

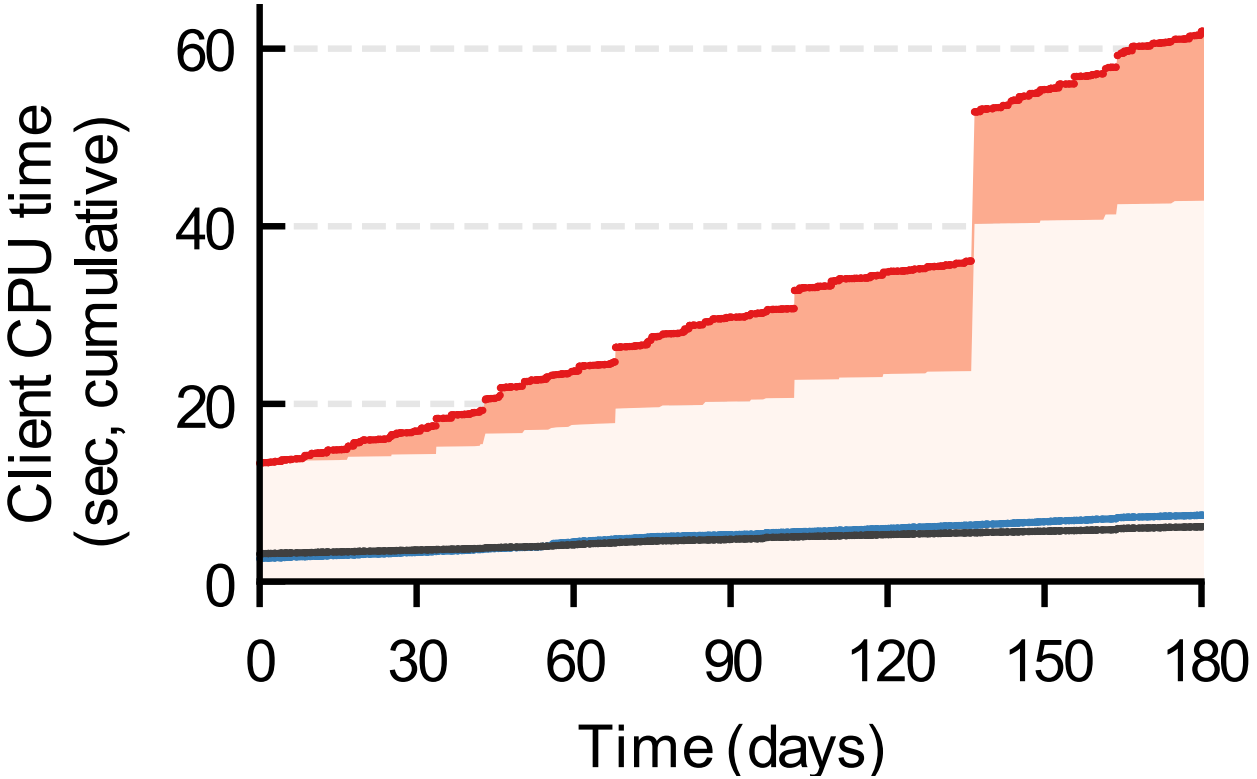
Replay recorded trace of a single user

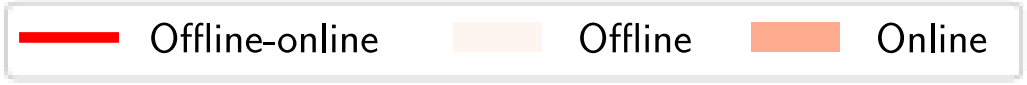


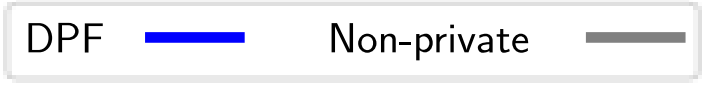
Server running on e2-standard-4 Google Compute Engine machine (4 vCPUs, 16 GB RAM)

Checklist with DPF-based PIR is more efficient for the client









Client running on a Pixel 5 mobile phone

Overview of results

Approach	Server Costs	Latency	Client computation		Communication		Client Storage	
	(servers per 1B users)	(ms)	Initial (sec)	Running (sec/month)	Initial (MB)	Running (MB/month)	Initial (MB)	Running (MB/month)

Overview of results

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Offline/online PIR	1348	90	13.3	8.0	10.3	9.8	24.5	1.6

Conclusion & future work

Two-server PIR is a practical tool for privacy preserving systems

- Several alternatives that allow for different trade-offs

Future direction: better single-server offline/online PIR

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Future direction: better single-server offline/online PIR

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https://eprint.iacr.org/2021/345

https://github.com/dimakogan/checklist