Protecting Web-based Single Sign-on Protocols against Relying Party Impersonation Attacks through a Dedicated Bi-directional Authenticated Channel

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Roadmap

- Single Sign-on
- Threat Model
- Problems with Existing Designs
- Our Design
- Evaluation

Single Sign-on (SSO) (1)

- Idea: log in to a website with your Facebook, Google, etc. account

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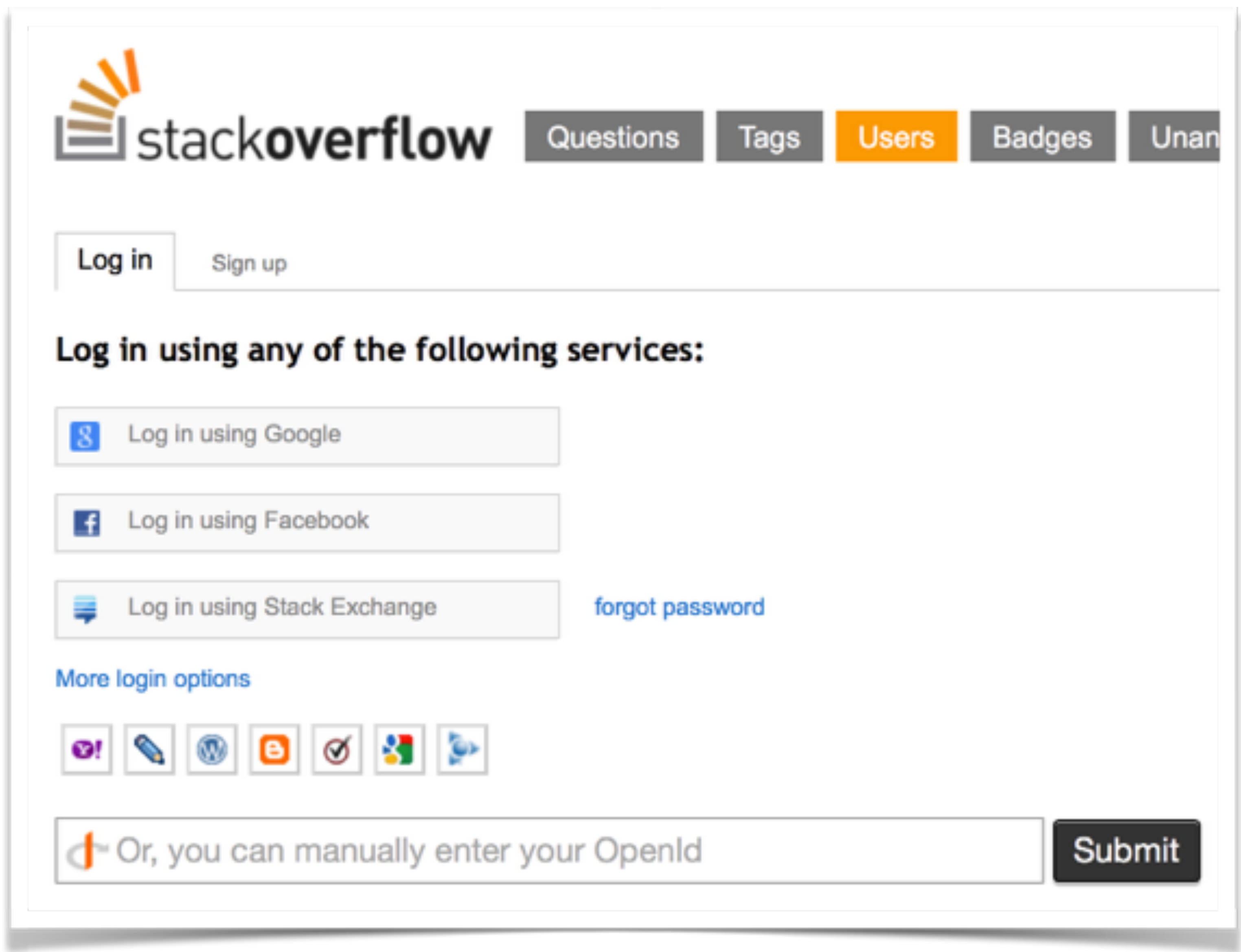

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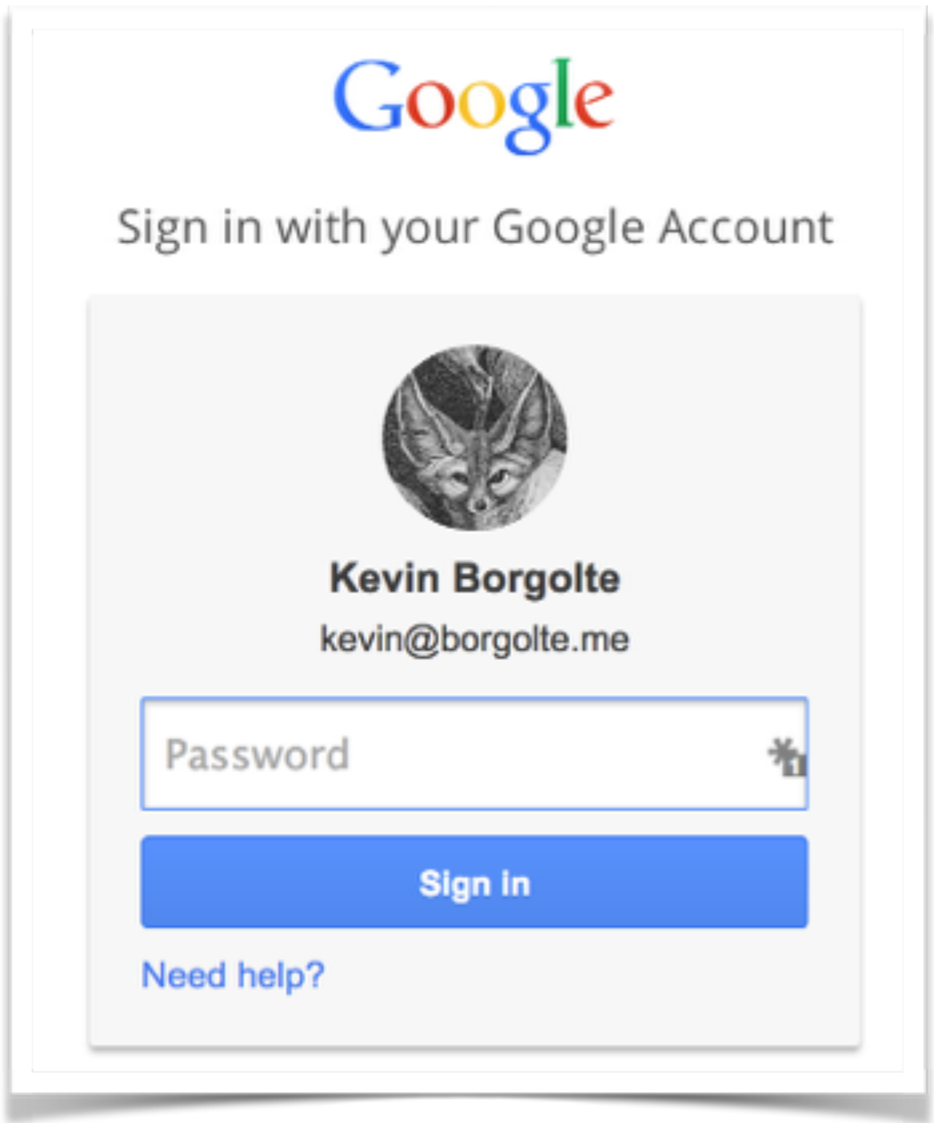

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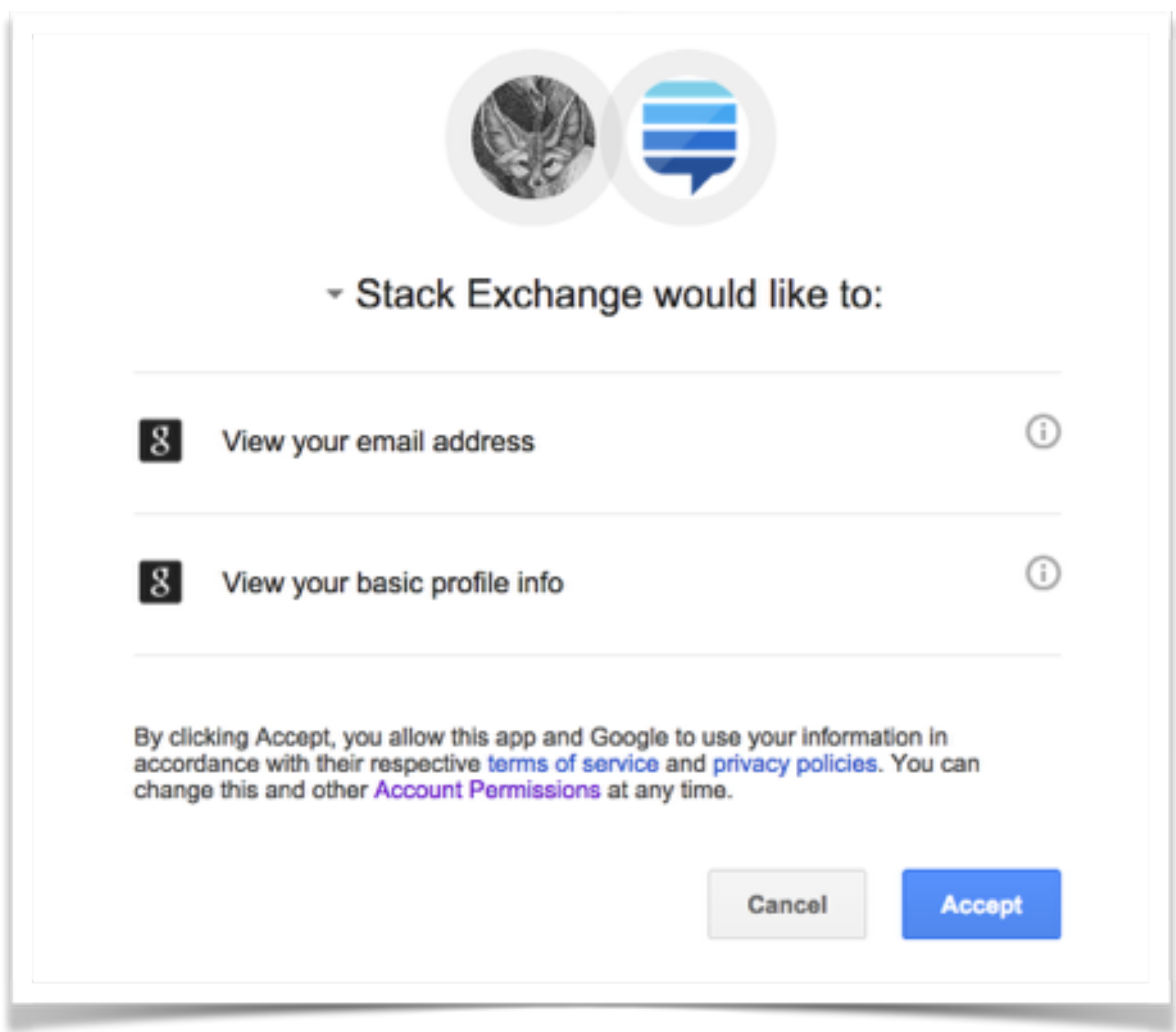

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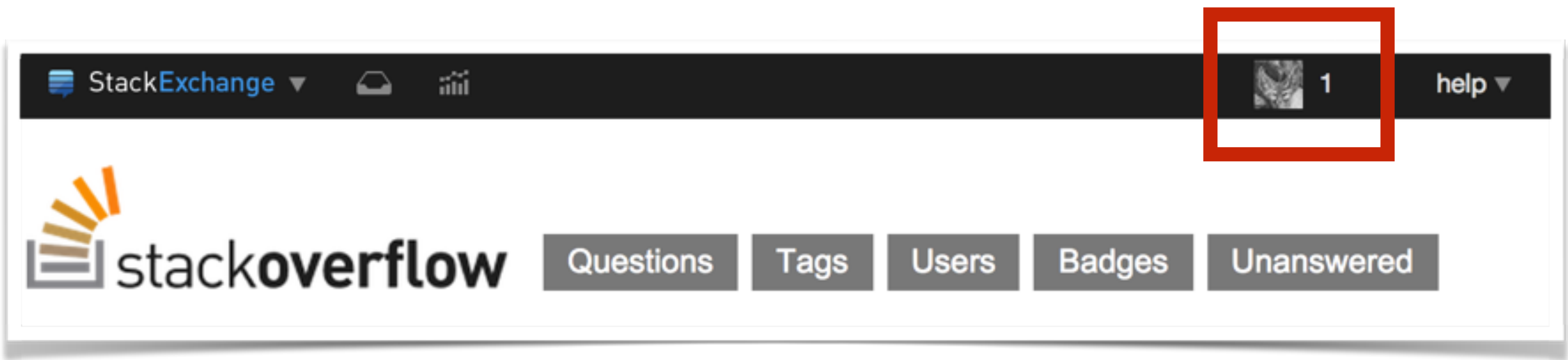

Single Sign-on (SSO) (2)

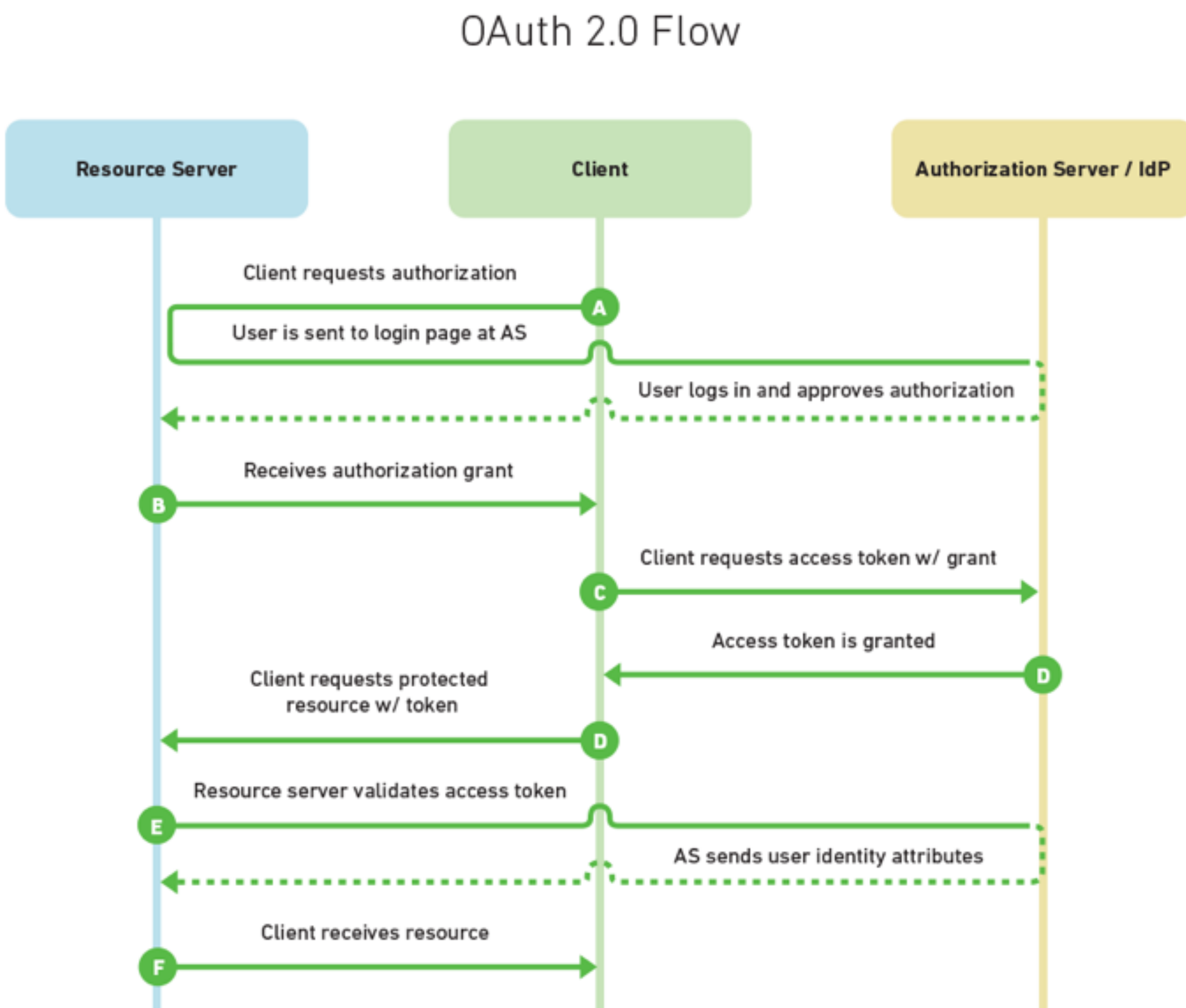

Image by Mutually Human, via http://www.mutuallyhuman.com/blog/2013/05/09/choosing-an-sso-strategy-saml-vs-oauth2/.

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- Vulnerabilities are prolific
  - Wang et al. identified five vulnerabilities in which an attacker can impersonate a user [Oakland ’12].
  - Sun et al. show that 6.5% of relying parties are vulnerable to impersonation attacks [CCS ’12].

Threat Model - Concepts

- Identity provider (IdP)
  - A centralized identification service
  - Trusted and benign
- Relying party (RP)
  - A third party using the IdP to authenticate users
  - Potentially malicious
- User
  - Wants to use the RP's service
  - Trusted and benign

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GET https://www.idp.com/login?
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next_url=https://www.rp.com/login

Host: www.idp.com

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- In-scope
  - Benign RP initiates request, malicious RP receives response
  - Malicious RP initiates the attack

⇒ Information leakage or user impersonation!

Threat Model - Attacks (2)

- Out-of-scope
  - Social engineering
  - Compromised or vulnerable RP
  - Malicious user (browser)
  - Implementation issues
  - Privacy leaks

Revisit - Identities

- Existing identities
  - IdP, usually web origin (<scheme, host, port>)
  - RP, unique identifier, depending on protocol, app_id or AppName
  - User, unique identifier like username or email address

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Main issue: RP identifier can be forged.

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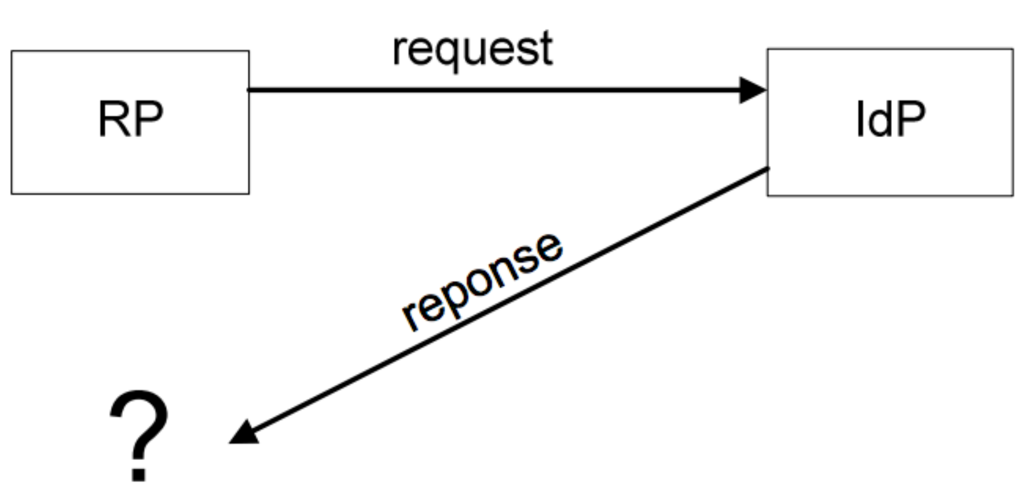

Revisit - Communication

- Communication between RP and IdP
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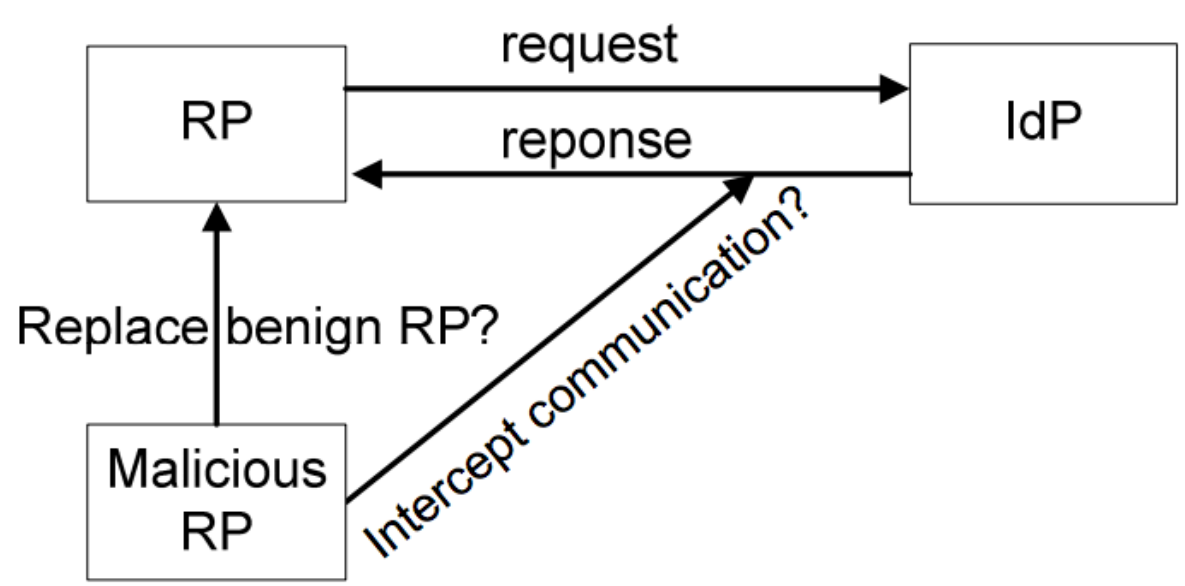
  - In-browser communication channel (no authentication)

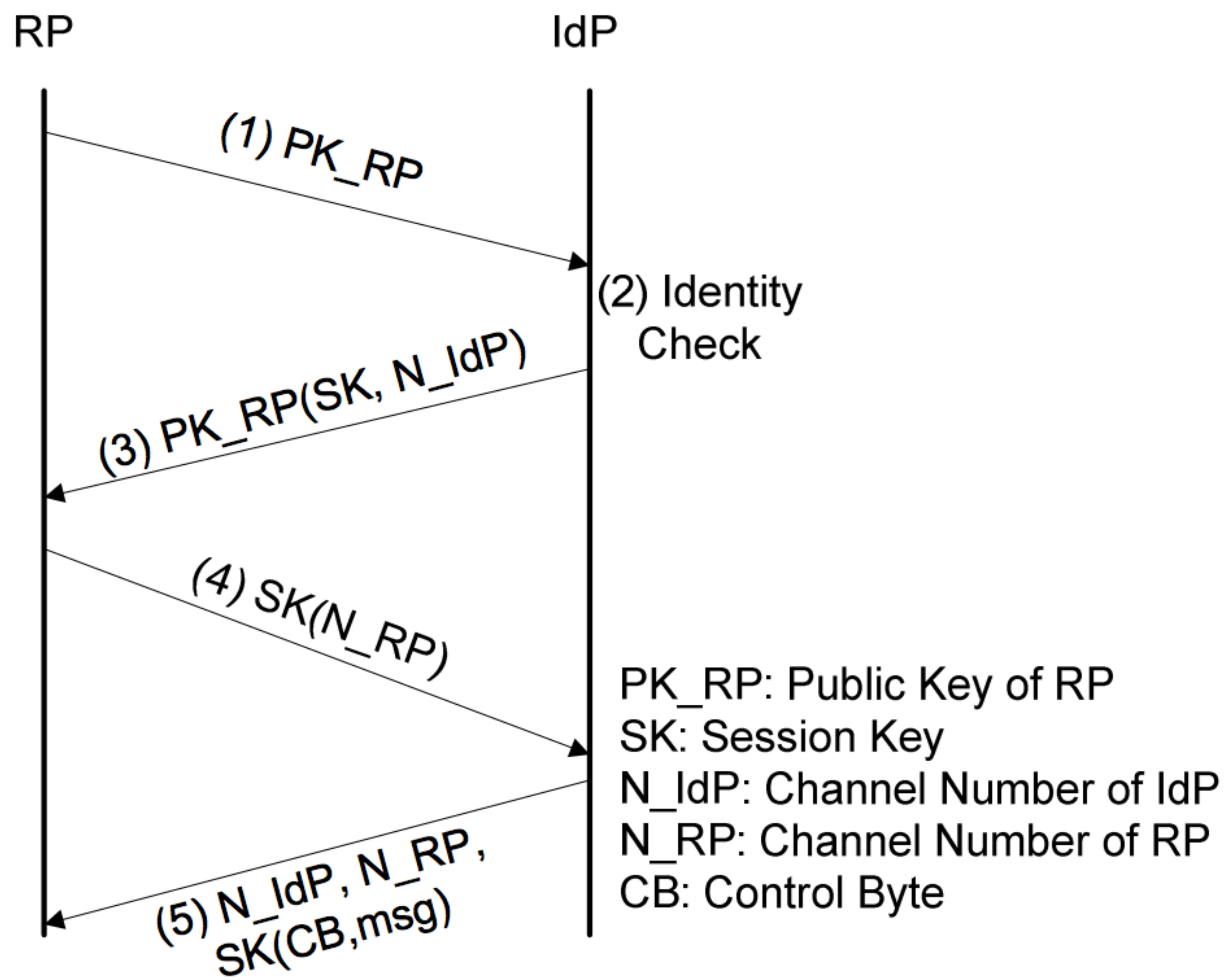


Identity Provider Deployment (1)

- Clean-slate design, replaces existing protocols
  - Identity
    - Web origin for RP and IdP: <scheme, host, port>
  - Communication channel
    - Dedicated
    - Bi-directional
    - Authenticated
    - Secure

Identity Provider Deployment (2)

- Establishing the channel: handshake



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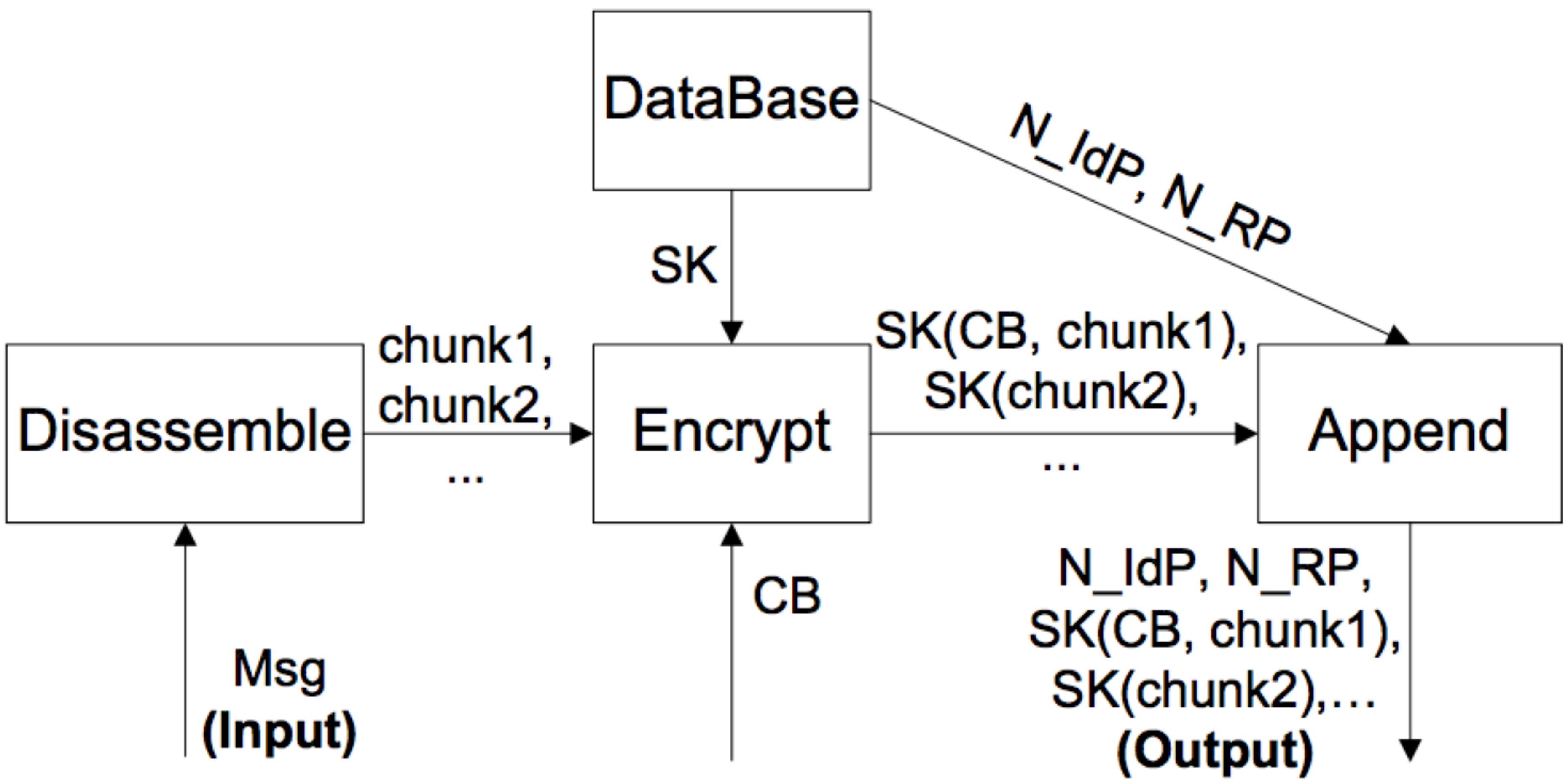

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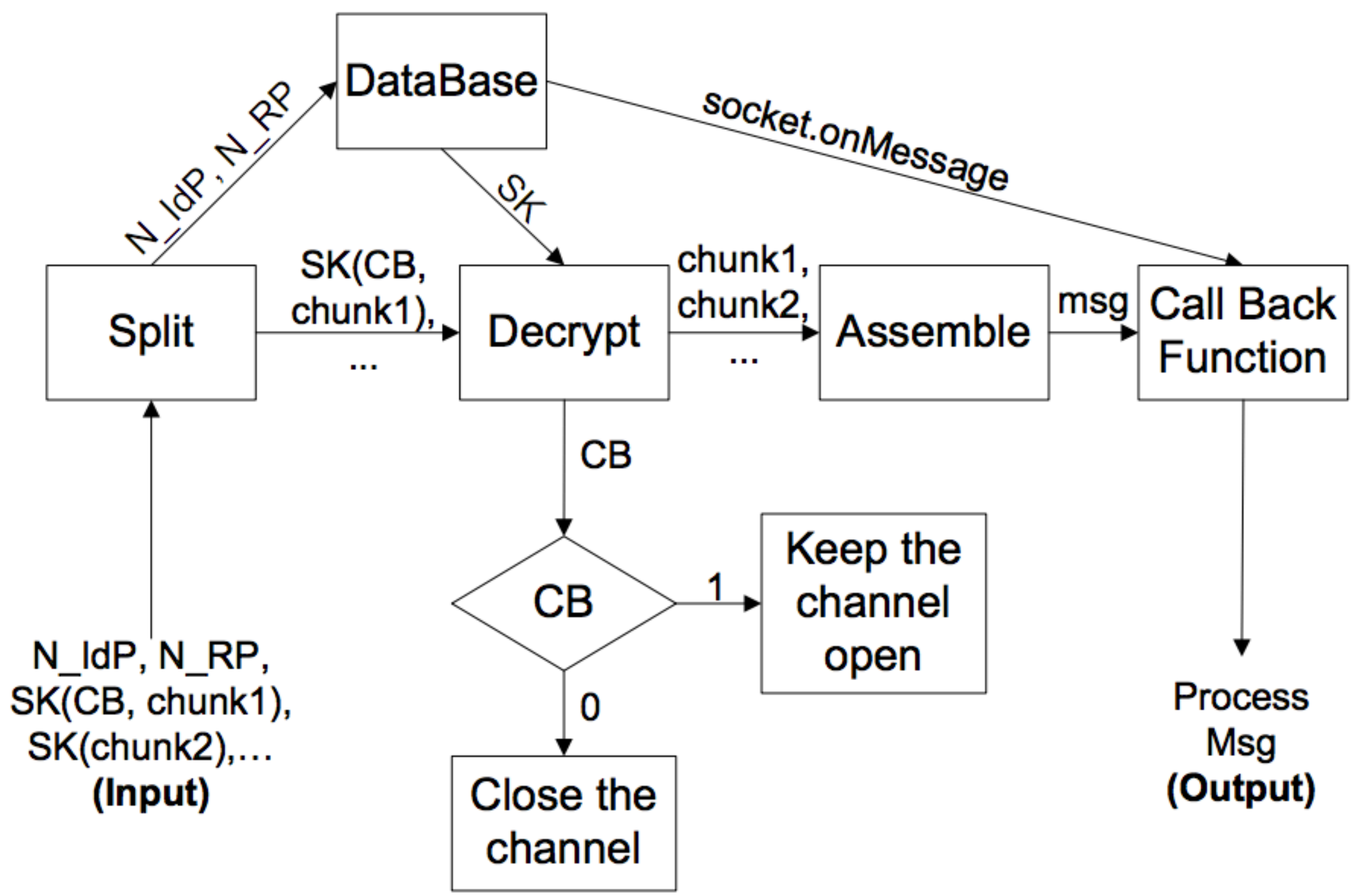

Identity Provider Deployment (2)

- Establishing the channel: handshake
- Sending messages
- Receiving messages
- Terminating the connection: releasing resources

Relying Party / Proxy Deployment

- Allows smooth transition to more secure protocol
  - Does not require you to replace existing protocol
- Proxy communicates with legacy IdP
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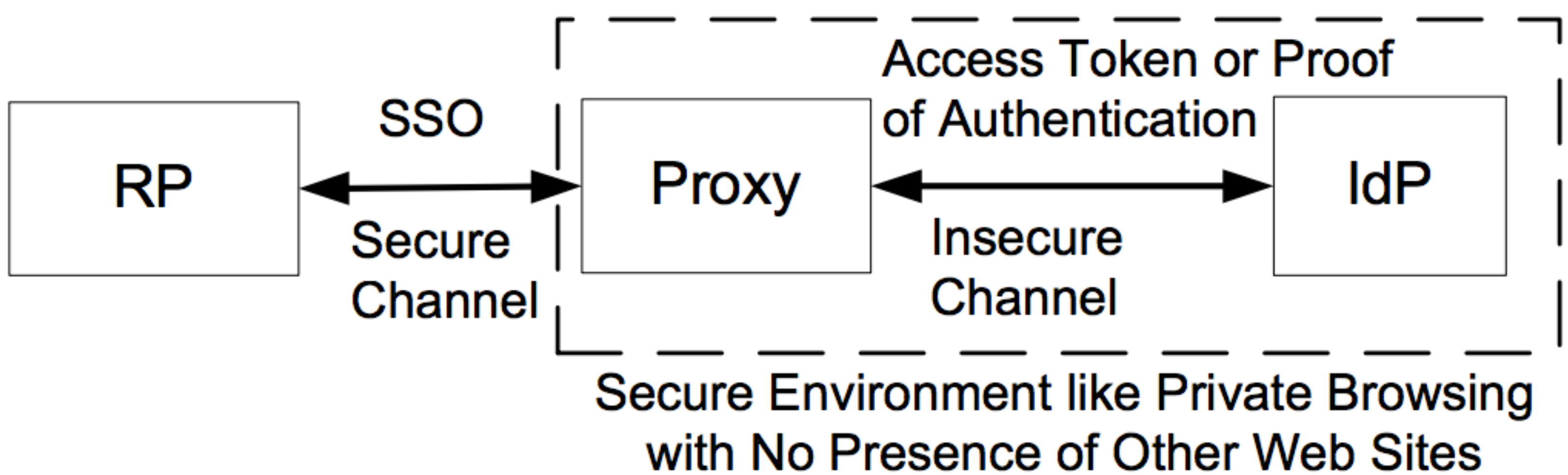

Implementation

- Prototype implementation
  - Clean-slate / IdP deployment
    - Two protocols: OpenID-like and OAuth-like
    - 252 LOC JavaScript, 264 LOC HTML, 243 LOC PHP
    - External libraries: JavaScript Cryptography Toolkit + Stanford JavaScript Crypto Library
  - Proxy / RP deployment
    - Based on a Facebook application

Evaluation - Formal Verification

- Formally verified design with ProVerif
  - Channel verification
    - Attacker: passive (sniffing), active (sending messages)
    - Result: an attacker cannot obtain the plain text message
  - Protocol verification
    - Attacker: network (passive) and web attackers (active)
    - Result: an attacker cannot obtain any useful information
  - Proxy verification
    - Attacker: passive (sniffing), active (sending messages)
    - Result: an attacker can obtain and modify the messages sent over the insecure communication channel between proxy and legacy IdP

Evaluation - Security Analysis

- Our protocol prevents all impersonation attacks identified by Wang et al. [Oakland ’12]:
  - Facebook and New York Times
  - Facebook and Zoho
  - Facebook Legacy Canvas Auth
  - JanRain wrapping GoogleID
  - JanRain wrapping Facebook

Evaluation - Performance

Channel operation

Operation	Delay [ms]
Establishing the channel	164±12
Sending a message	32±2
Destroying a channel	70±3

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Establishing the channel

Operation	Delay [ms]
Message #1: PK_RP	92±9
Message #2: PK_RP(SK, N_IdP)	29±2
Message #3: SK(N_RP)	43±3

Evaluation - Performance

Detailed breakdown of the protocol

Operation	Delay [ms]
(1) Creating the channel between RP and IdP	164±11
(2) Creating the IdP inline frame	57±3
(3) Sending the first message from RP to IdP	32±2
(4) Creating the IdP inline frame for authentication	57±3
(5) Creating the second channel inside the IdP	165±11
(6) Authenticating the user	56±4
(7) Requesting the user’s permissions	57±3
(8) Sending the token inside the IdP’s inline frame	32±2
(9) Sending the token to the RP	33±2
Total	**653±21**

(2), (4), (6), and (7) are dominated by network latency, which is 50ms here.

Conclusion

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- Proposed a dedicated bi-directional secure channel to remedy existing short-comings
- Designed SSO protocol on top of channel design
- Presented a proxy design for easy adoptability
- Formally verified security of the SSO protocol
- Evaluated protocol performance / overhead

Thank you for your attention!

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Questions?

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Related Work

seclab

	Deployment	Protection Crowd	Preventing Impersonation Attacks	Proactive Deployment
InteGuard	IdP, Gateway	IdP Users, physical machines	✓	✗
AuthScan	IdP	IdP Users	✓	✗
Explicating SDKs	IdP	IdP Users	✓	✗
Defensive JavaScript	IdP, RP	IdP Users, RP Users	✗	✓
WebSSO (our work)	**IdP, RP**	**IdP Users, RP Users**	✓	✓