Hardening Persona: Improving Federated Login on the Web

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and
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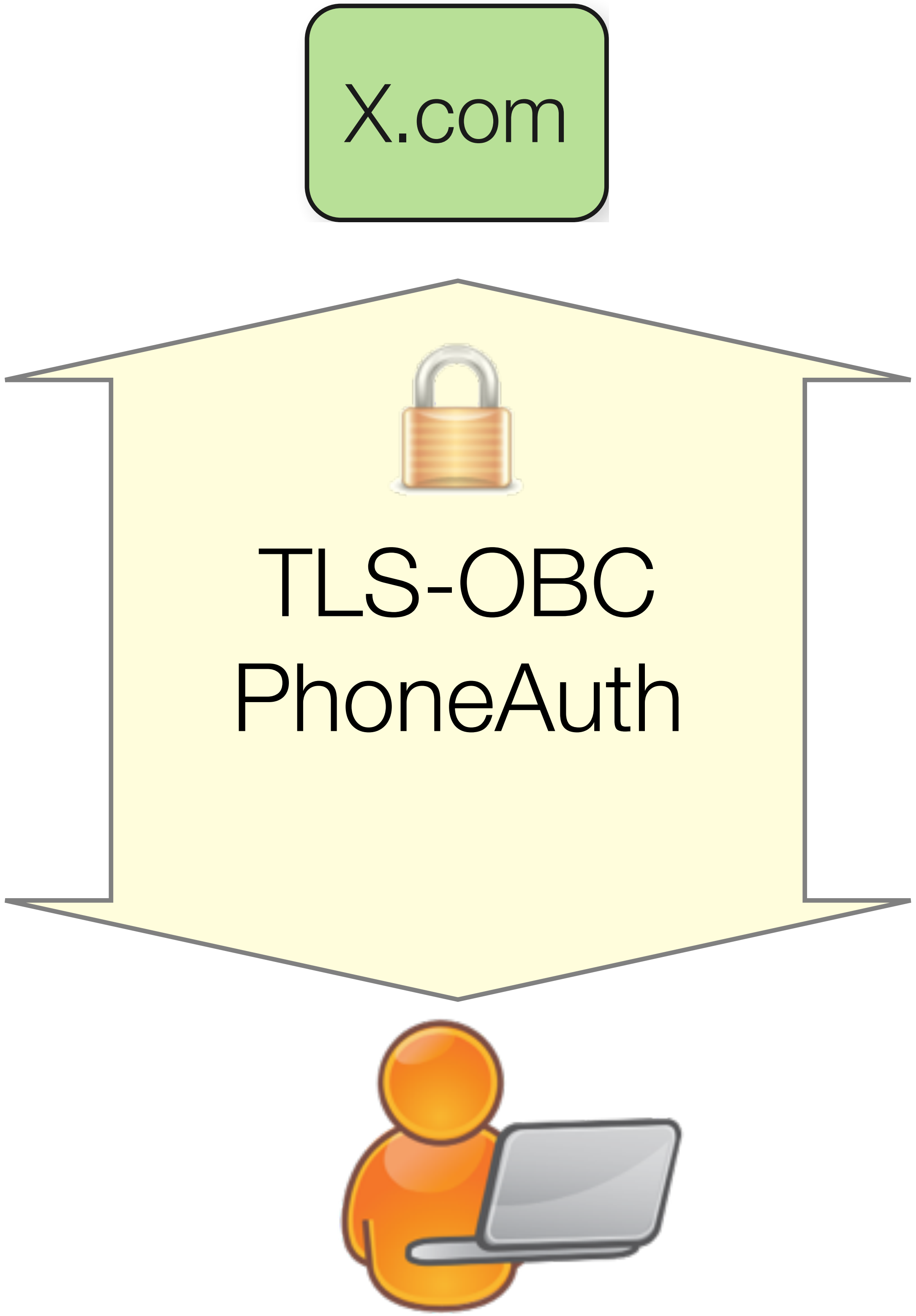
RICE
Unconventional Wisdom

COMPUTER SECURITY LAB
Rice University

Motivation



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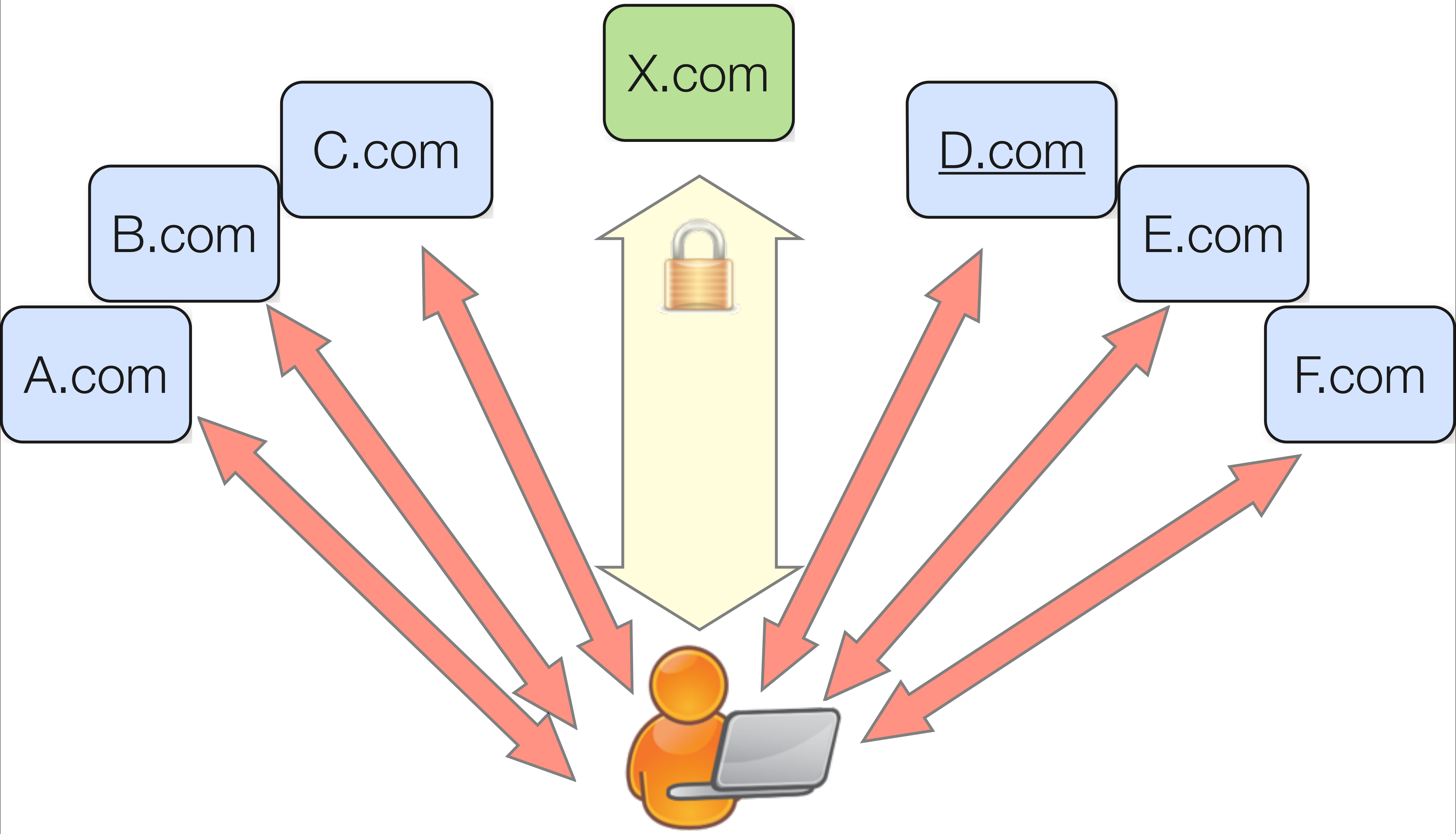

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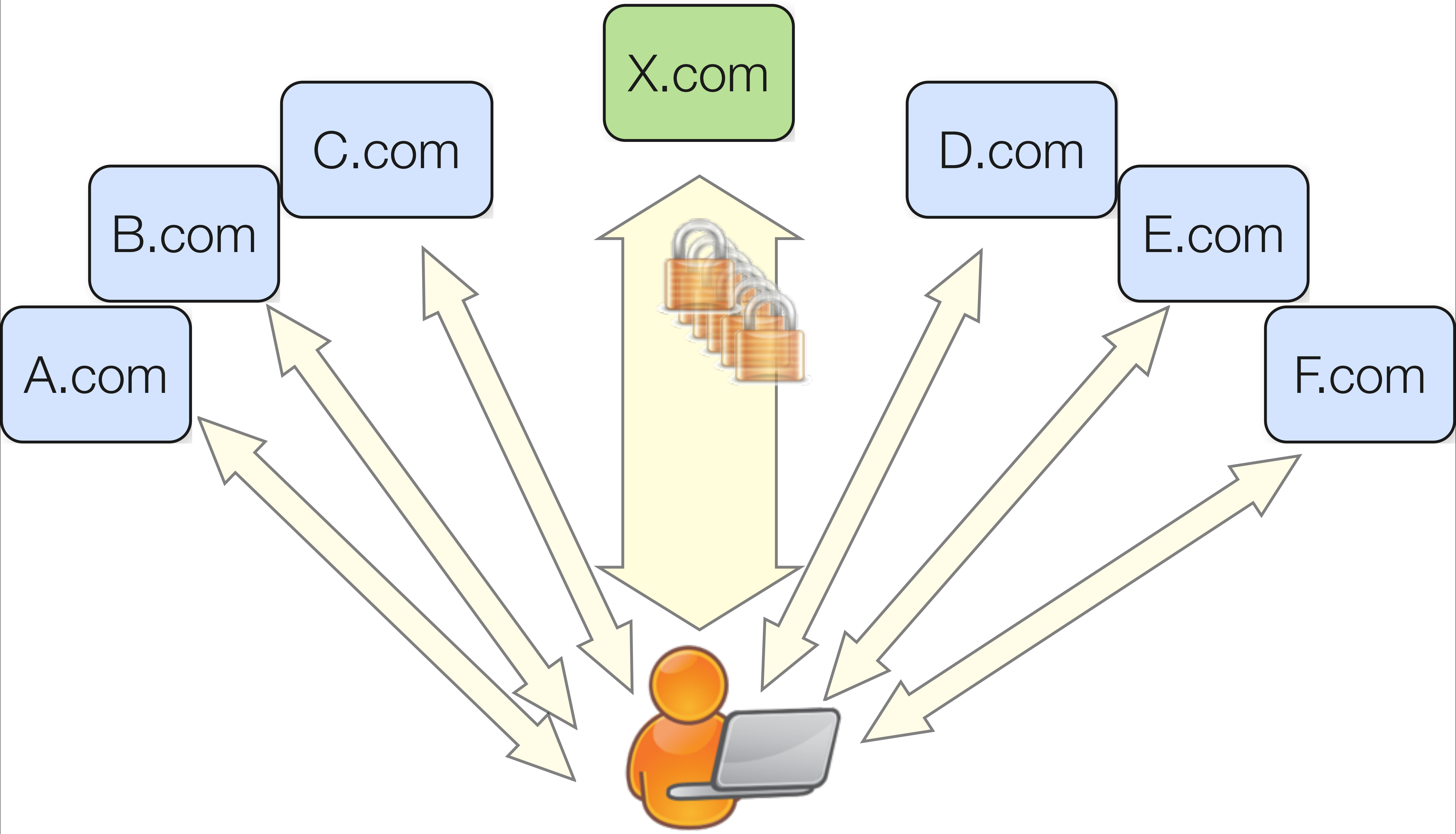

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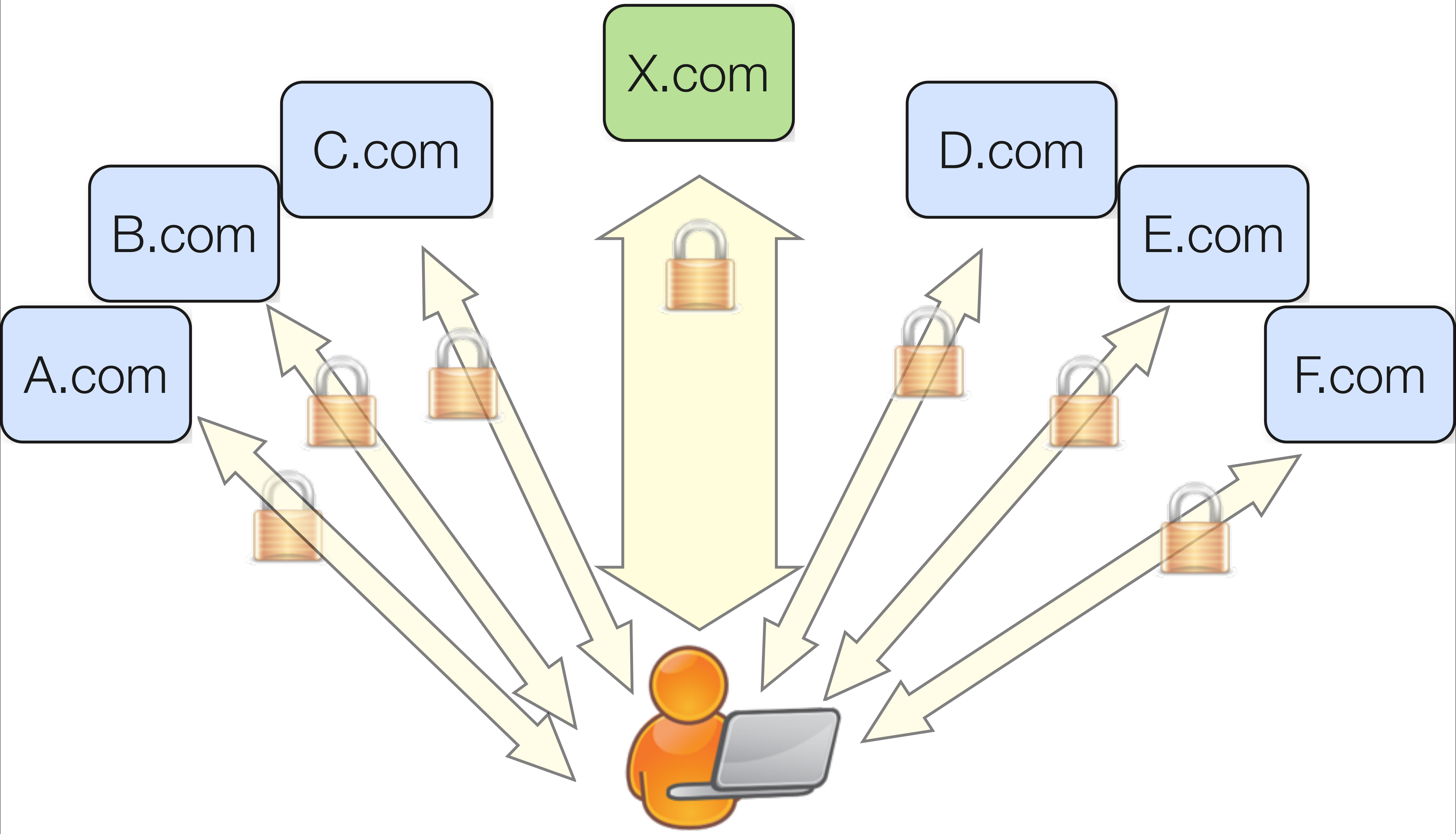
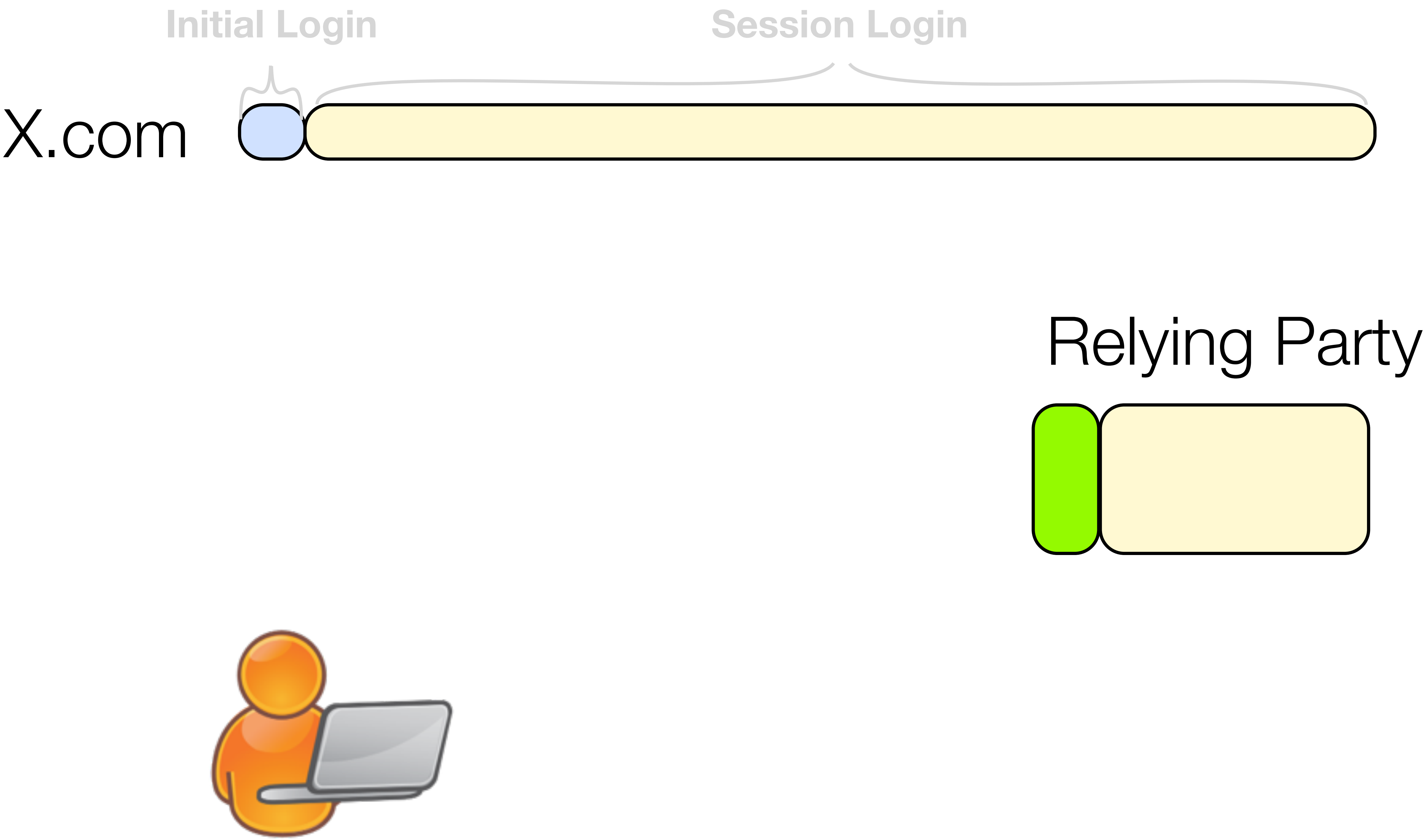


Existing federated login protocols

- SAML
- OpenID
- Persona (BrowserId)
- OAuth
- OAuth2 / OpenIdConnect
- Kerberos

Persona Overview



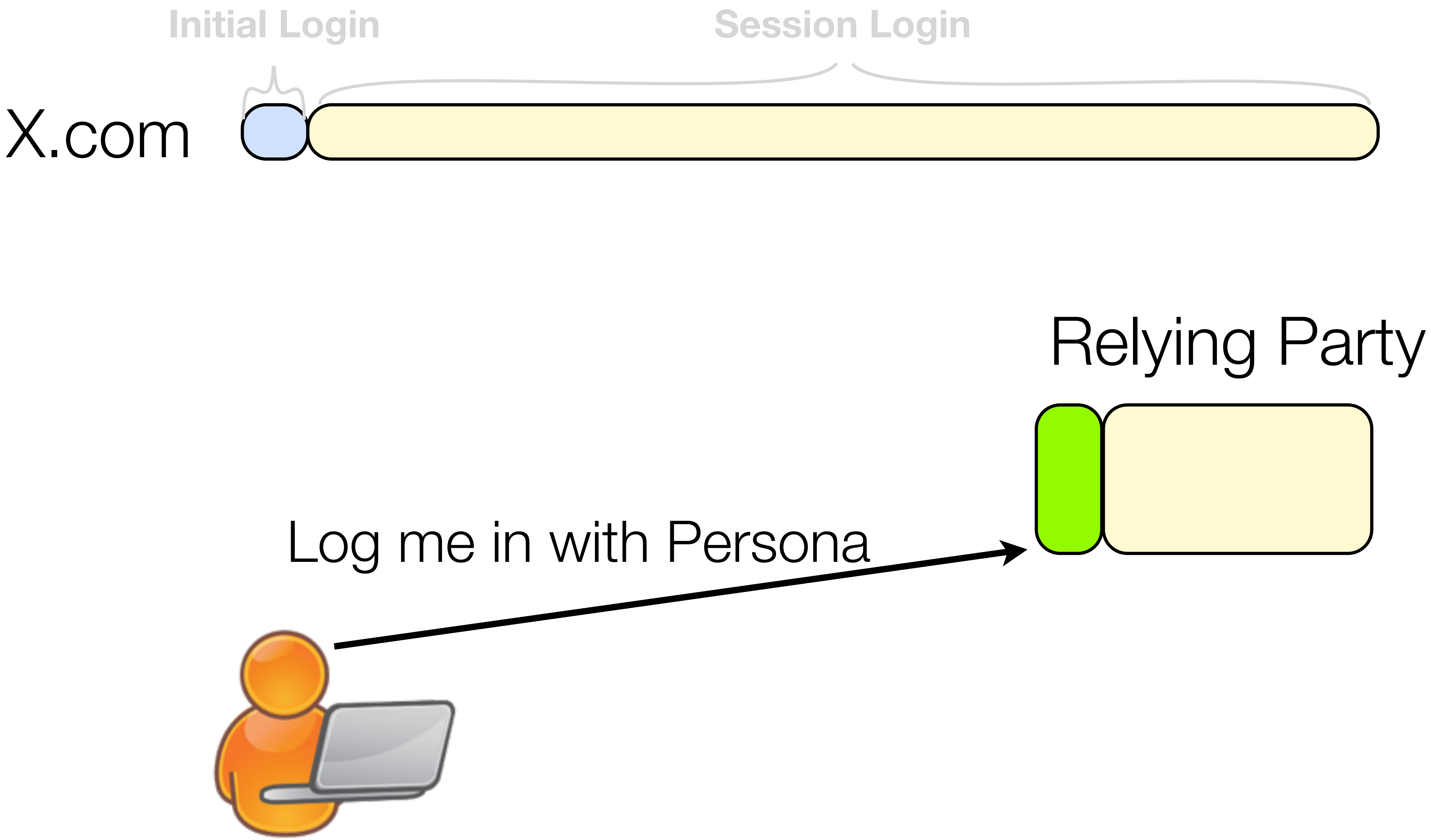
Initial Login

Session Login

X.com

Relying Party

Persona Overview



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Log me in with Persona

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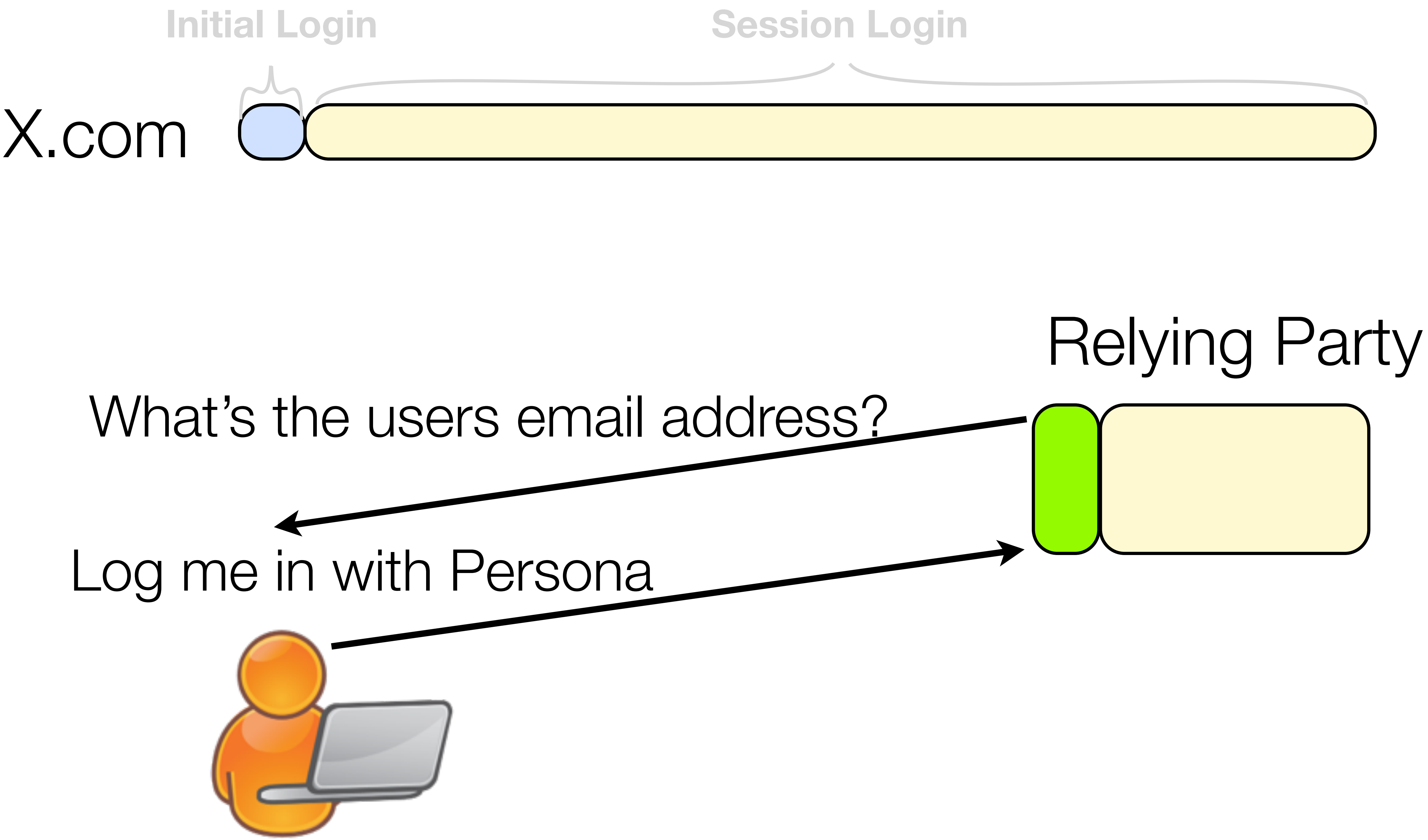

Initial Login

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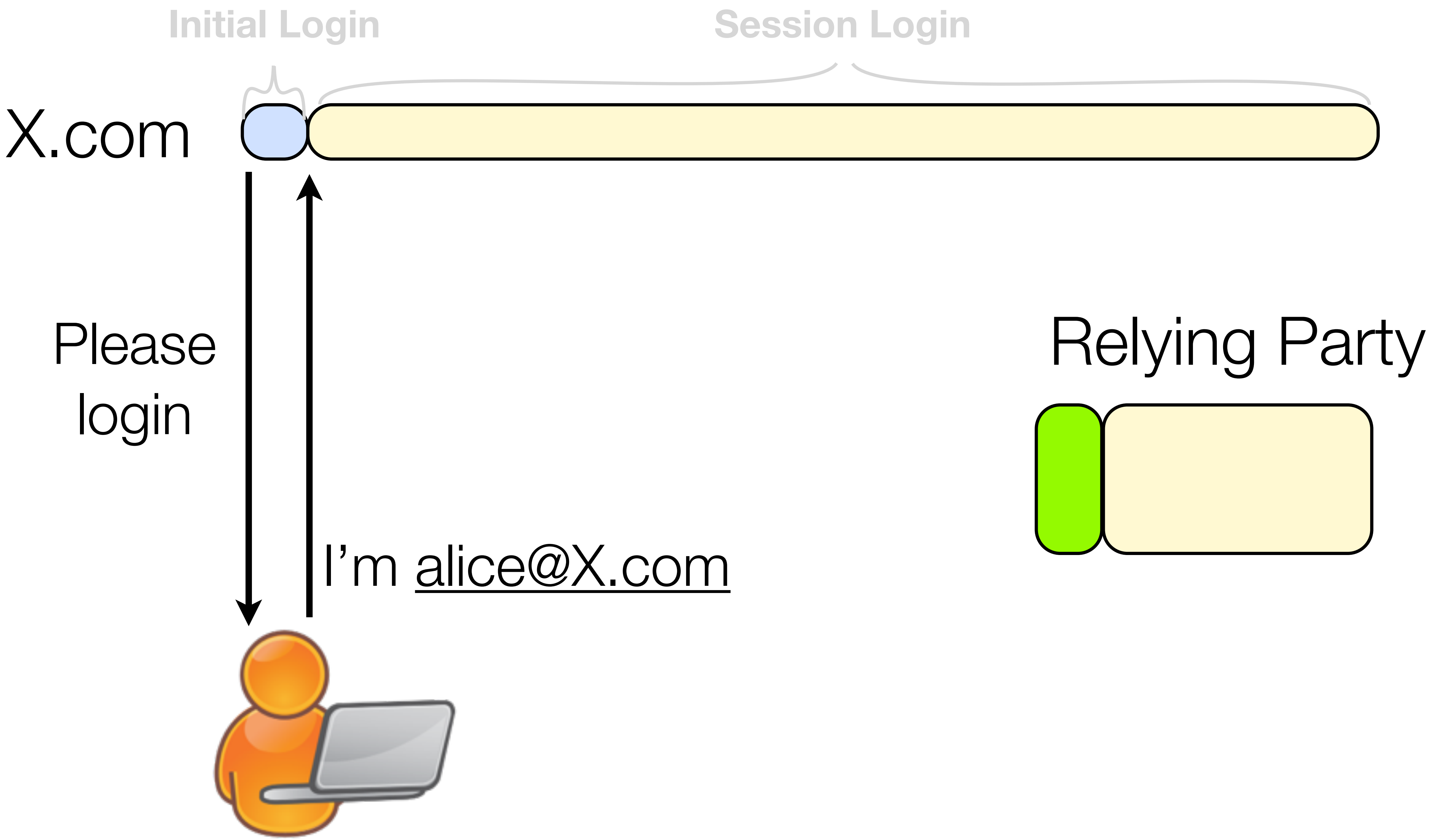
Relying Party

What’s the users email address?

Log me in with Persona

Persona Overview



Initial Login

Session Login

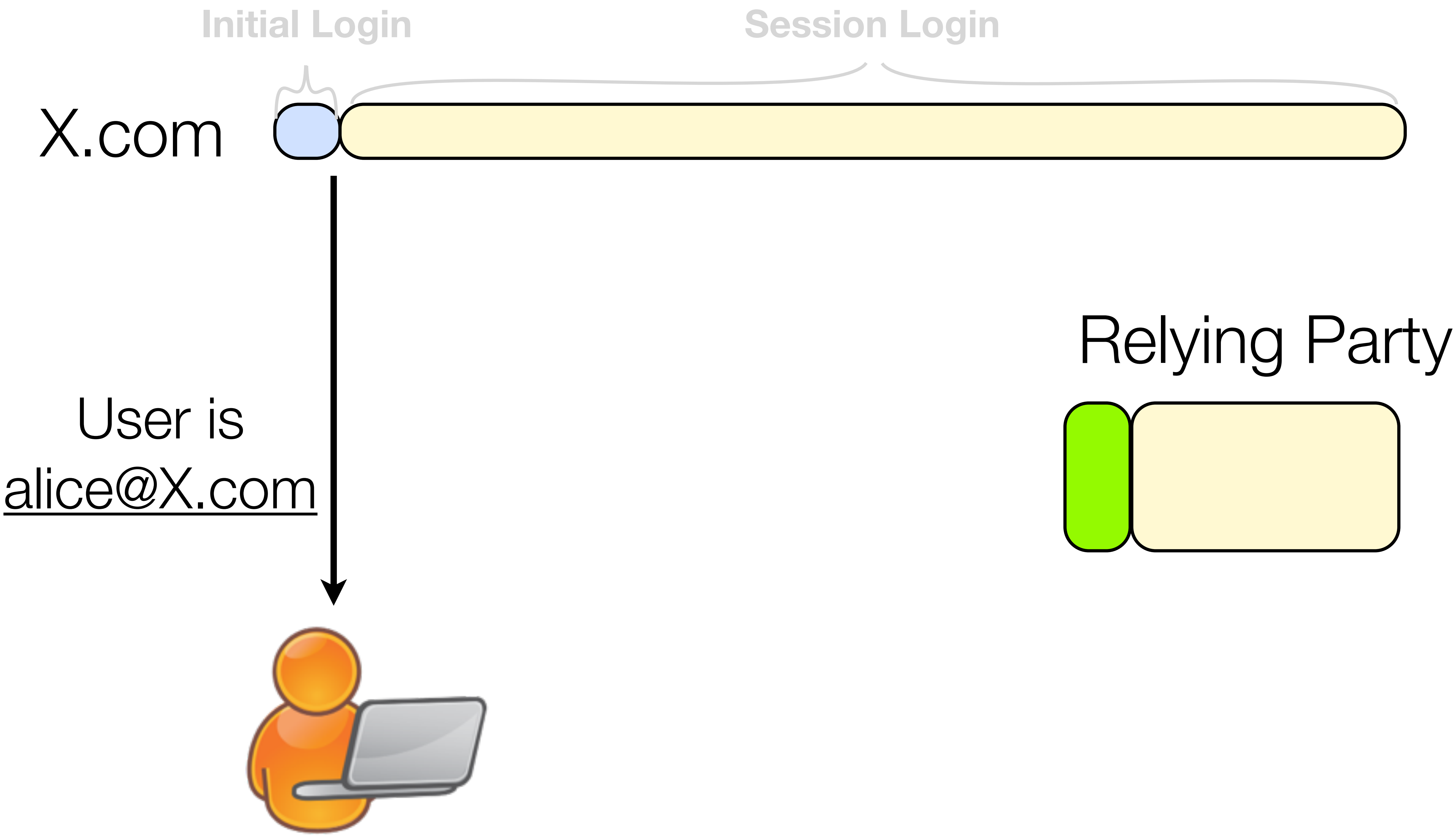
X.com

Please login

I’m alice@X.com

Relying Party

Persona Overview



Initial Login

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X.com

User is alice@X.com

Relying Party

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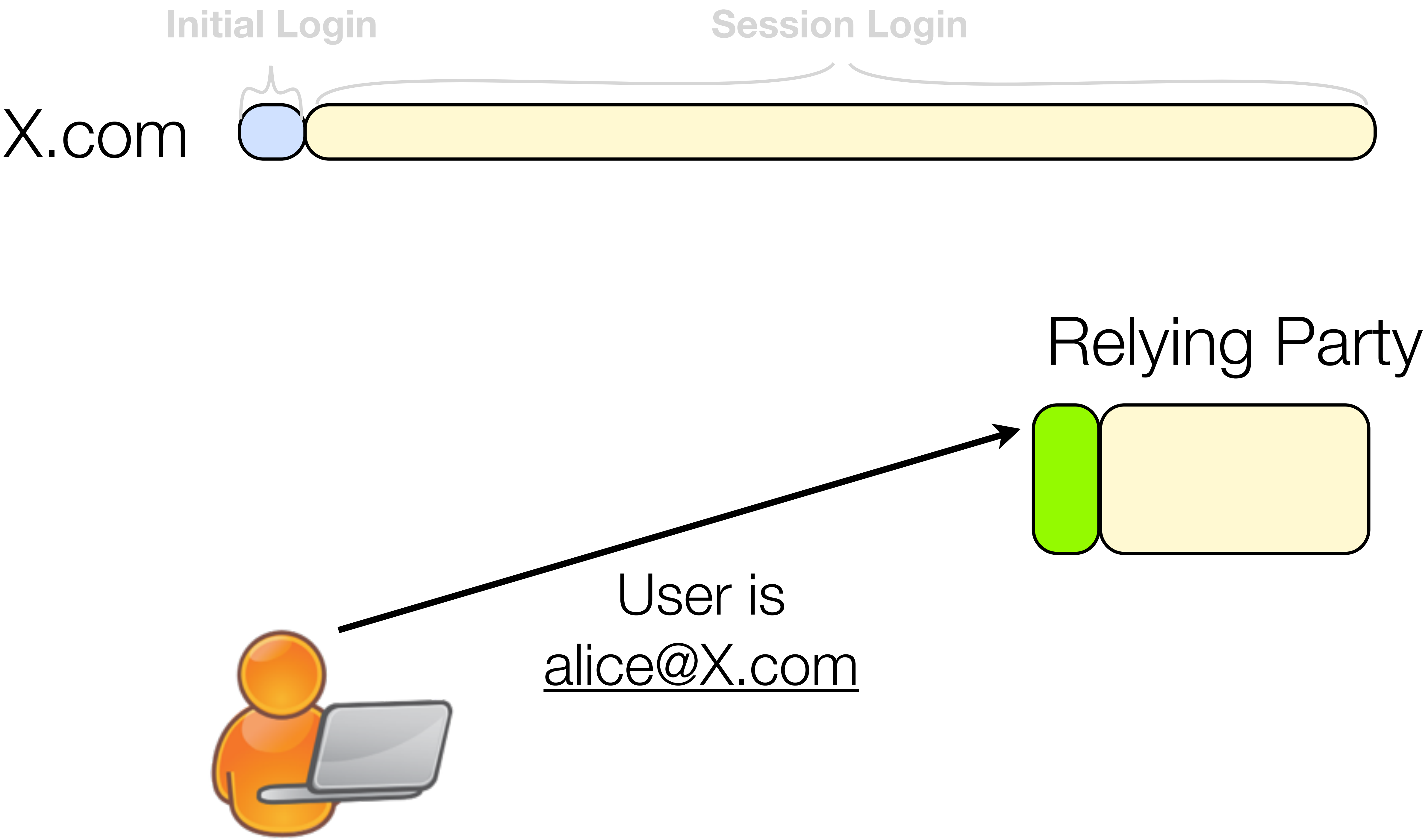

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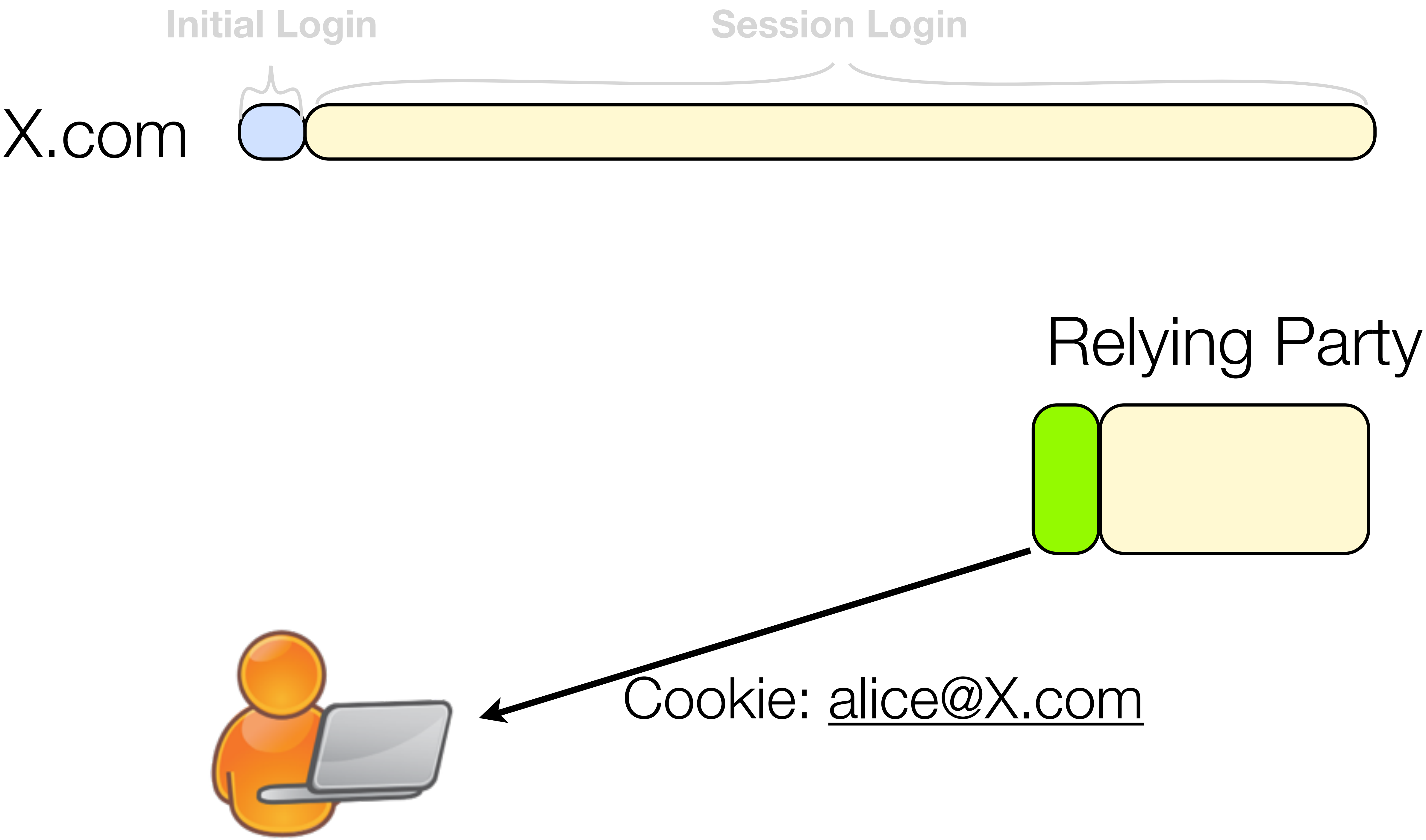


Initial Login

Session Login

X.com

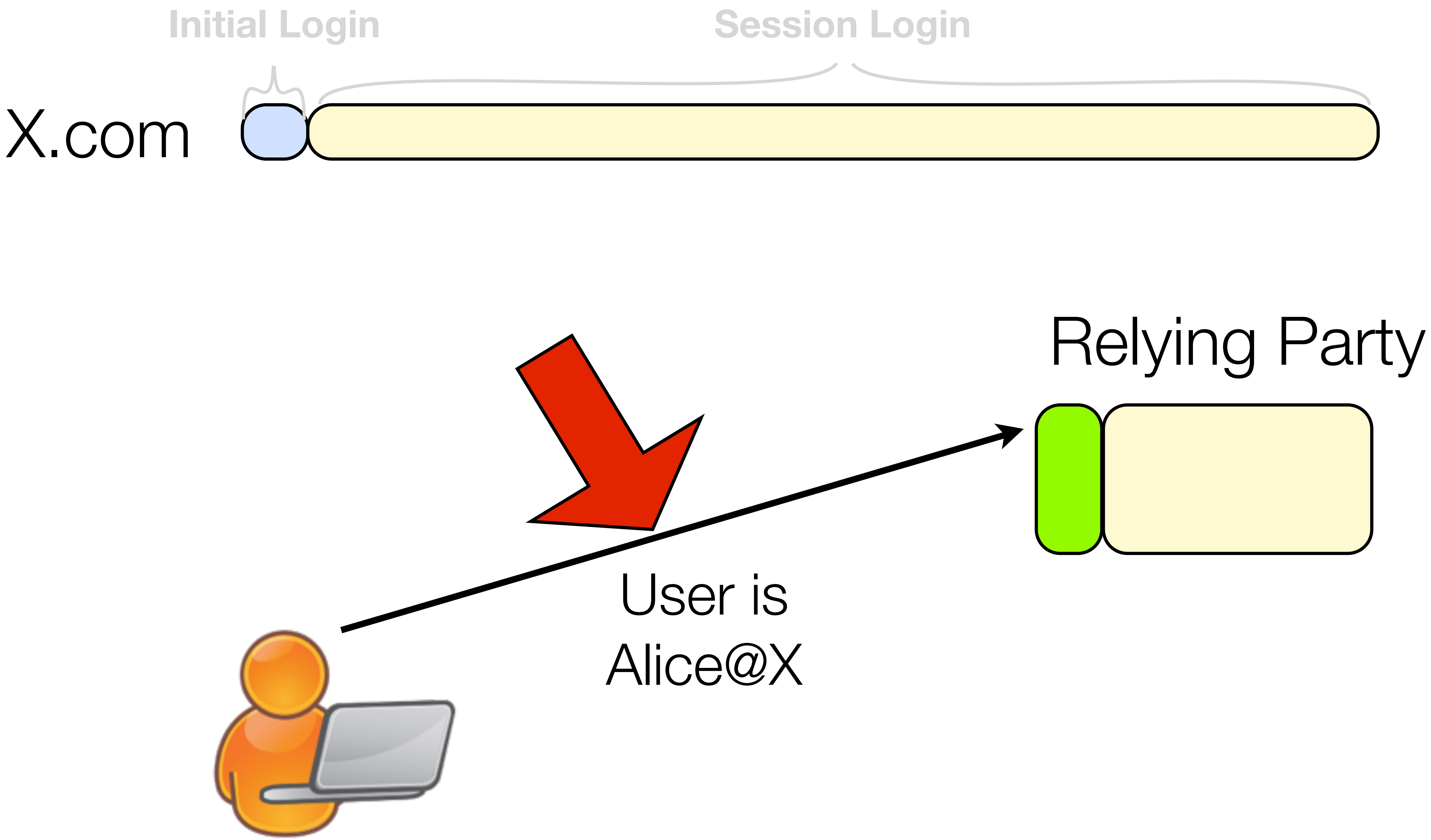
Relying Party

Cookie: alice@X.com

Two areas for attack

- MITM the connection between user and RP
    - Replay identity assertions
- Steal relying party cookie after login

Identity assertion theft



Initial Login

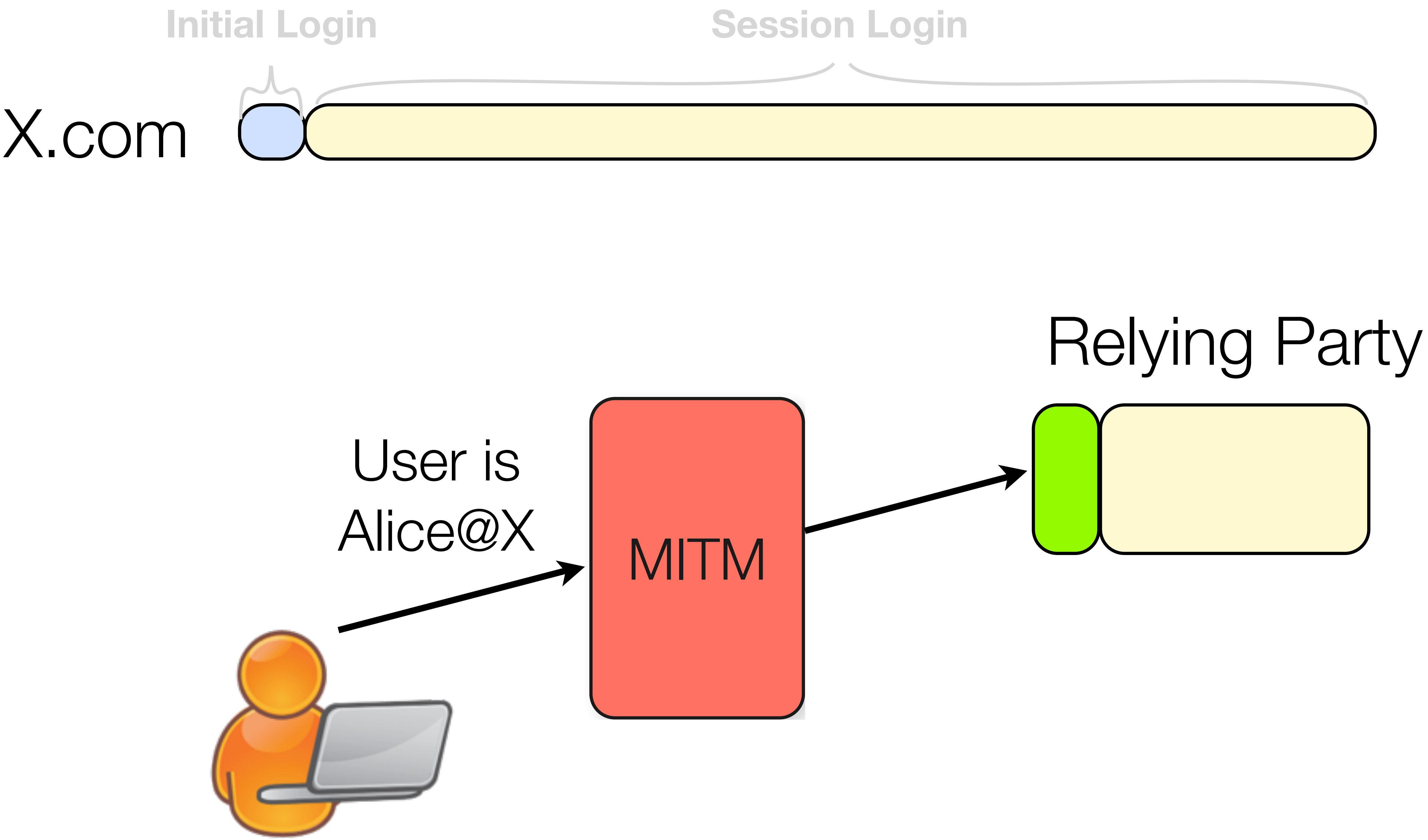
Session Login

X.com

Relying Party

User is
Alice@X

Identity assertion theft



Initial Login

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Relying Party

User is Alice@X

MITM

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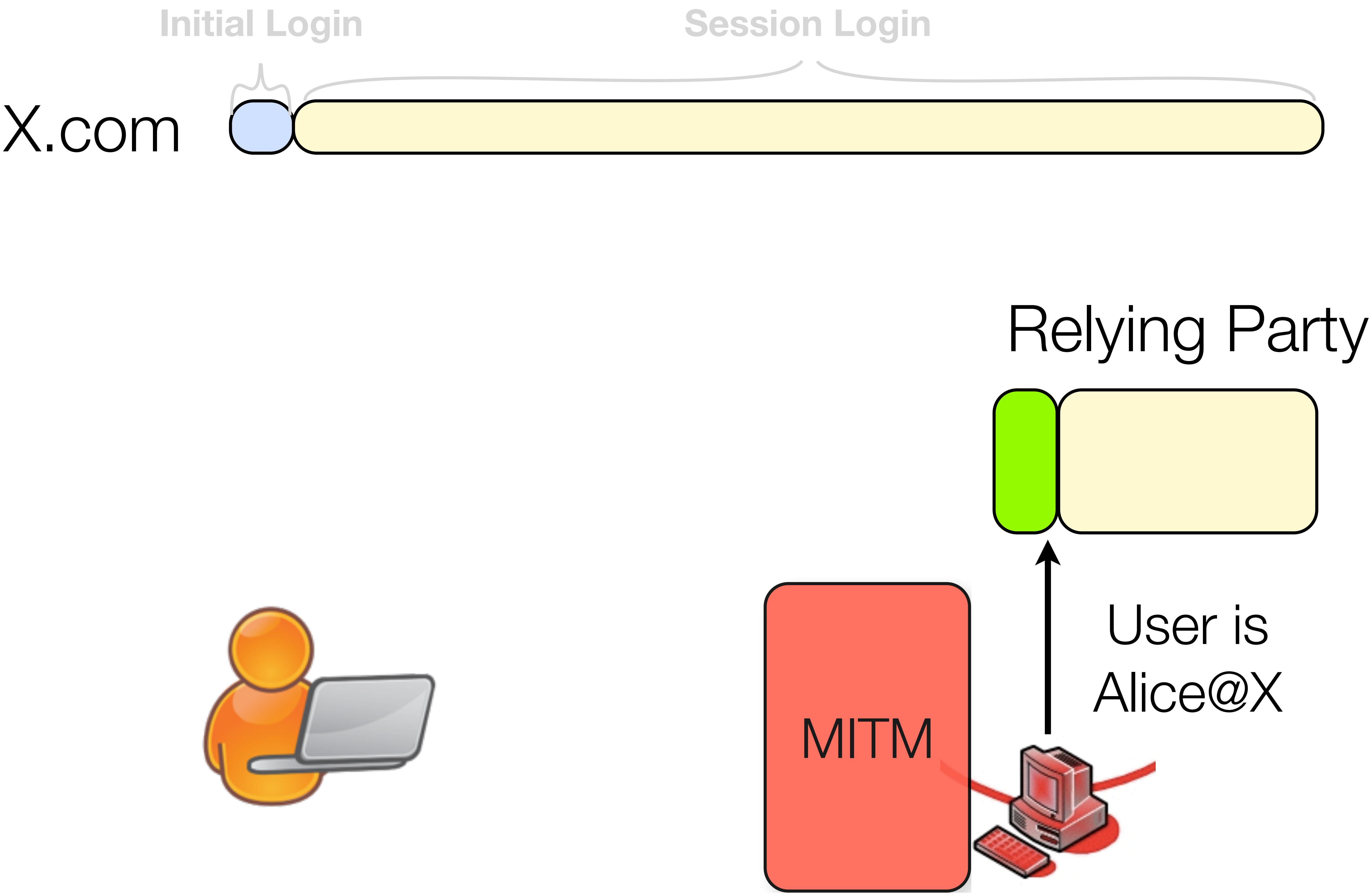

Initial Login

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Relying Party

MITM

User is Alice@X

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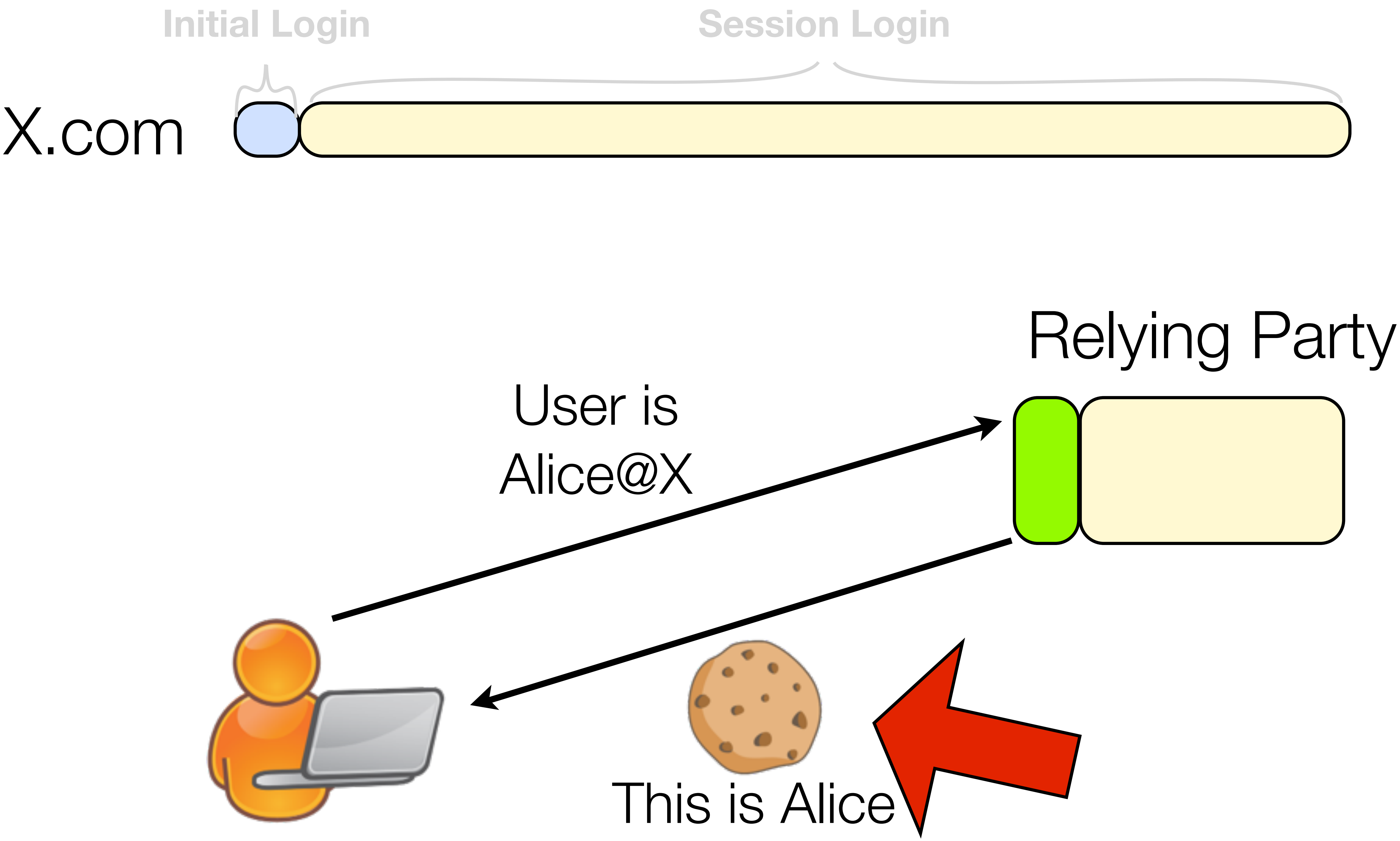
RP cookie theft



Initial Login

Session Login

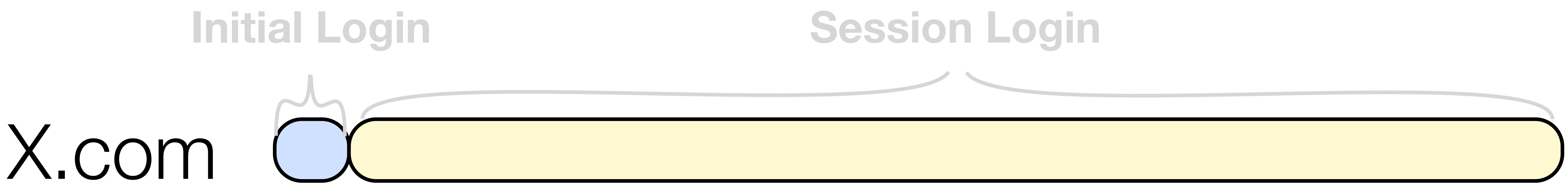
X.com

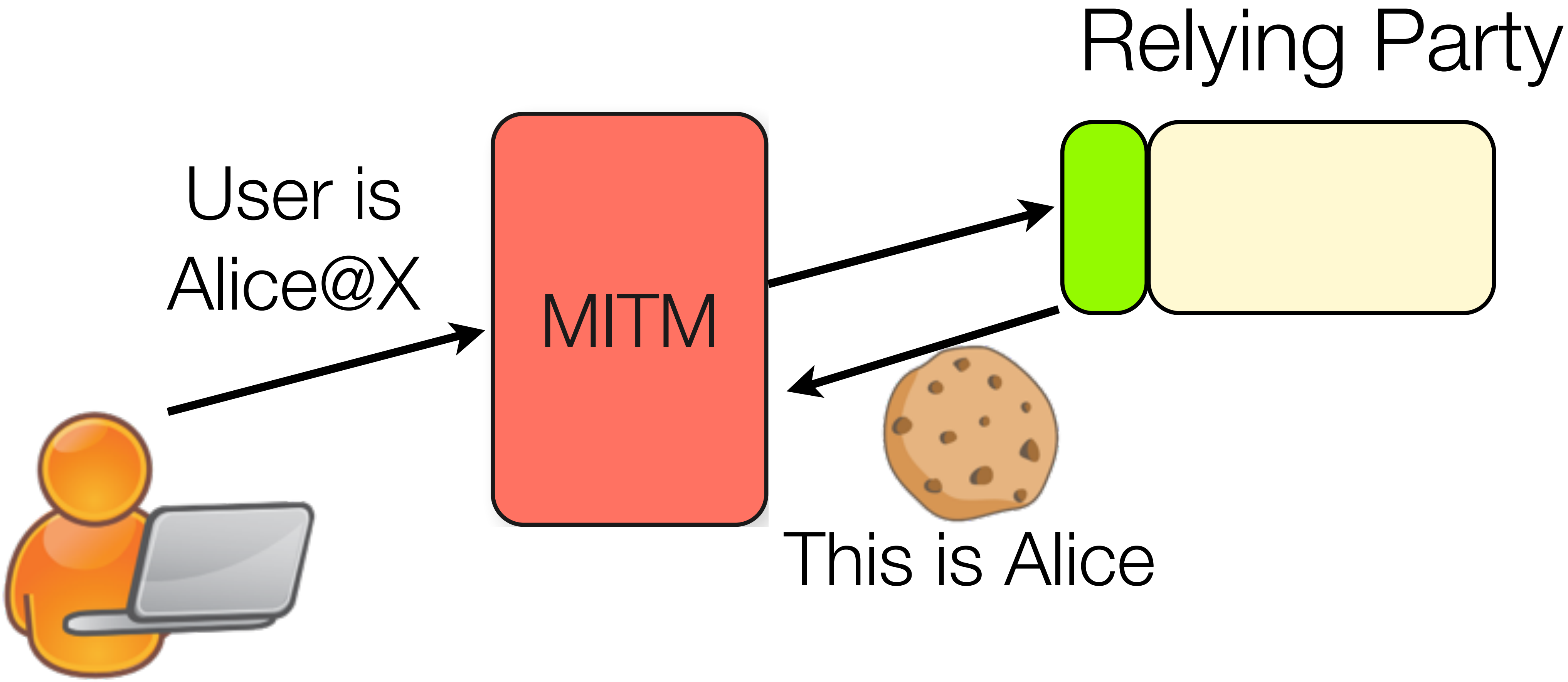
Relying Party

User is Alice@X

This is Alice

RP cookie theft





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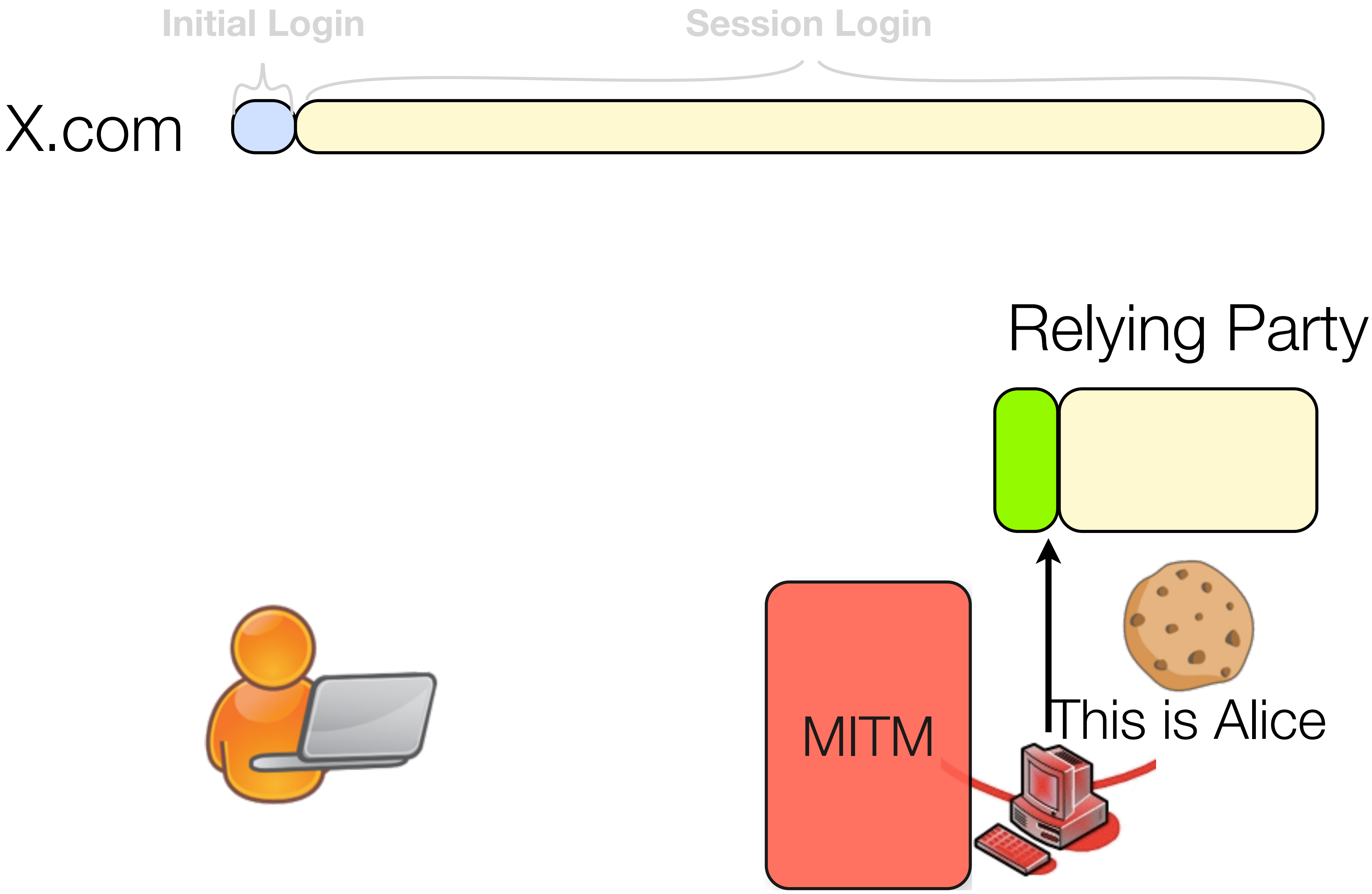


Initial Login

Session Login

X.com

Relying Party

MITM

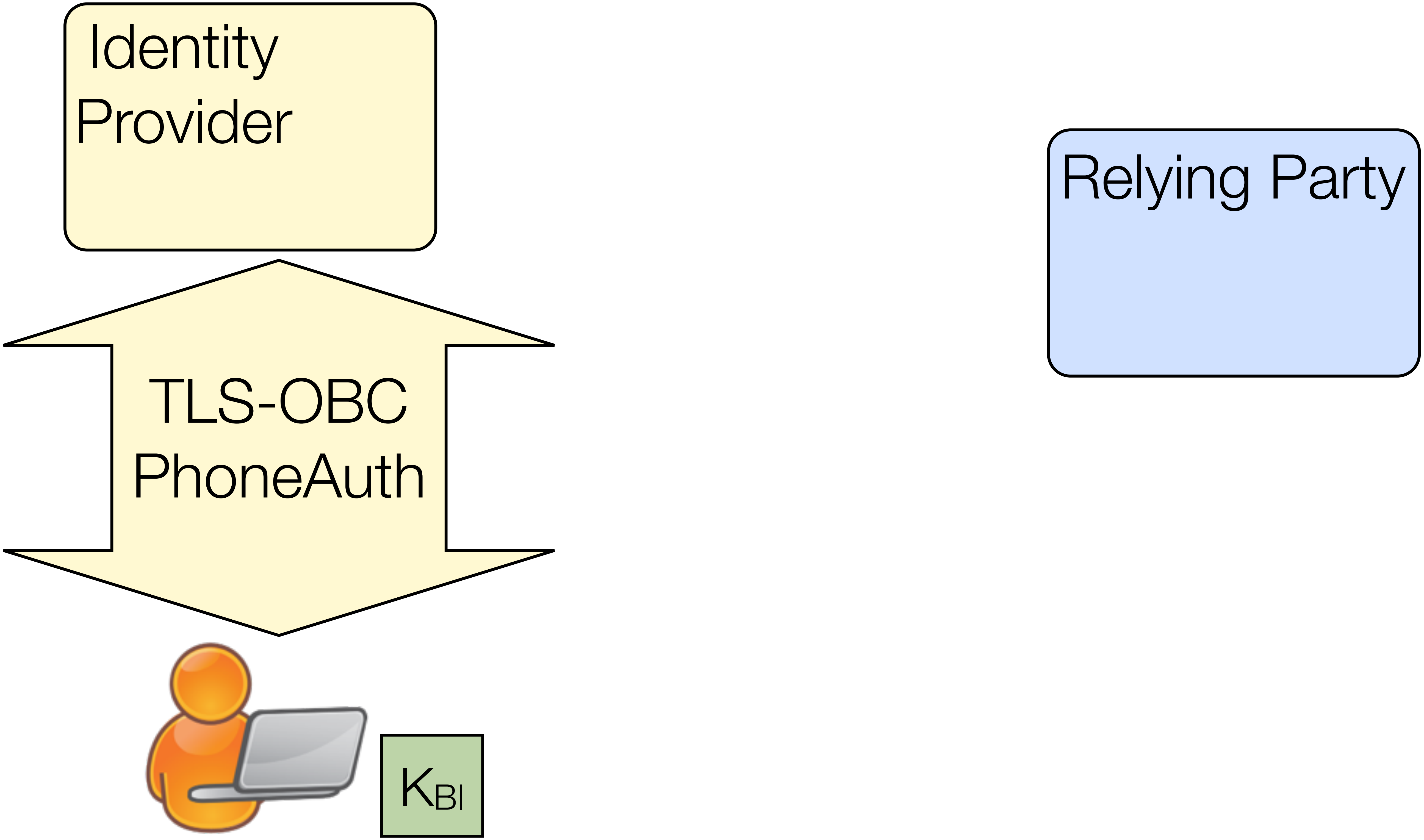
This is Alice

Extensions to Persona

Design Goals

- Strengthen identity assertions against MITM theft
- Allow relying parties to establish a key for communication with the user

Initial Assumptions



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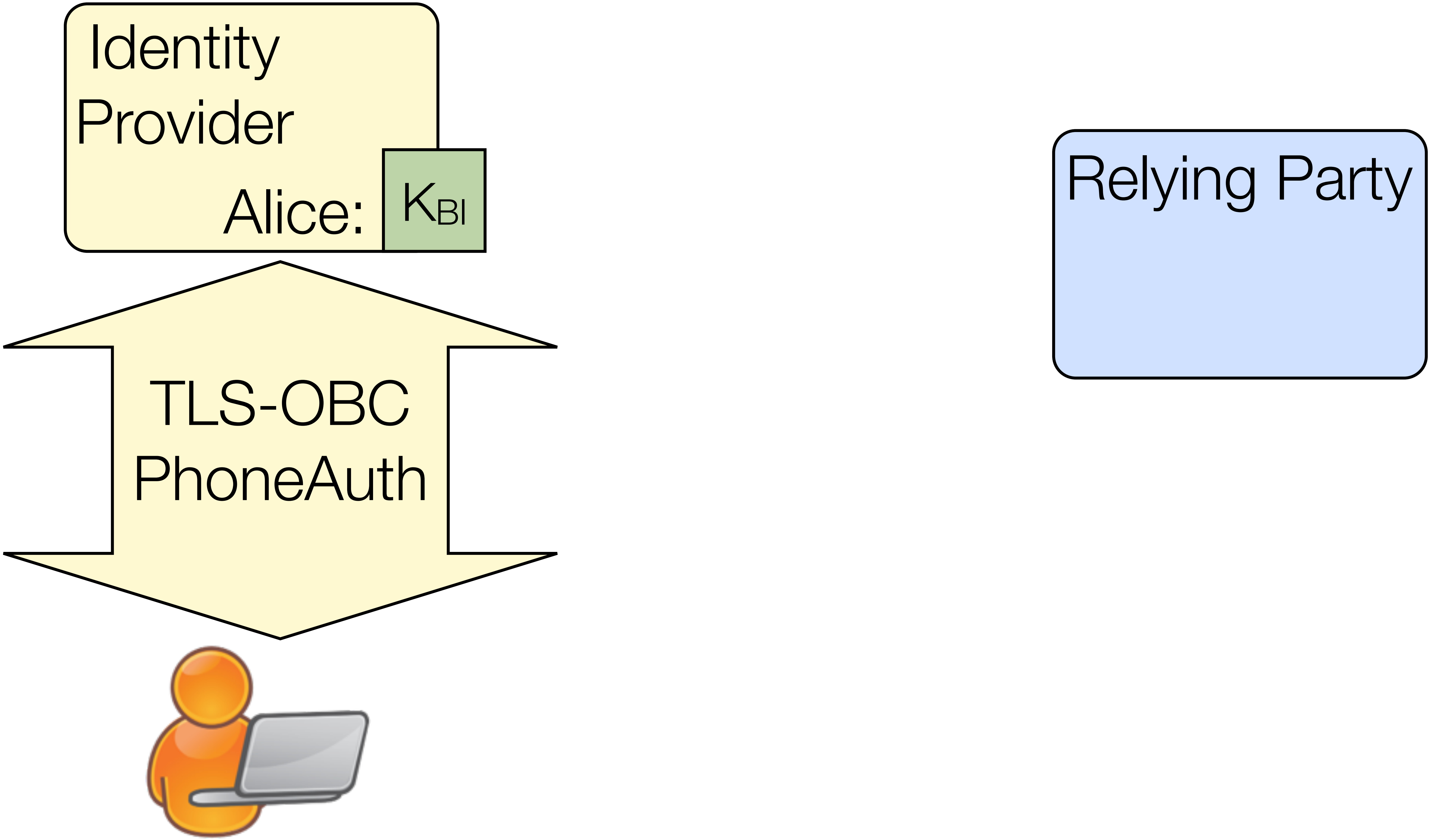


Identity Provider

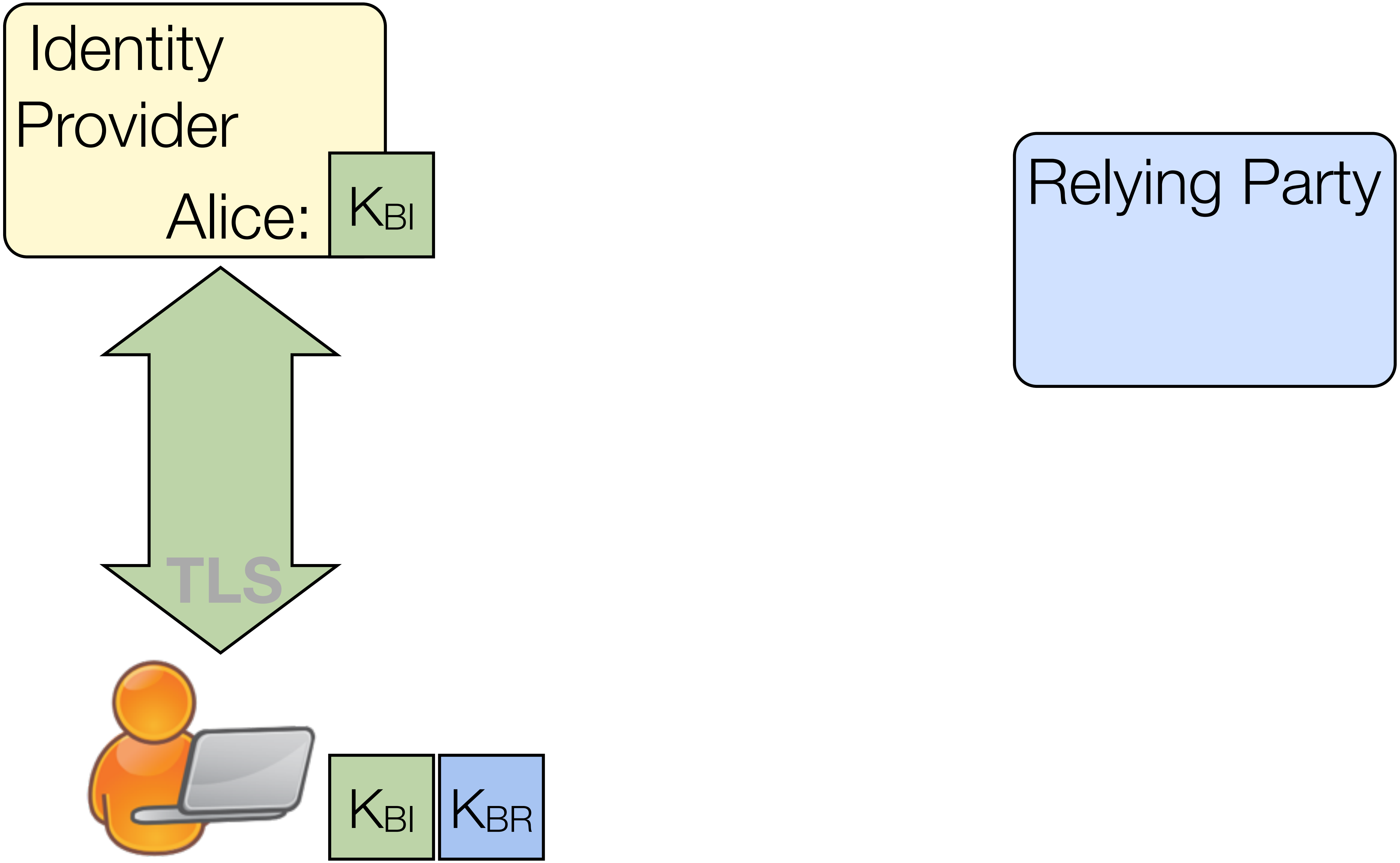
Alice: K_{BI}

TLS-OBC

PhoneAuth

Relying Party

Initial Assumptions



Identity Provider

Alice: K_{BI}

TLS

K_{BI} K_{BR}

Relying Party

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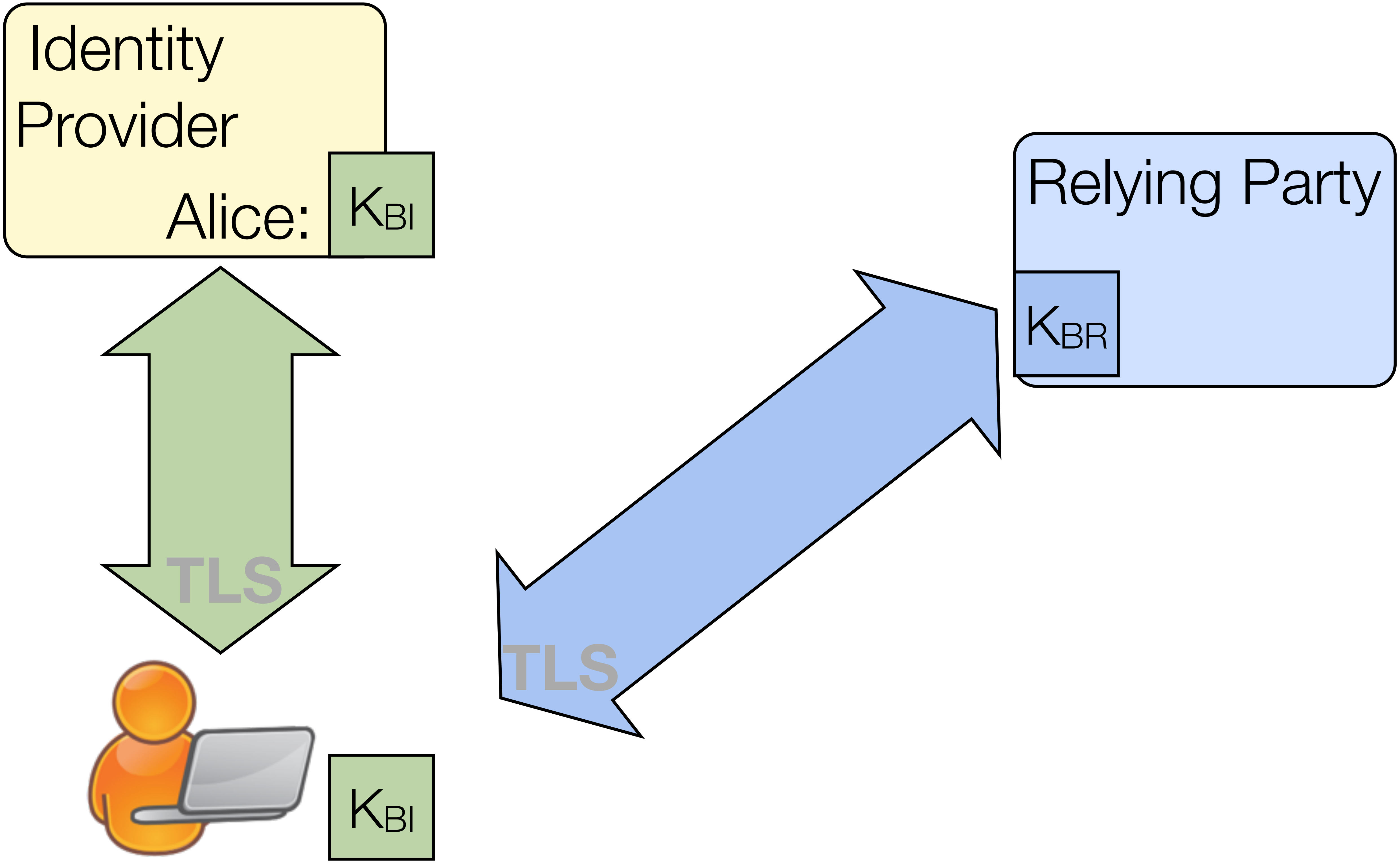


Identity Provider

Alice: K_{BI}

Relying Party

K_{BR}

TLS

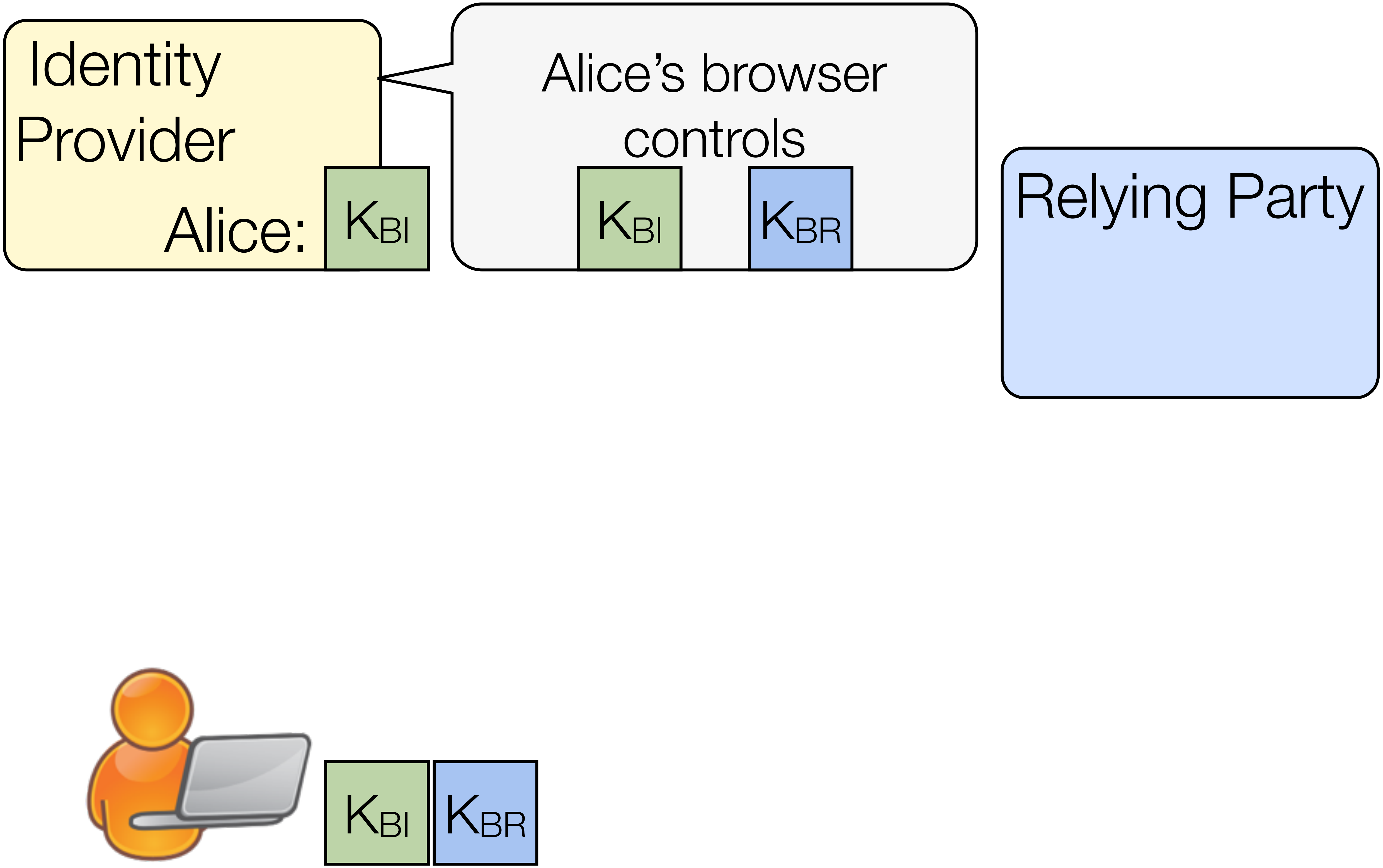
TLS

K_{BI}

Persona-OBC-Central

- Uses the Persona underpinnings, works more like OAuth2
  - IDP sees RP’s public key
  - Can track user logins to RPs
  - Simple to implement

Goal



Identity Provider

Alice: K_{BI}

Alice's browser controls

K_{BI} K_{BR}

Relying Party

K_{BI} K_{BR}

Post Key API

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- **Goal**: Convince IDP that browser controls two OBCs used on two different domains

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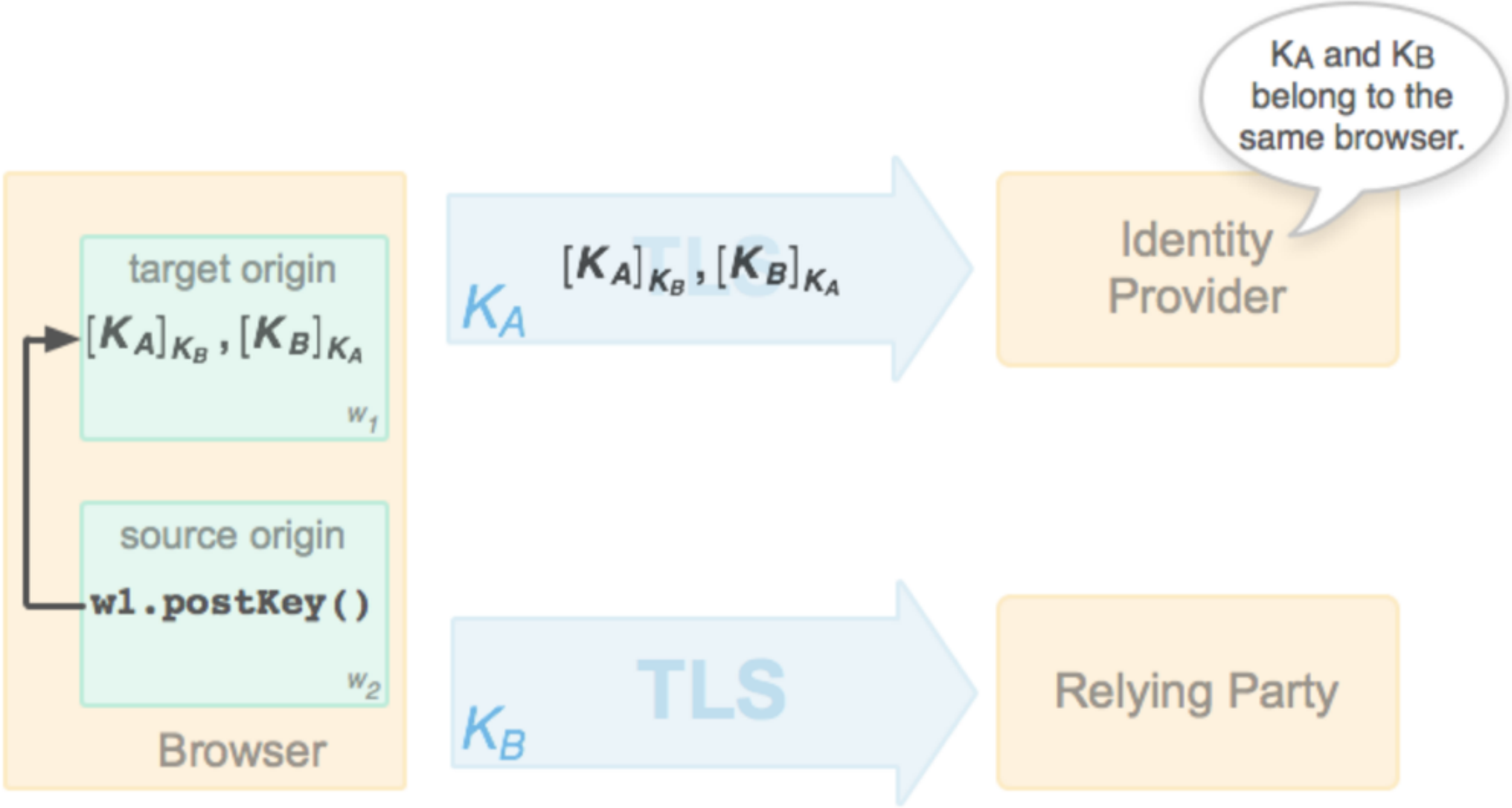
- Creates cross certification between two origin bound certificate keys
- API exposed as browser extension
    - Similar to postMessage() call

Post Key API



K_A and K_B belong to the same browser.

Post Key API

- Assumptions
  - IDP received cross cert on TLS channel associated with K_A
  - IDP knows K_A is a key Alice's browser controls

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$$[K_A, \text{A.com}]_{KB} \text{ , } [K_B, \text{B.com}]_{KA}$$

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Alice's browser says K_B

$$[K_A, \text{A.com}]_{KB} , [K_B, \text{B.com}]_{KA}$$

Post Key API

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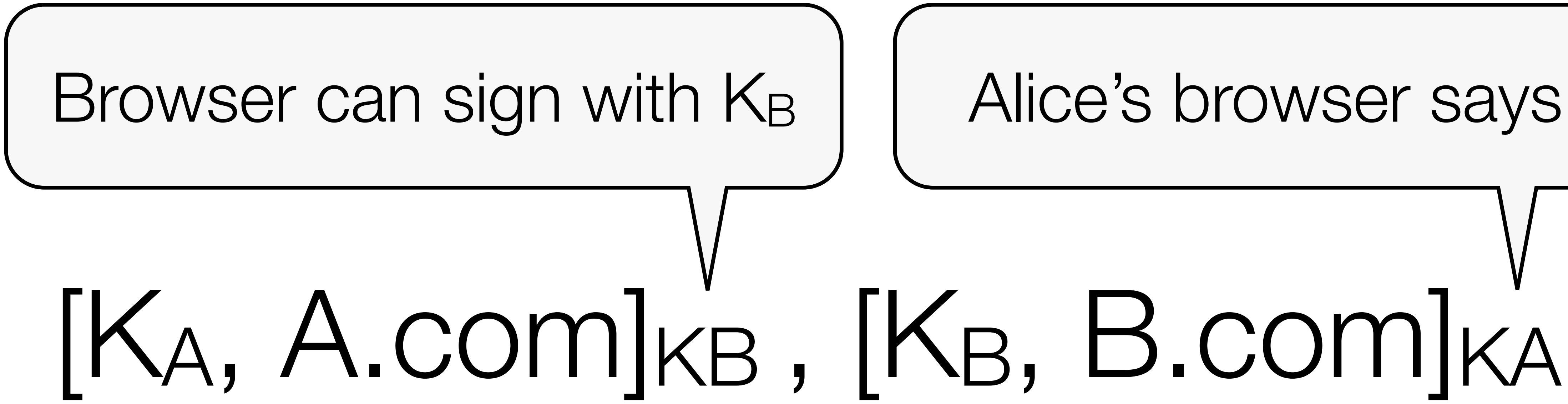
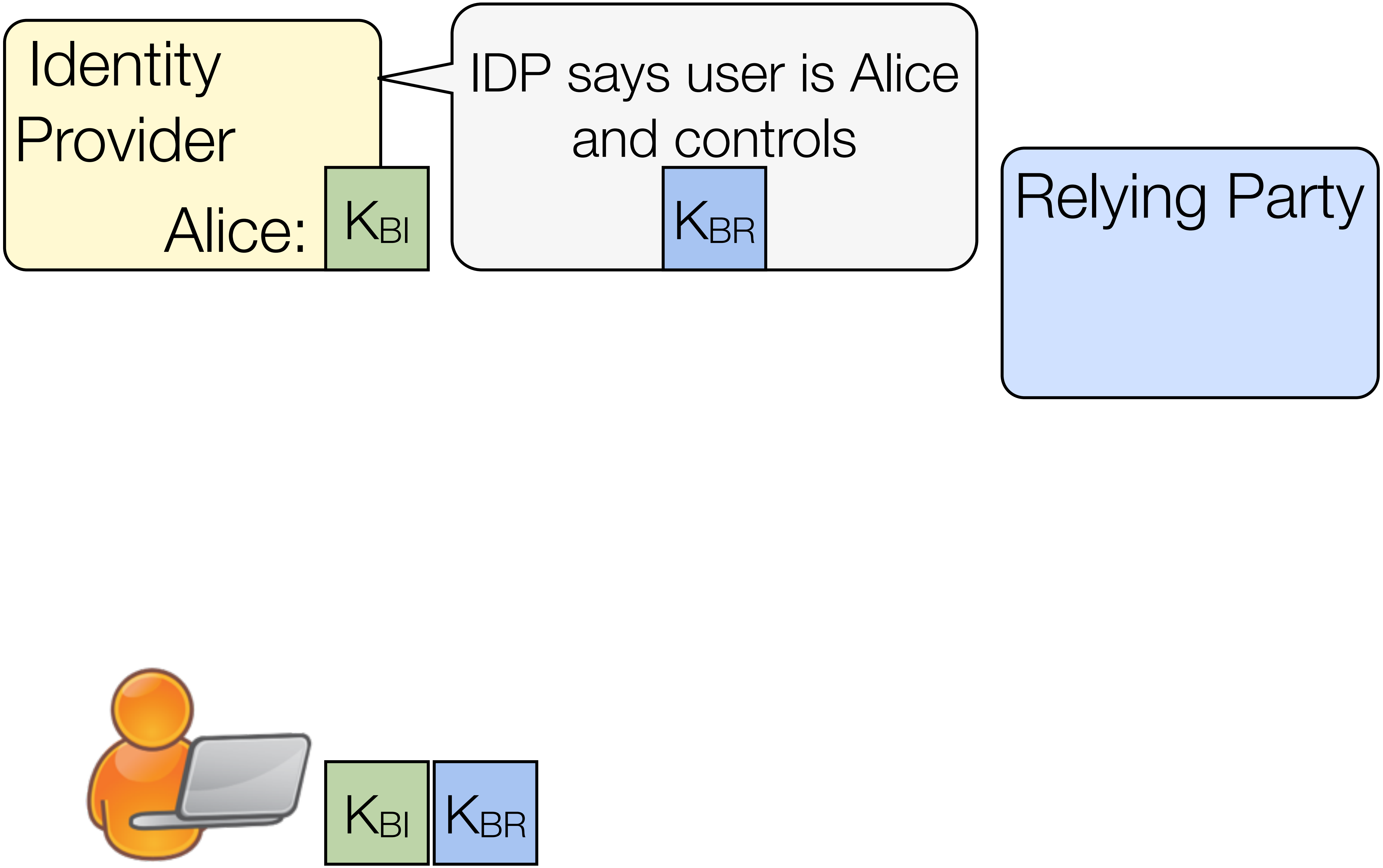


Browser can sign with K_B

Alice's browser says K_B

$$[K_A, \text{A.com}]_{KB} , [K_B, \text{B.com}]_{KA}$$

Goal



Identity Provider

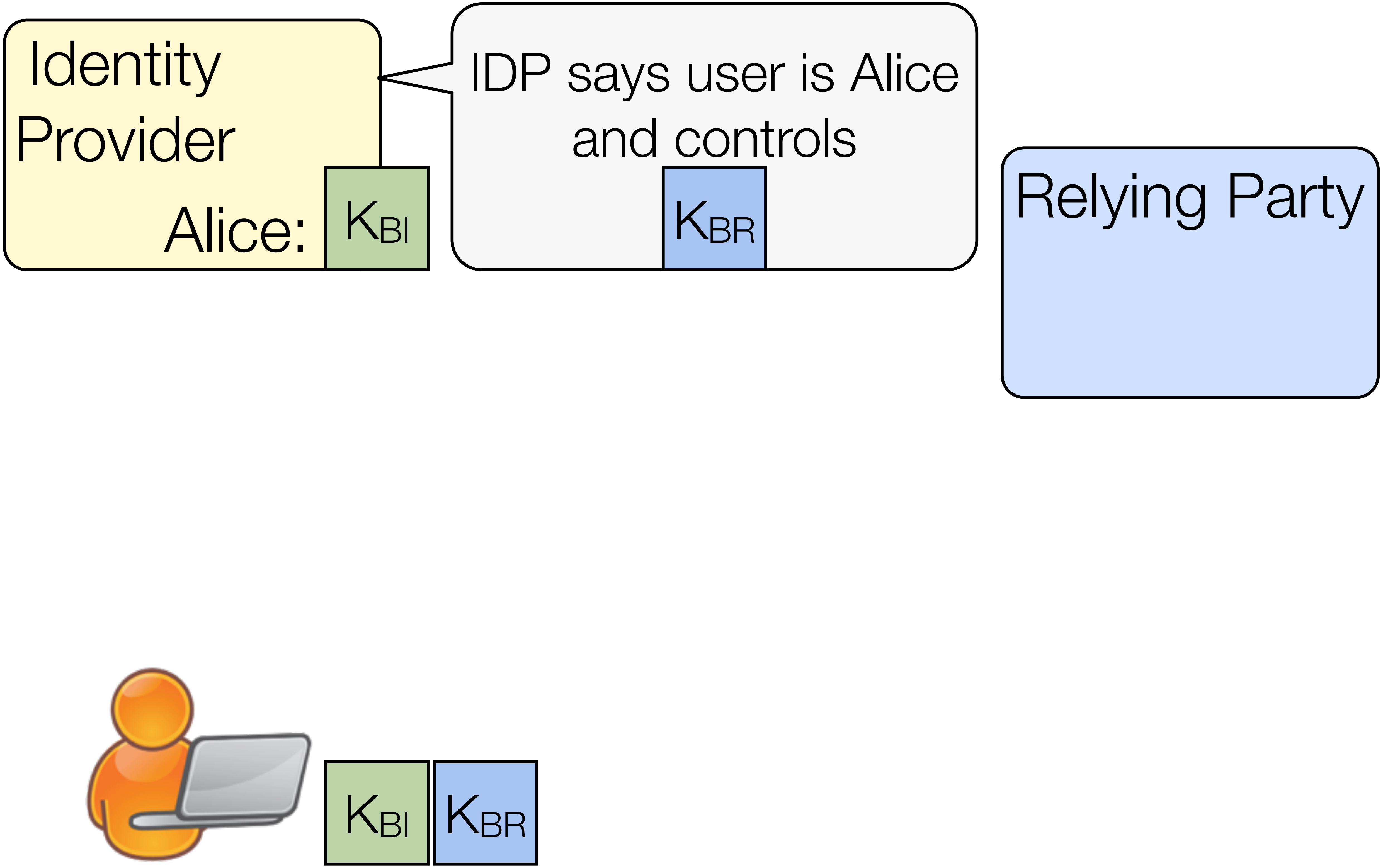
Alice: K_{BI}

IDP says user is Alice and controls K_{BR}

Relying Party

K_{BI} K_{BR}

Goal



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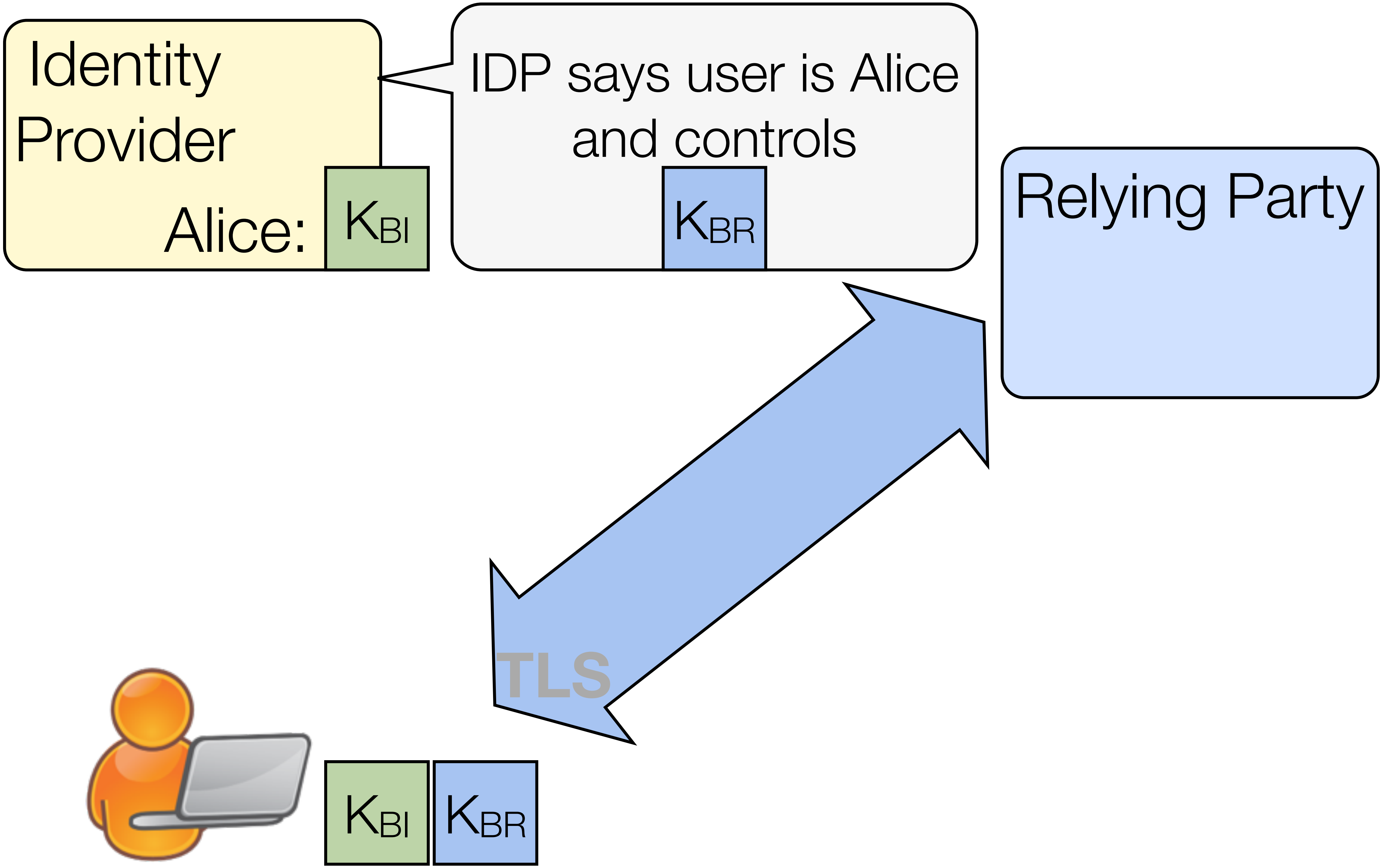
Relying Party

K_{BI} K_{BR}

Goal



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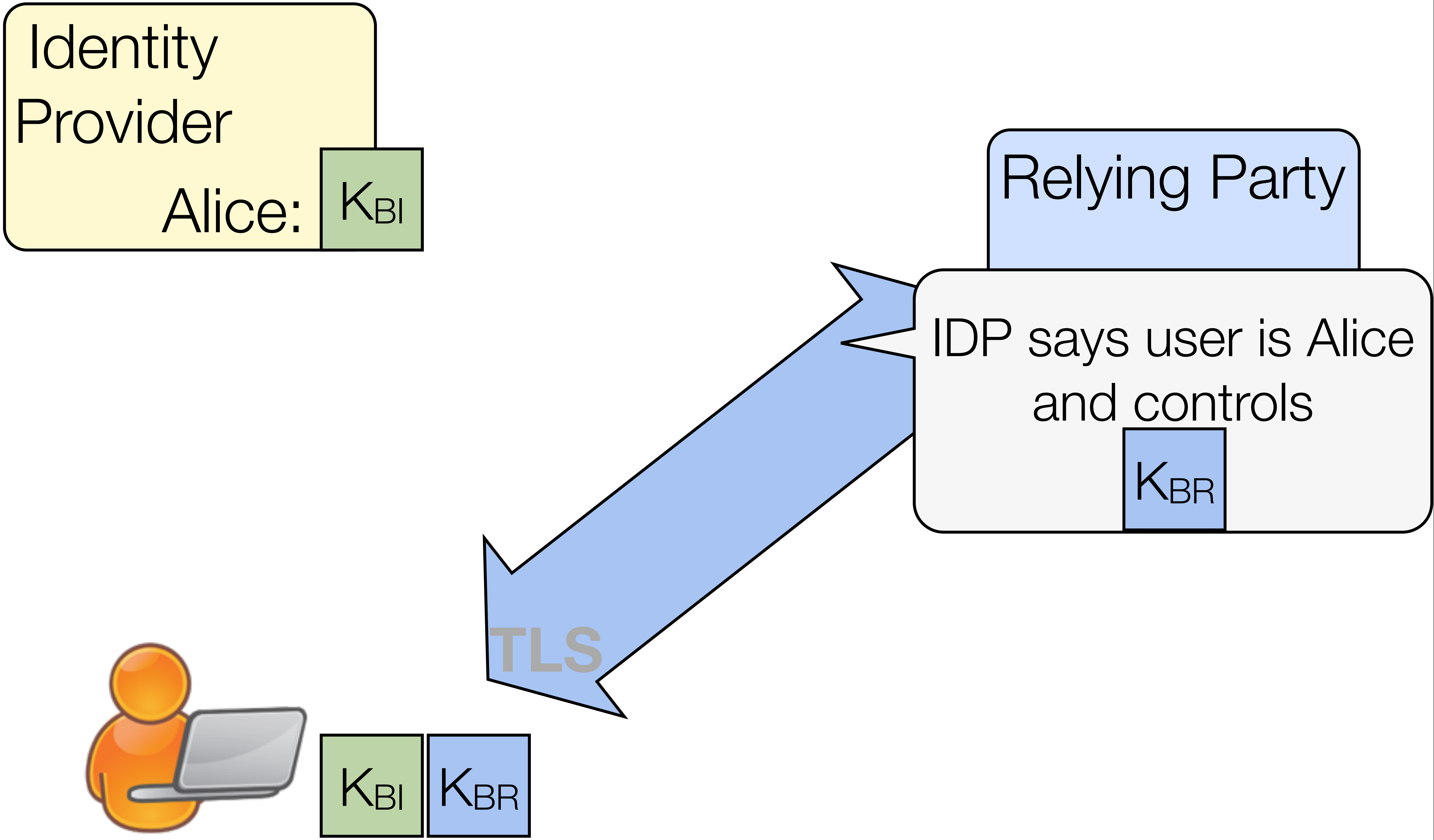
Relying Party

TLS

K_{BI} K_{BR}

Goal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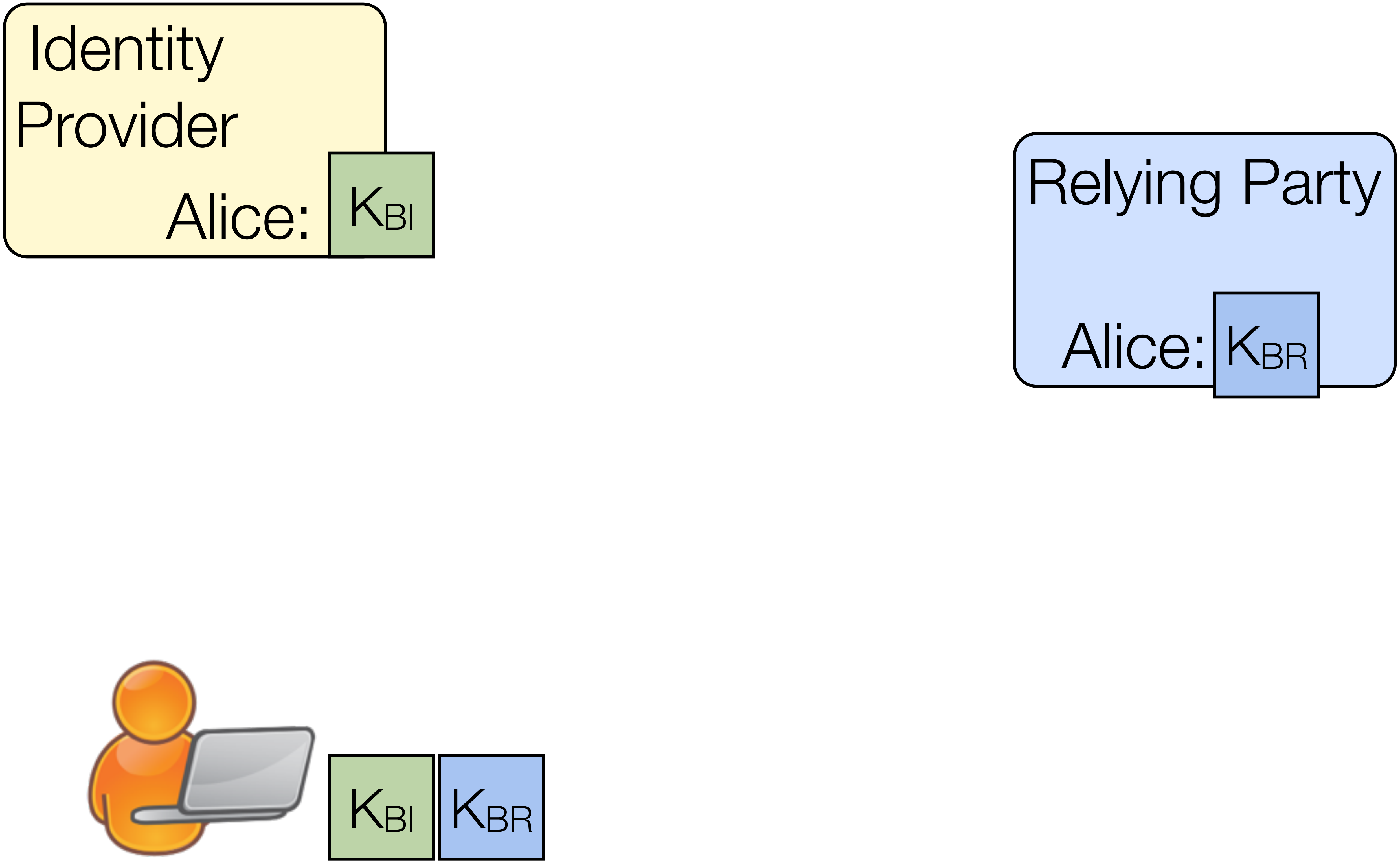

Identity Provider

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Relying Party

Alice: K_{BR}

K_{BI} K_{BR}

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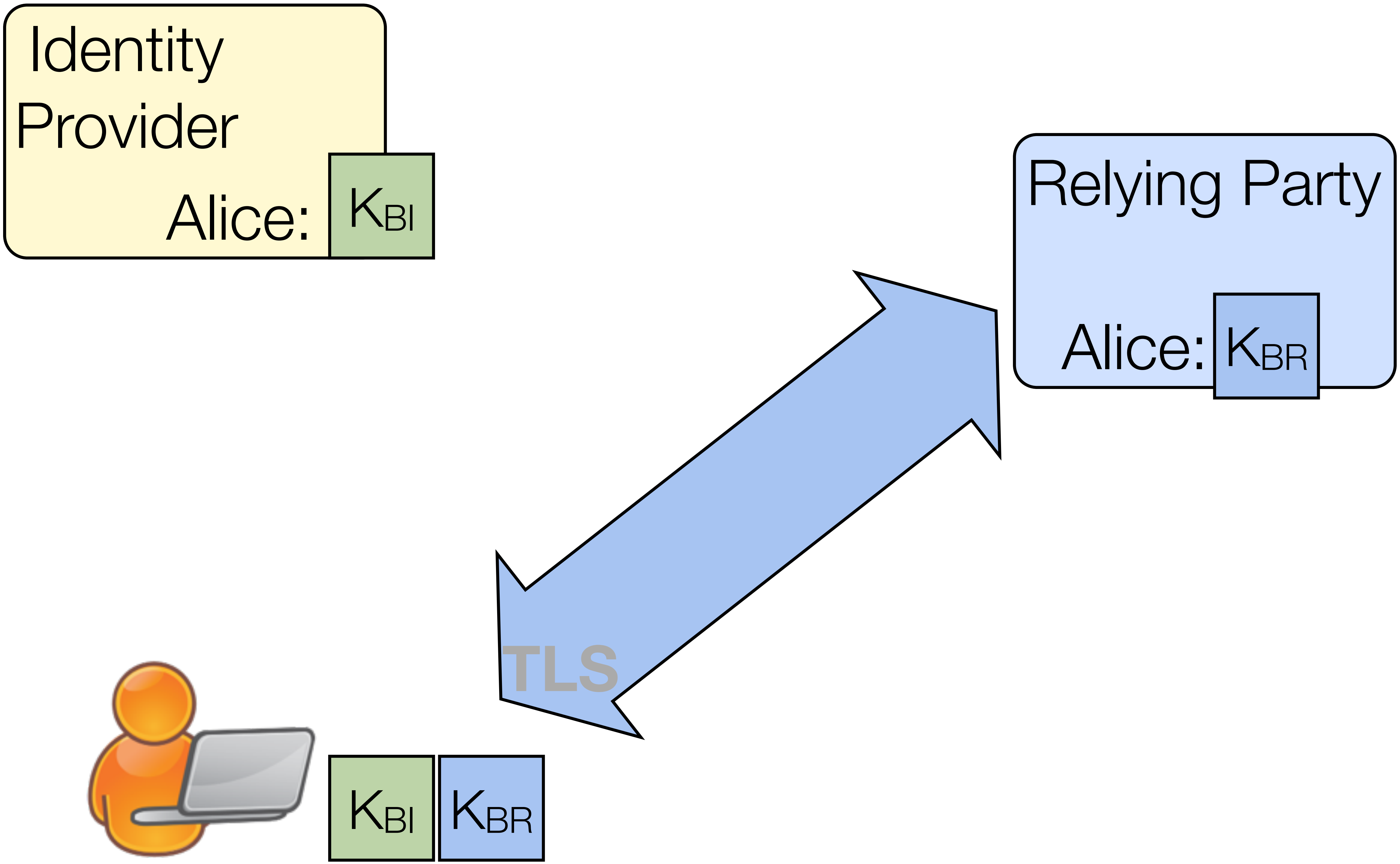

Identity Provider

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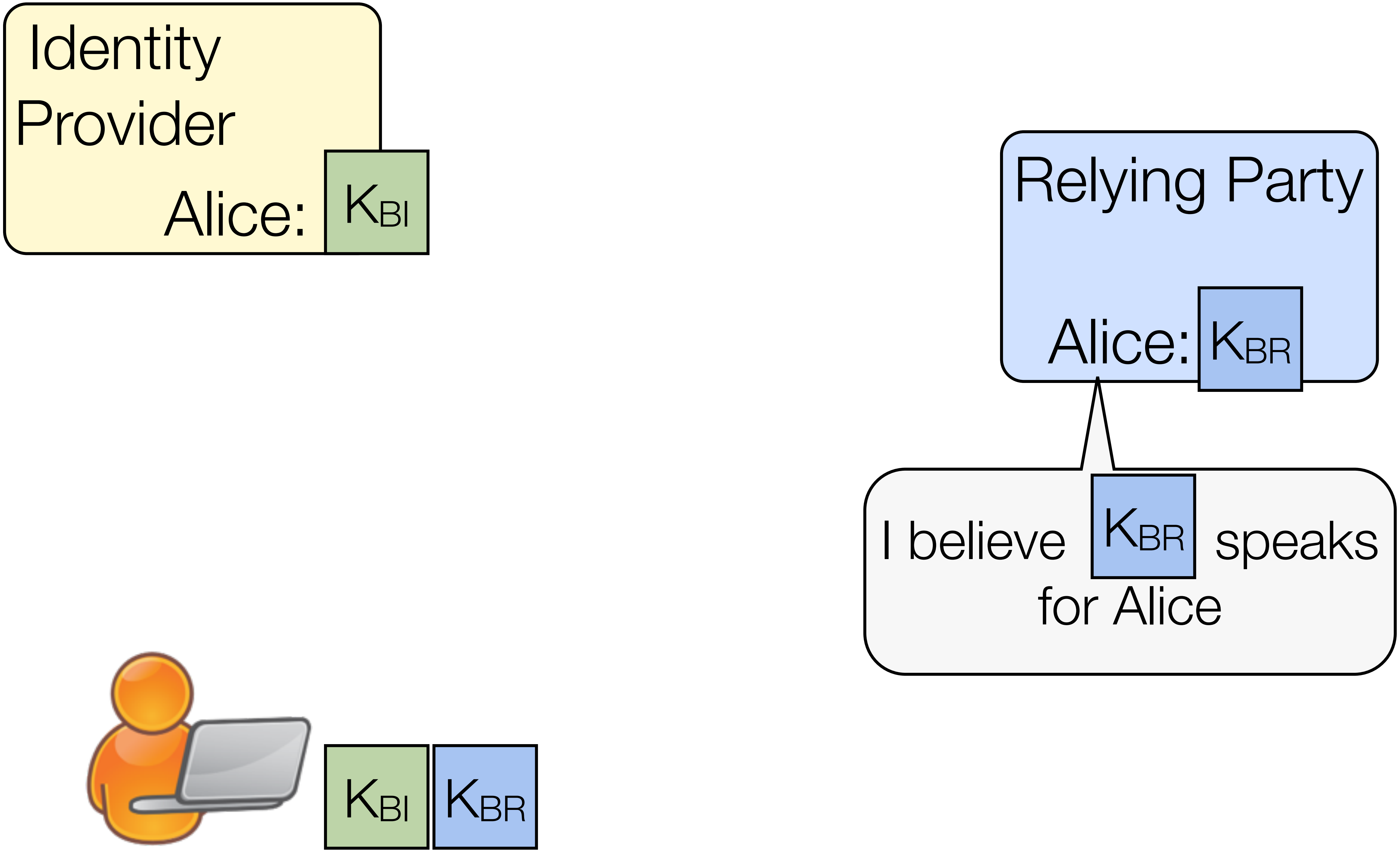
Relying Party

Alice: K_{BR}

TLS

K_{BI} K_{BR}

Goal



Identity Provider

Alice: K_{BI}

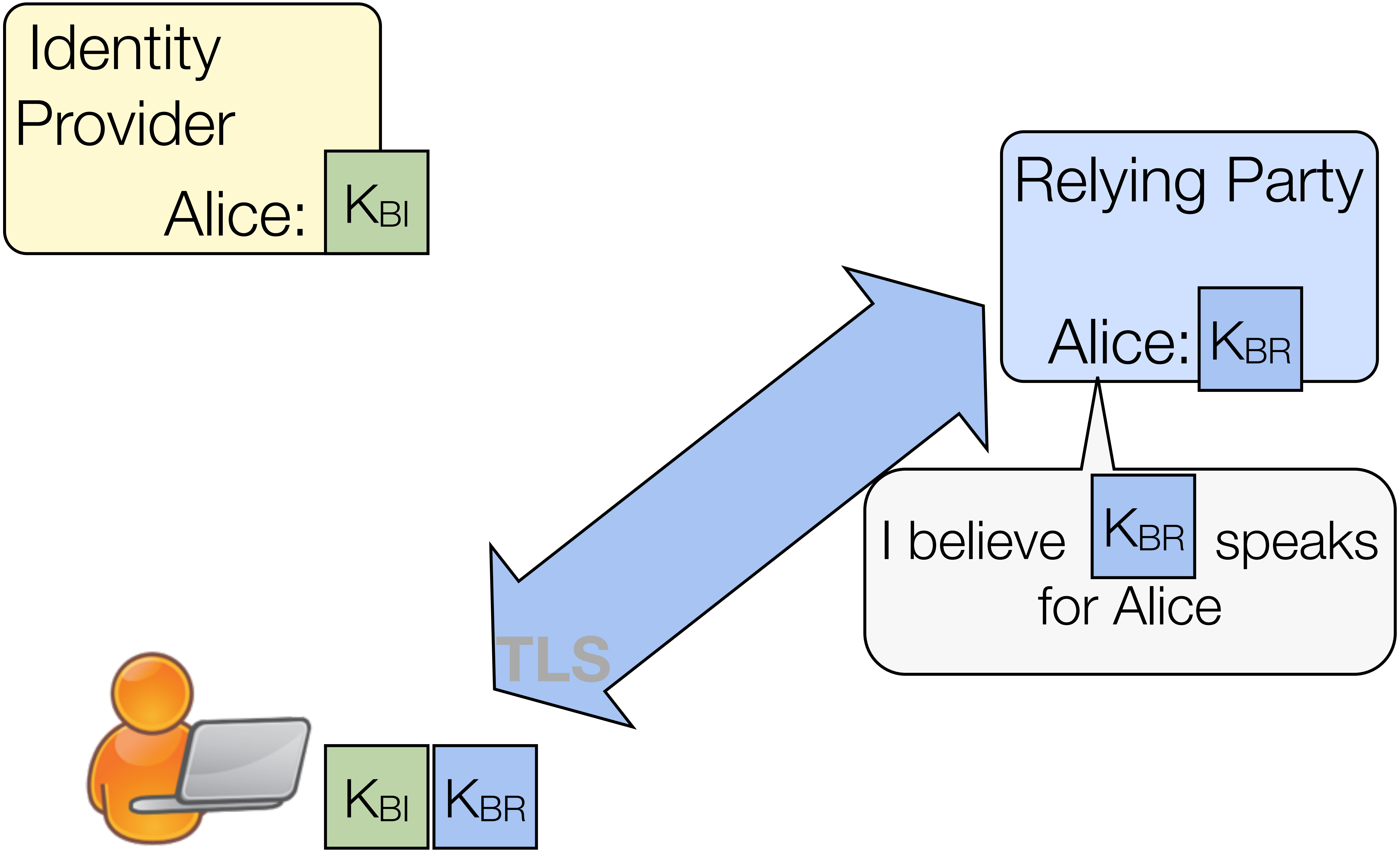
Relying Party

Alice: K_{BR}

I believe K_{BR} speaks for Alice

K_{BI} K_{BR}

Goal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Relying Party
Alice: K_{BR}
I believe K_{BR} speaks for Alice
TLS
K_{BI} K_{BR}

Persona-OBC-Local:

Preserve Persona semantics

Persona Specifics

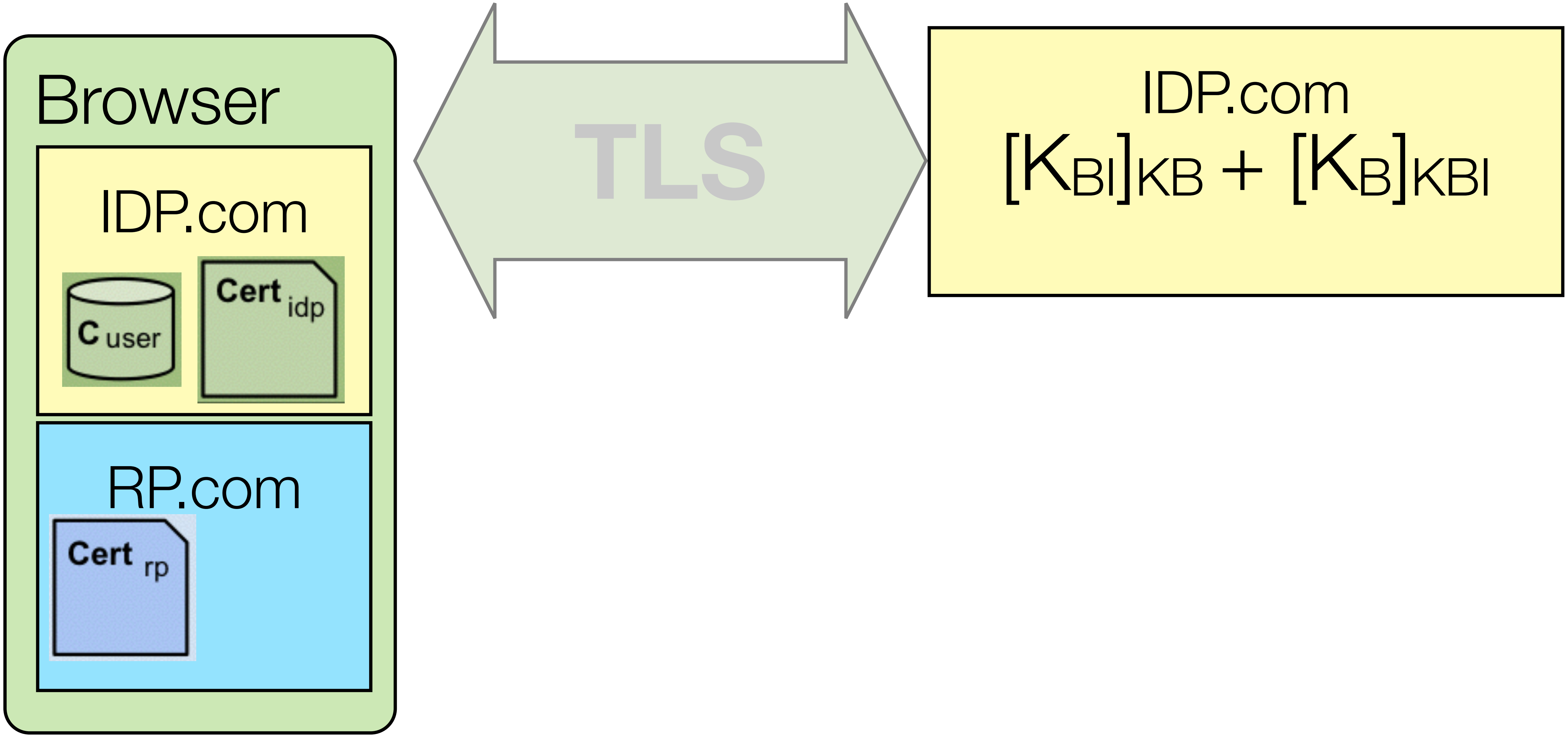
- IDP cannot track where the user logs in
- Uses public key crypto (in the browser)
  - IDP signs short lived browser key
  - Browser creates identity assertion with browser key
  - RP can verify assertions without an online IDP

Persona-OBC-Local

- IDP signs browser controlled key K_B and user identity with its well known key K_I
- Browser creates identity assertions on the fly by signing new TLS-OBC key for RP with K_B

Persona-OBC-Local protocol

1. Browser sends cross certification and channel bound cookie to IDP



Browser

IDP.com

C_{user}

$Cert_{idp}$

RP.com

$Cert_{rp}$

TLS

IDP.com

$[K_{BI}]_{KB} + [K_{B}]_{KBI}$

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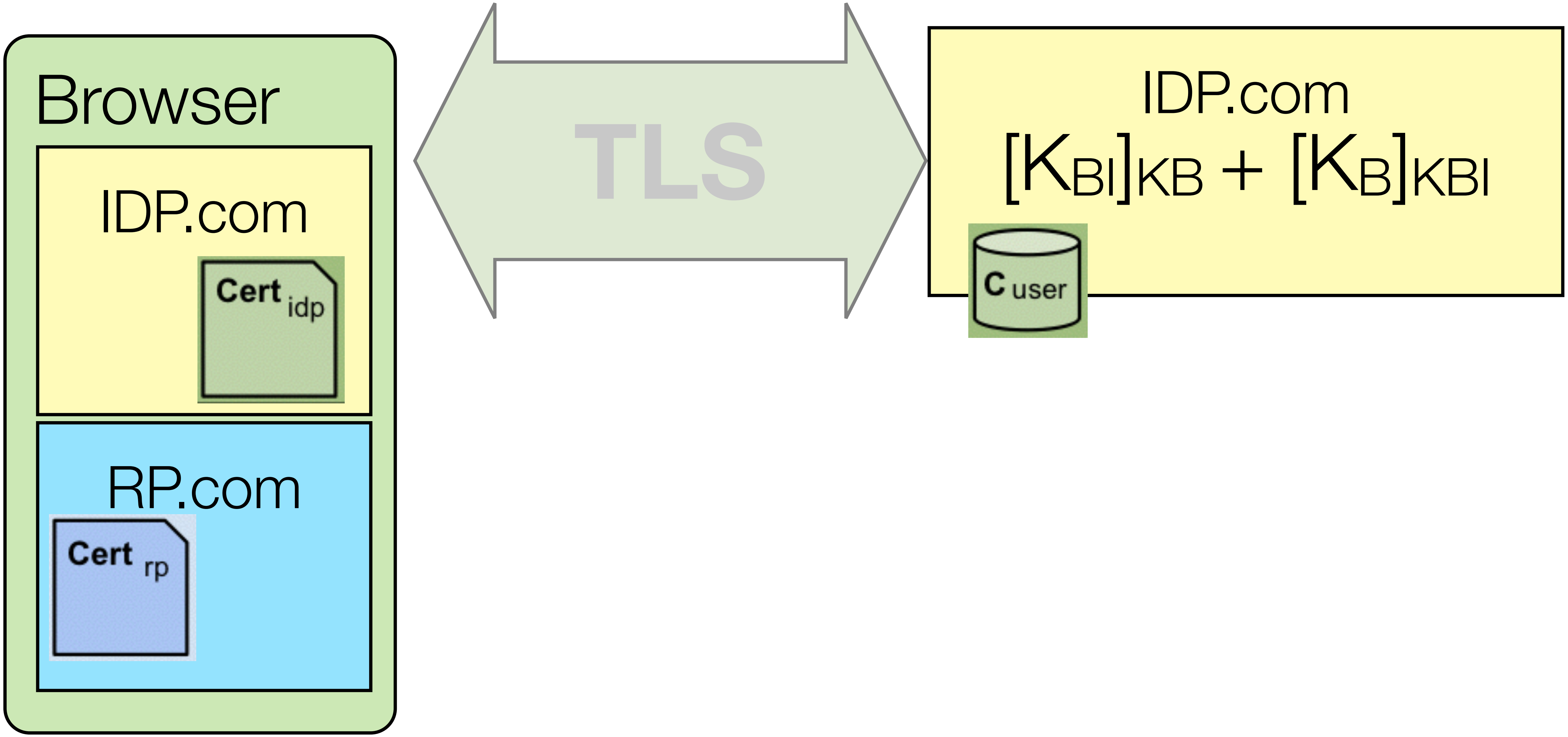
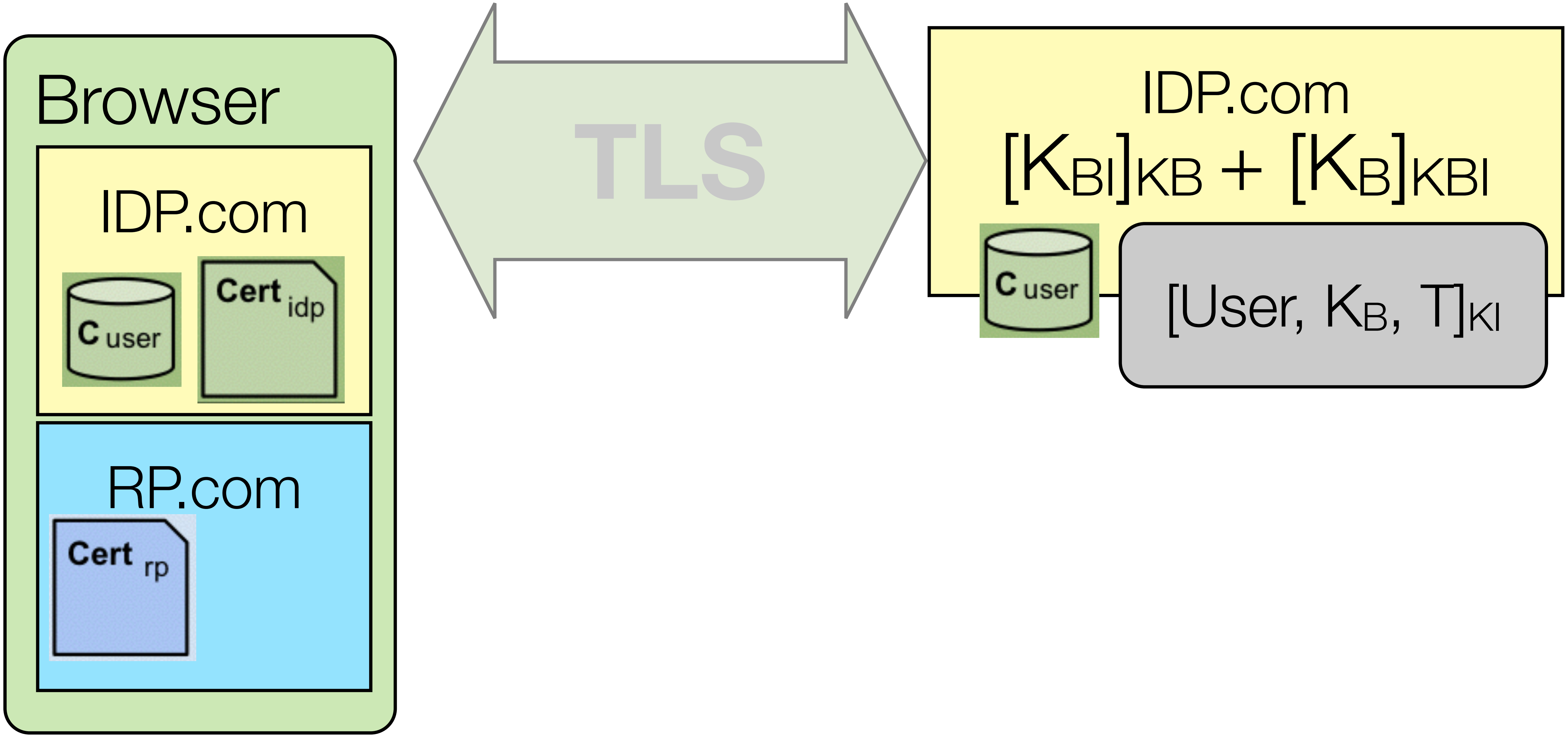


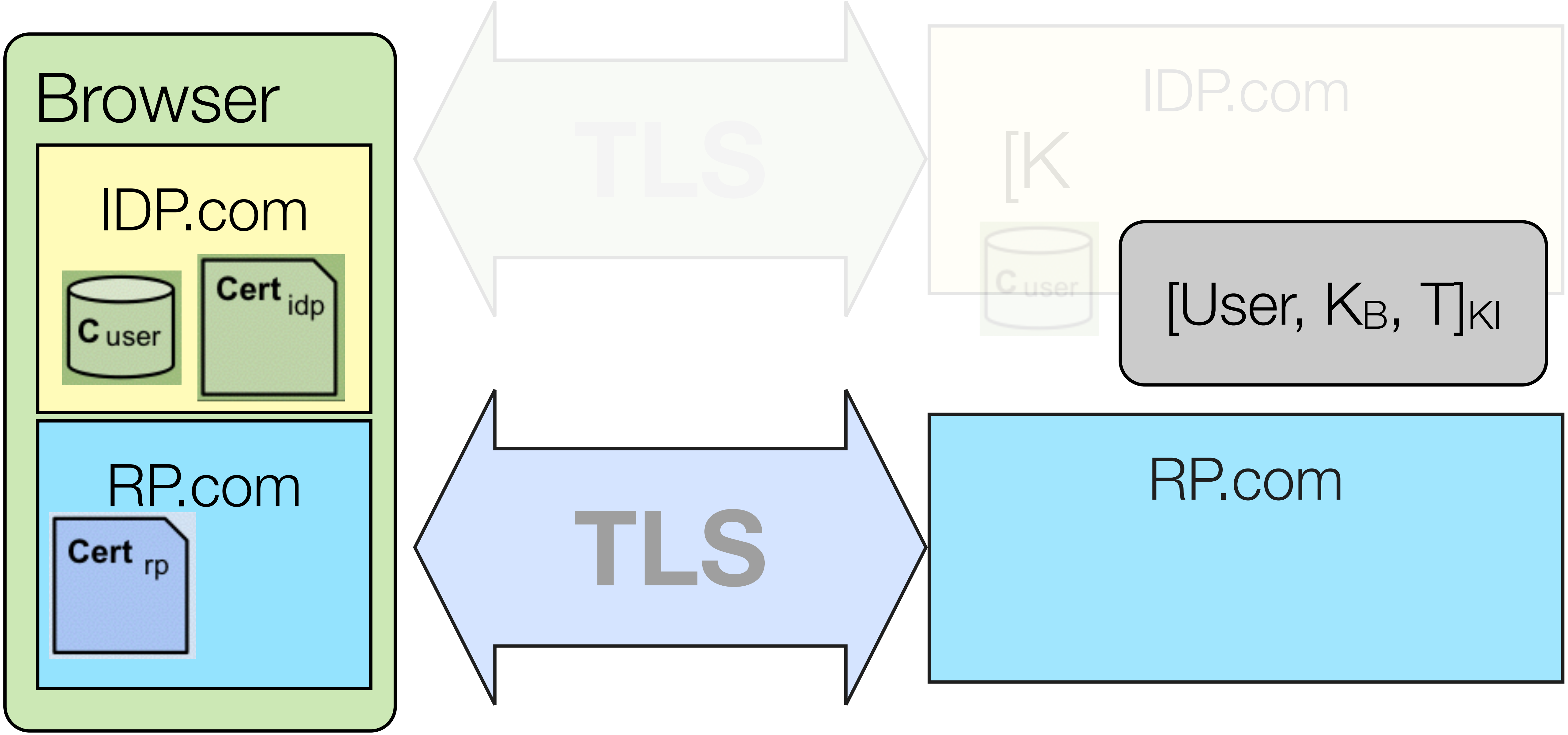
Persona-OBC-Local protocol

2. IDP creates identity certificate



Persona-OBC-Local protocol

3. IDP sends identity certificate to browser for storage



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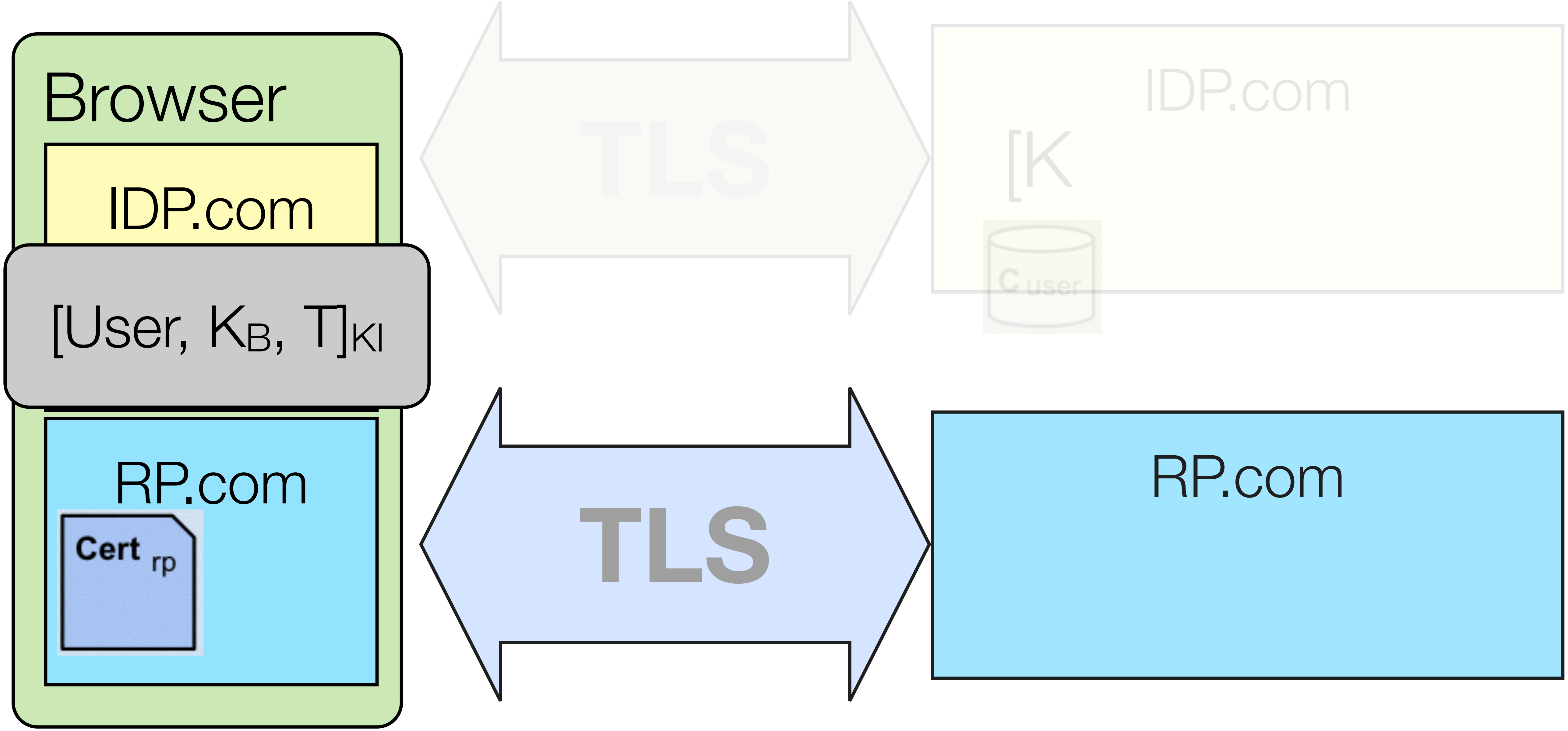
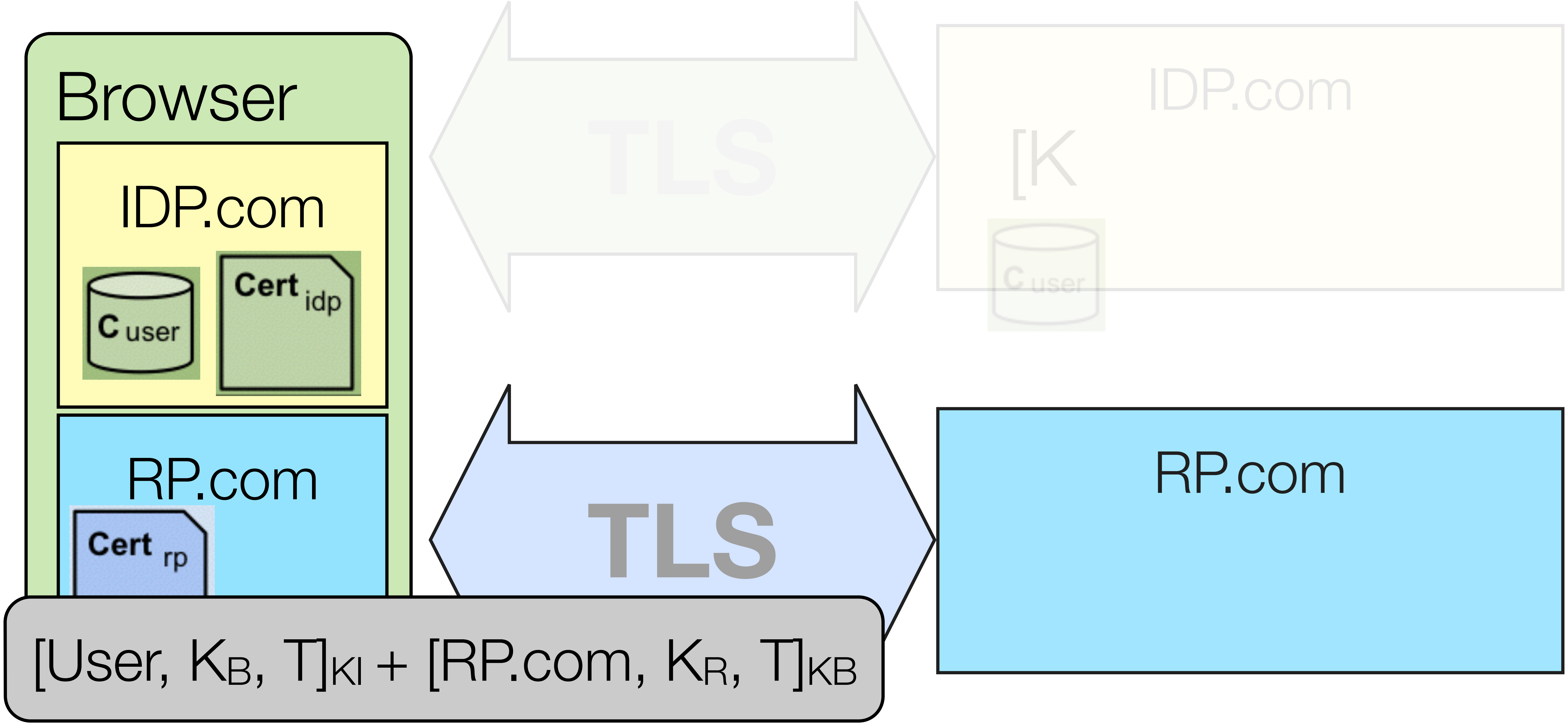


Persona-OBC-Local protocol

4. User wants to log into RP, Browser creates identity assertion



[User, K_B, T]$_{KI}$ + [RP.com, K_R, T]$_{KB}$

Persona-OBC-Local protocol

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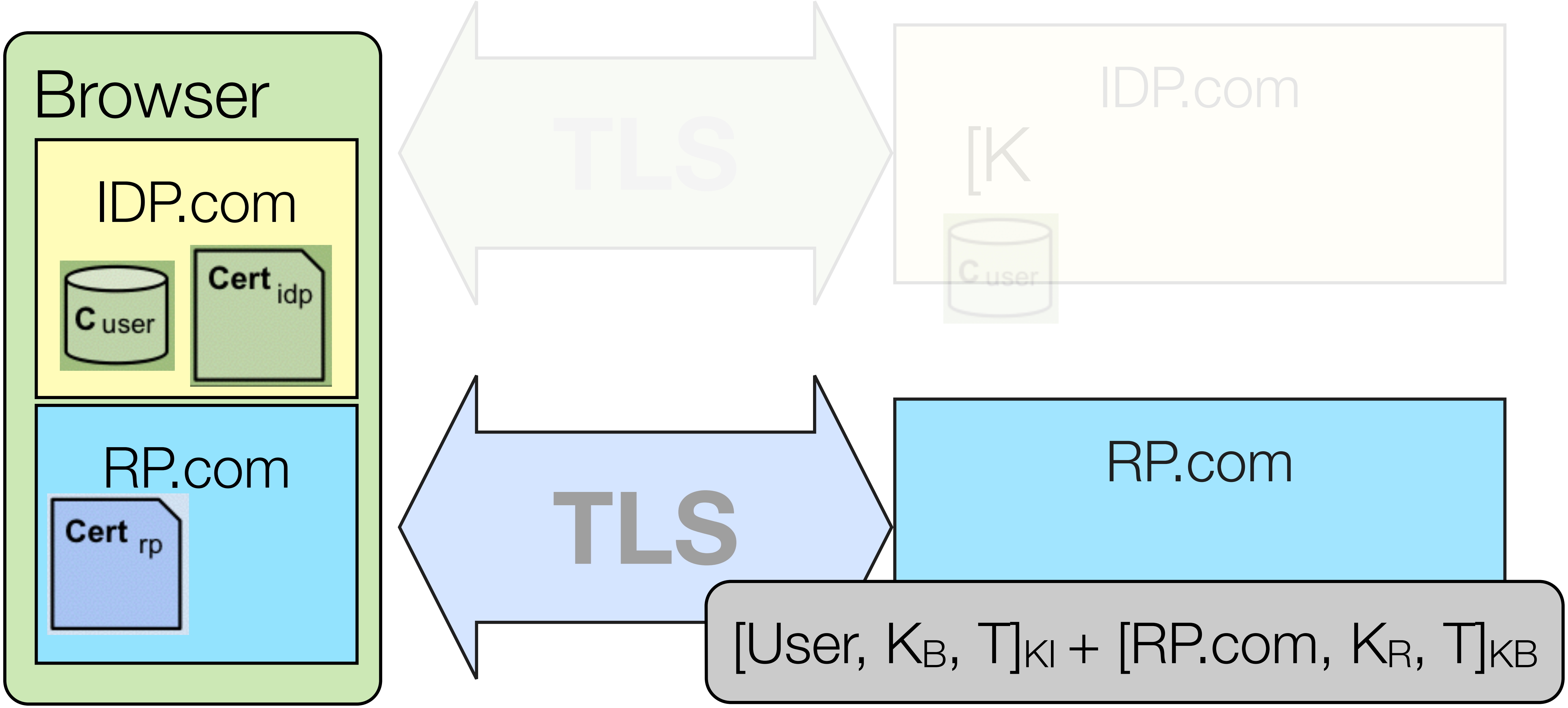

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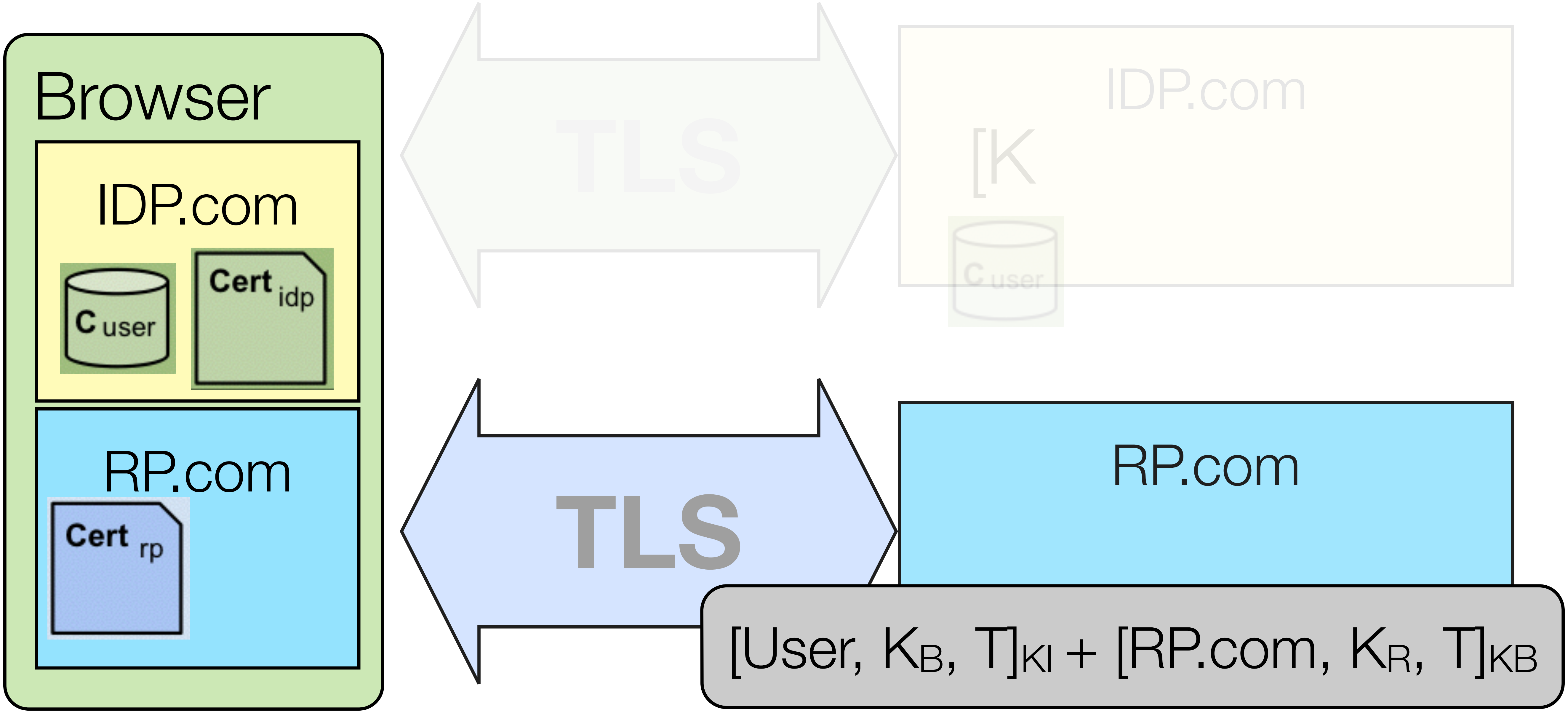
Persona-OBC-Local protocol

5. RP verifies assertion



Browser

IDP.com

C_{user}

$Cert_{idp}$

RP.com

$Cert_{rp}$

TLS

IDP.com

[K

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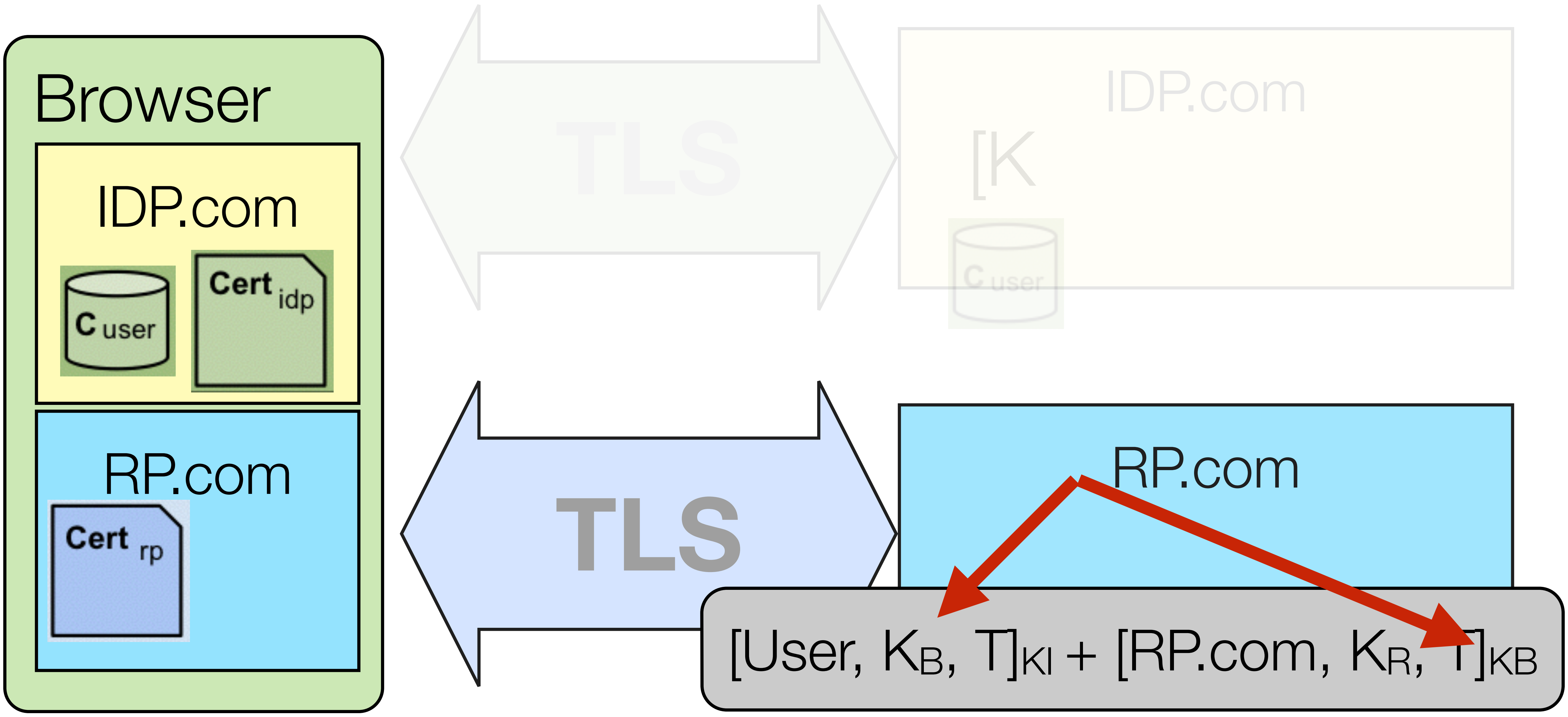

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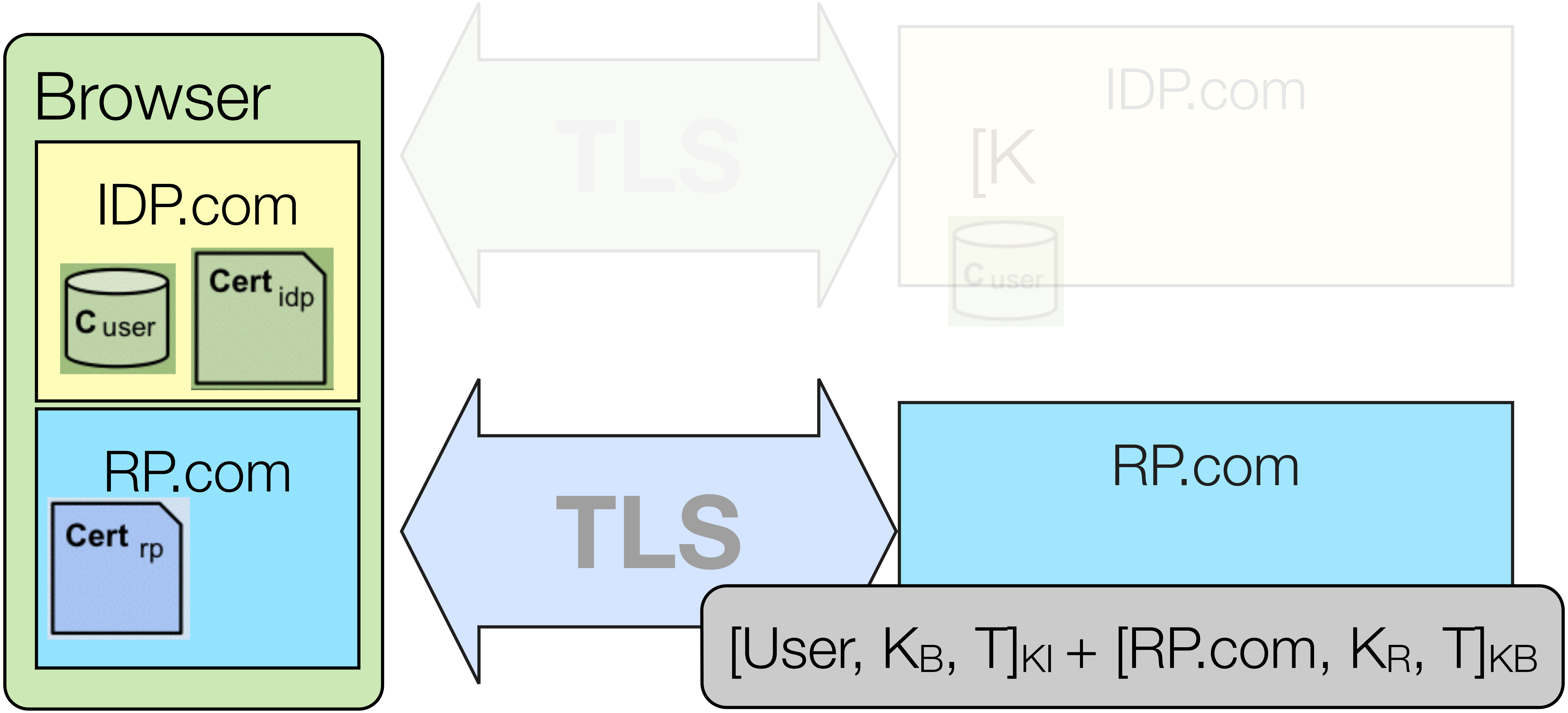

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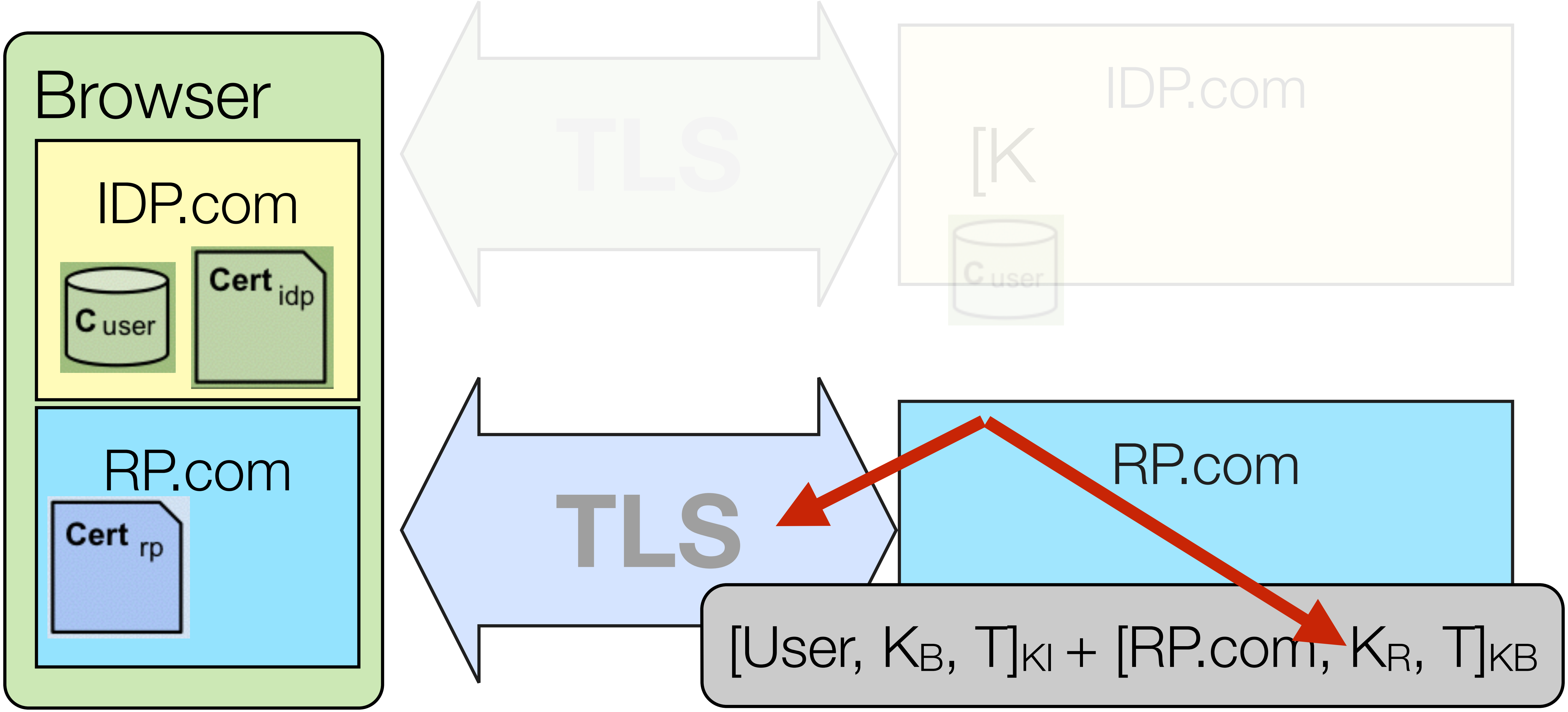
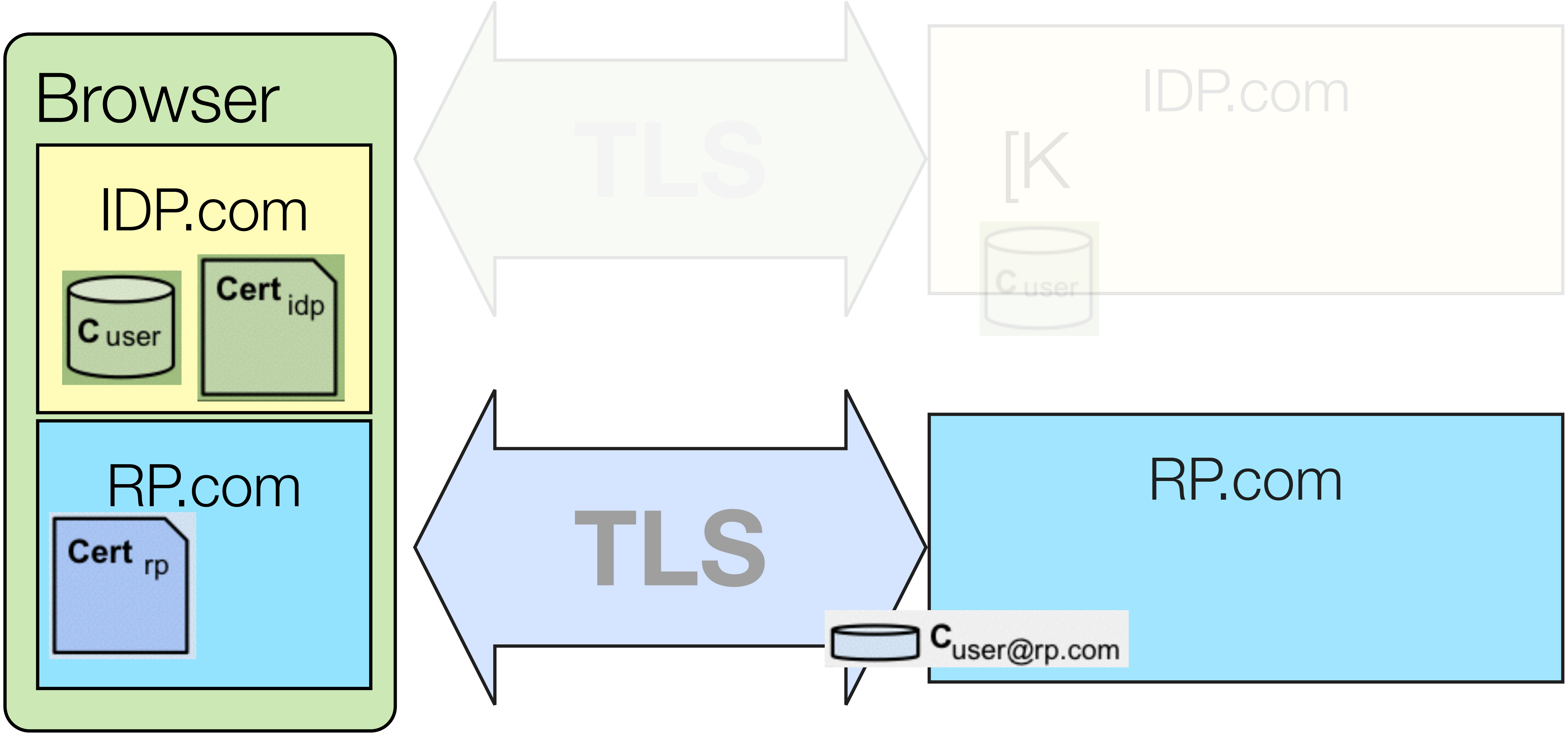


Persona-OBC-Local protocol

5. RP mints (channel-bound) cookie for user



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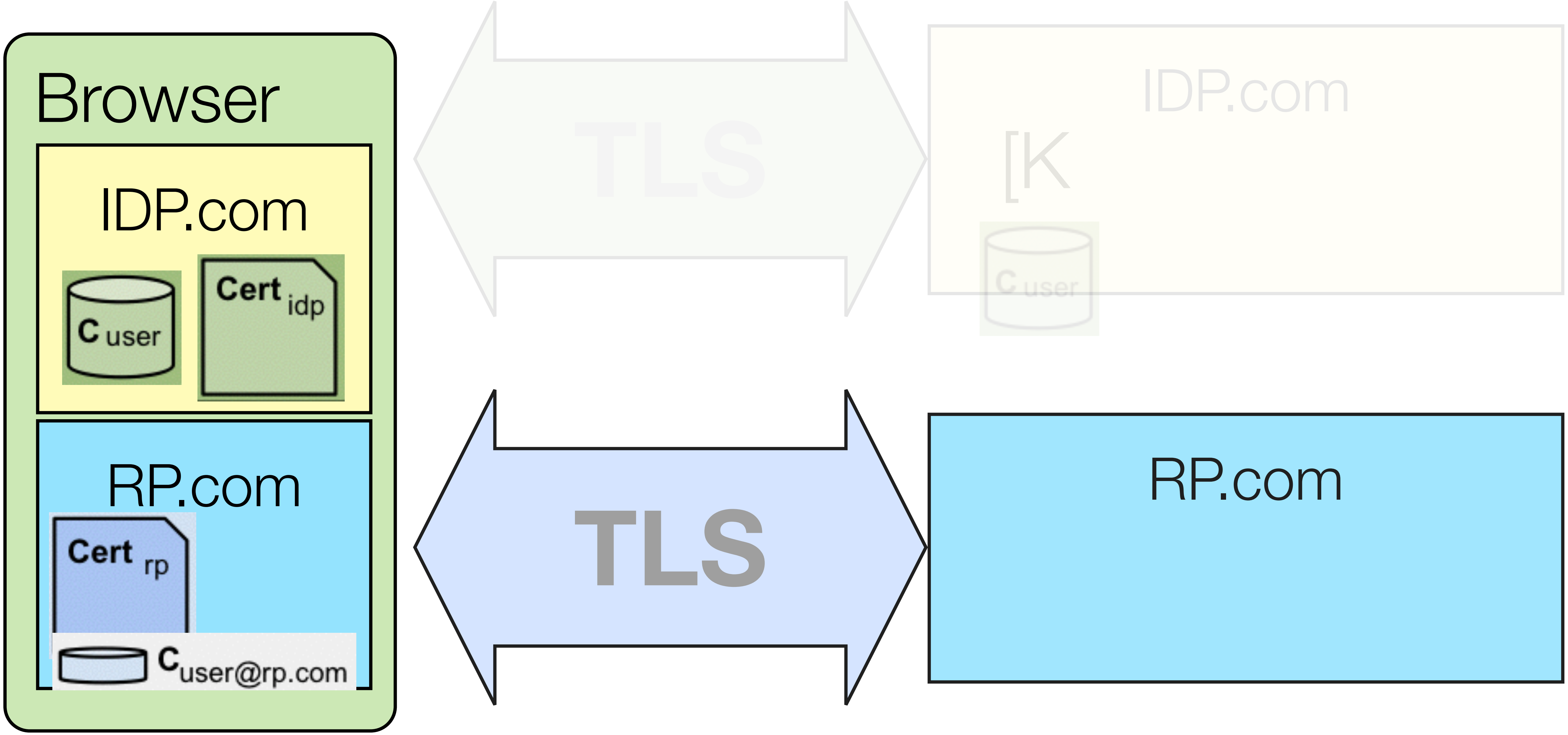
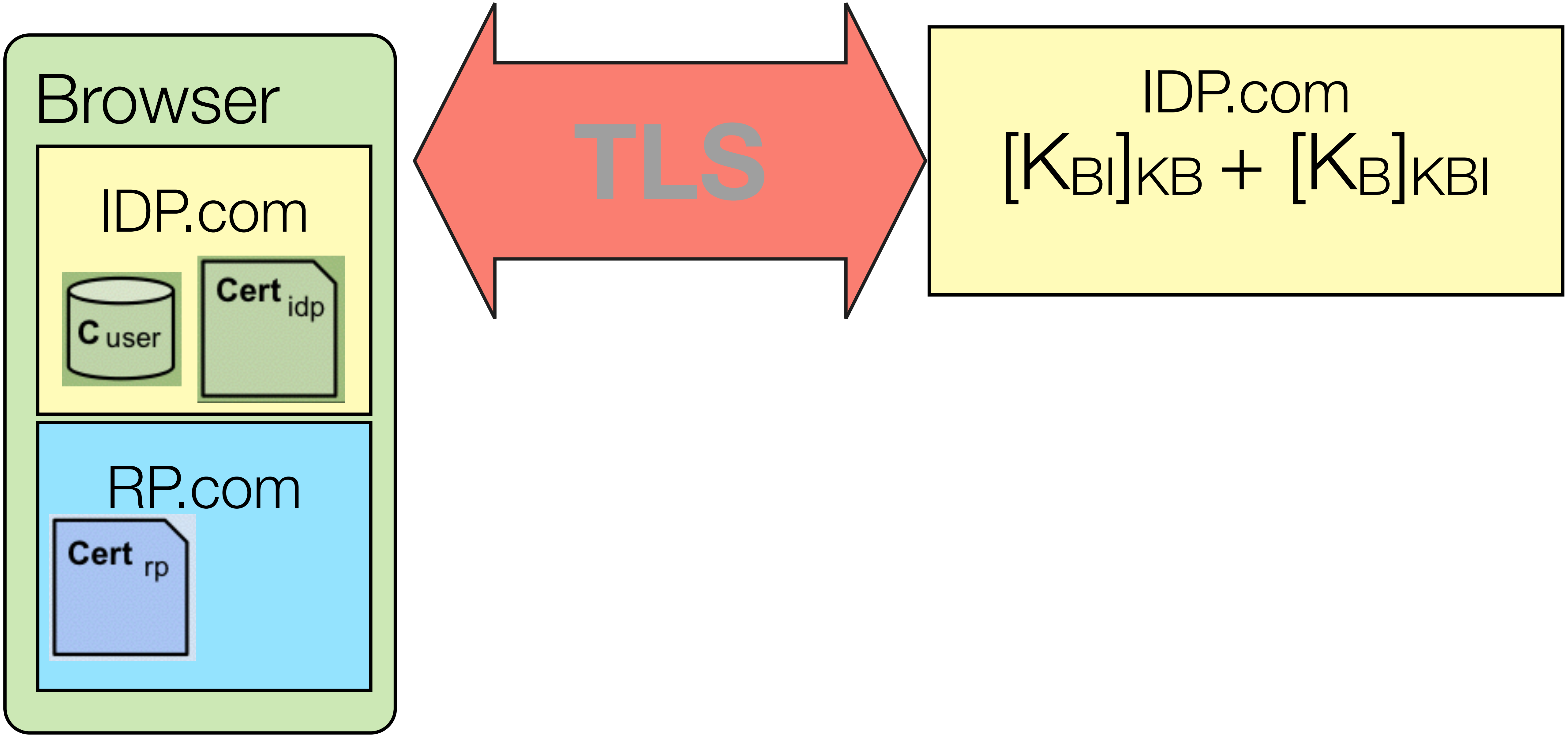


Attack #1

- Attacker between browser and IDP



Browser

IDP.com

C_{user}

$Cert_{idp}$

RP.com

$Cert_{rp}$

TLS

IDP.com

$[K_{BI}]_{KB} + [K_{B}]_{KBI}$

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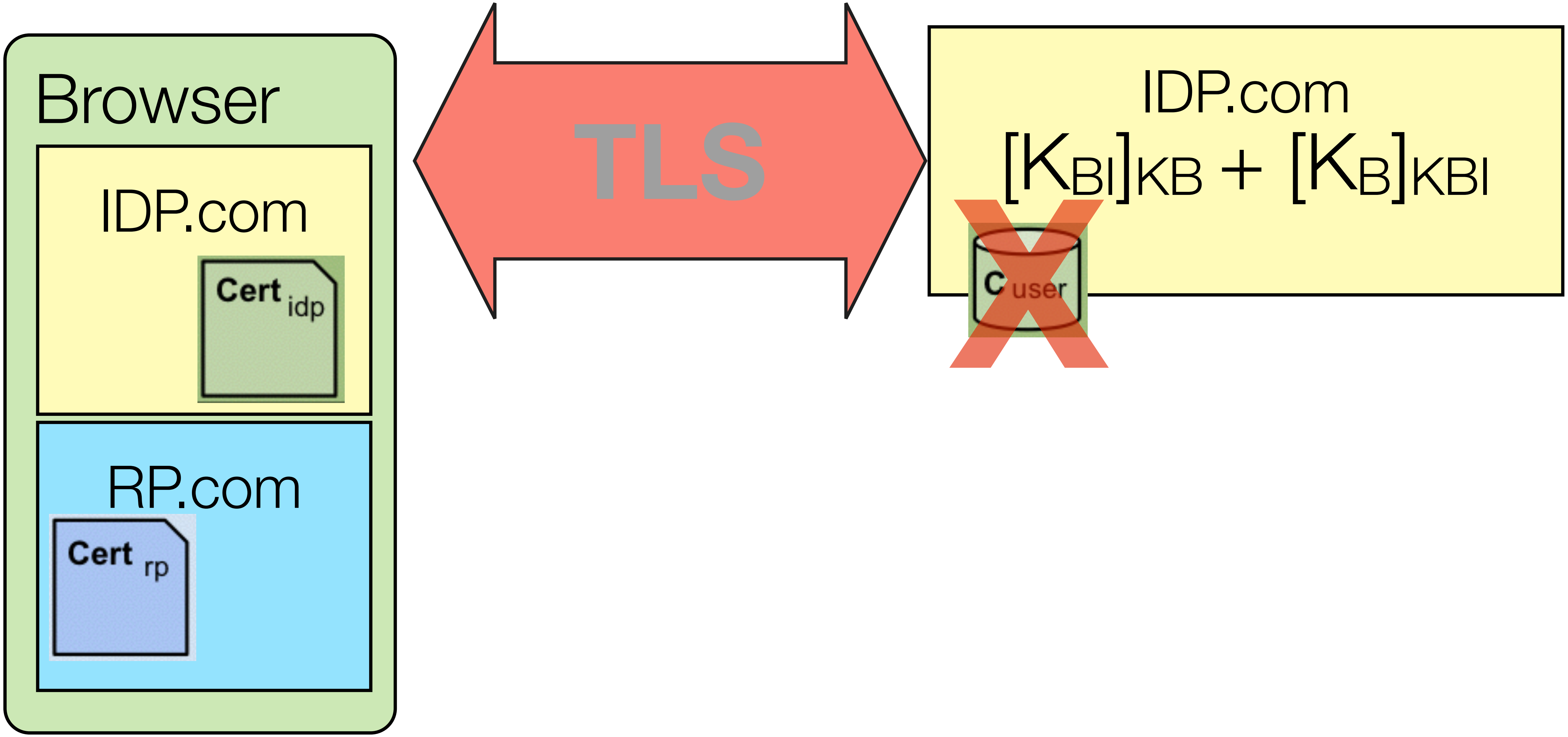
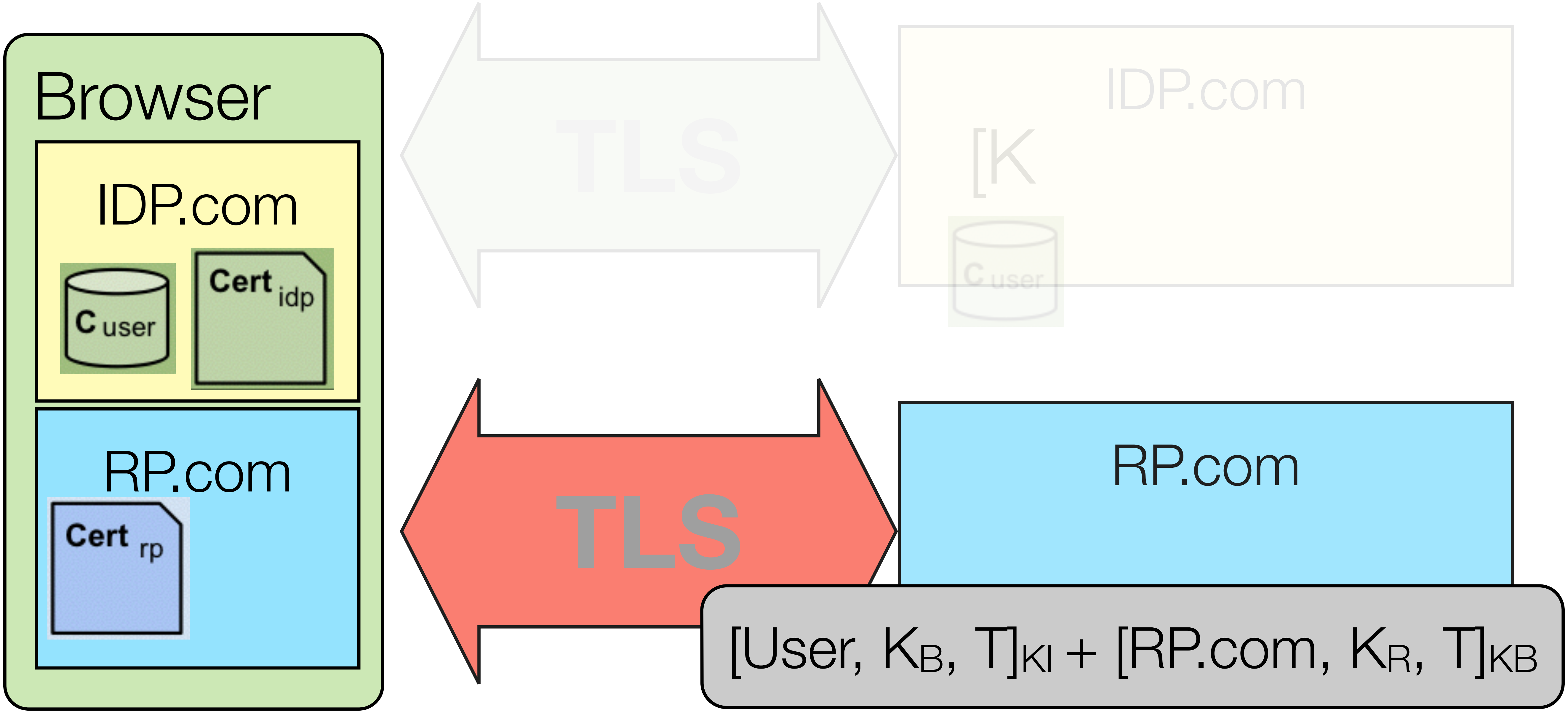


Attack #2

- Attacker between browser and RP



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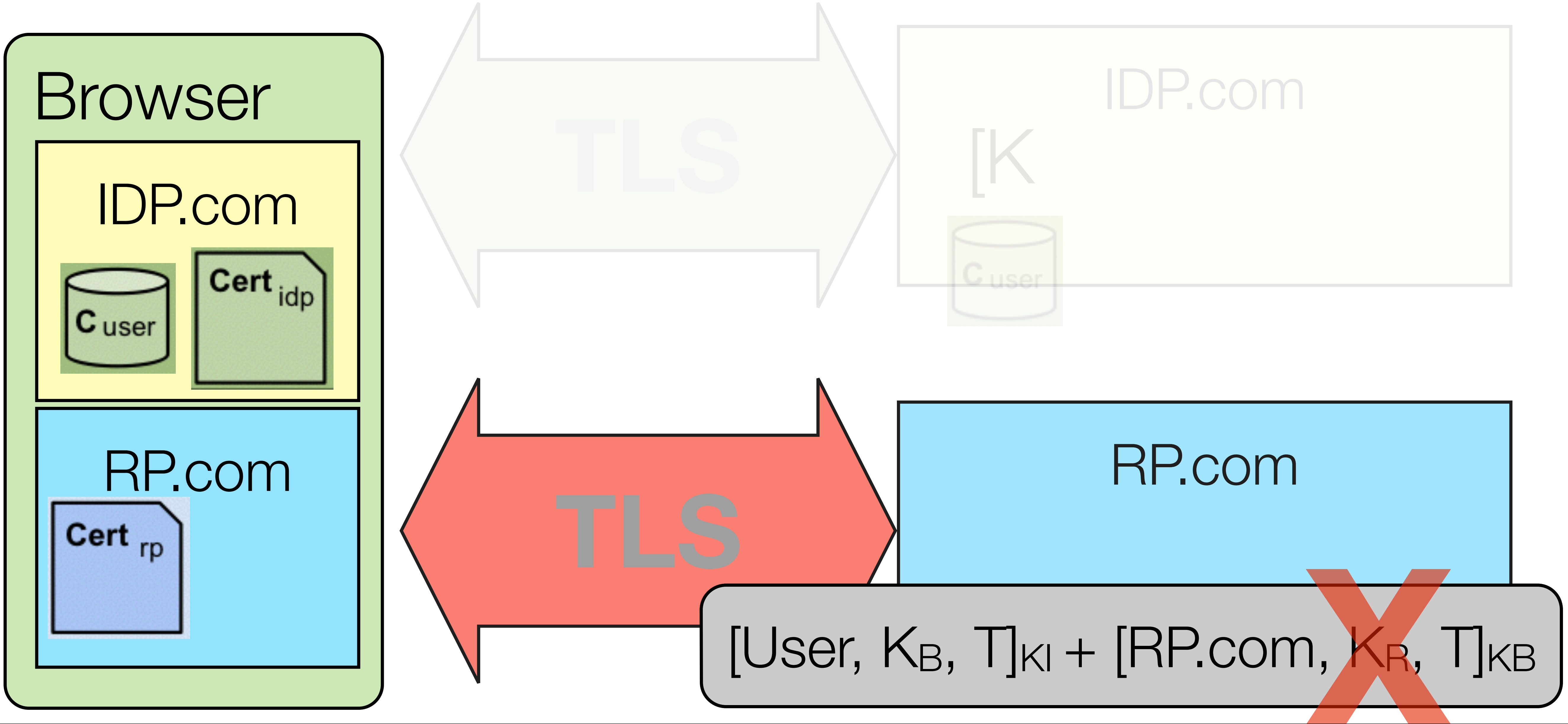

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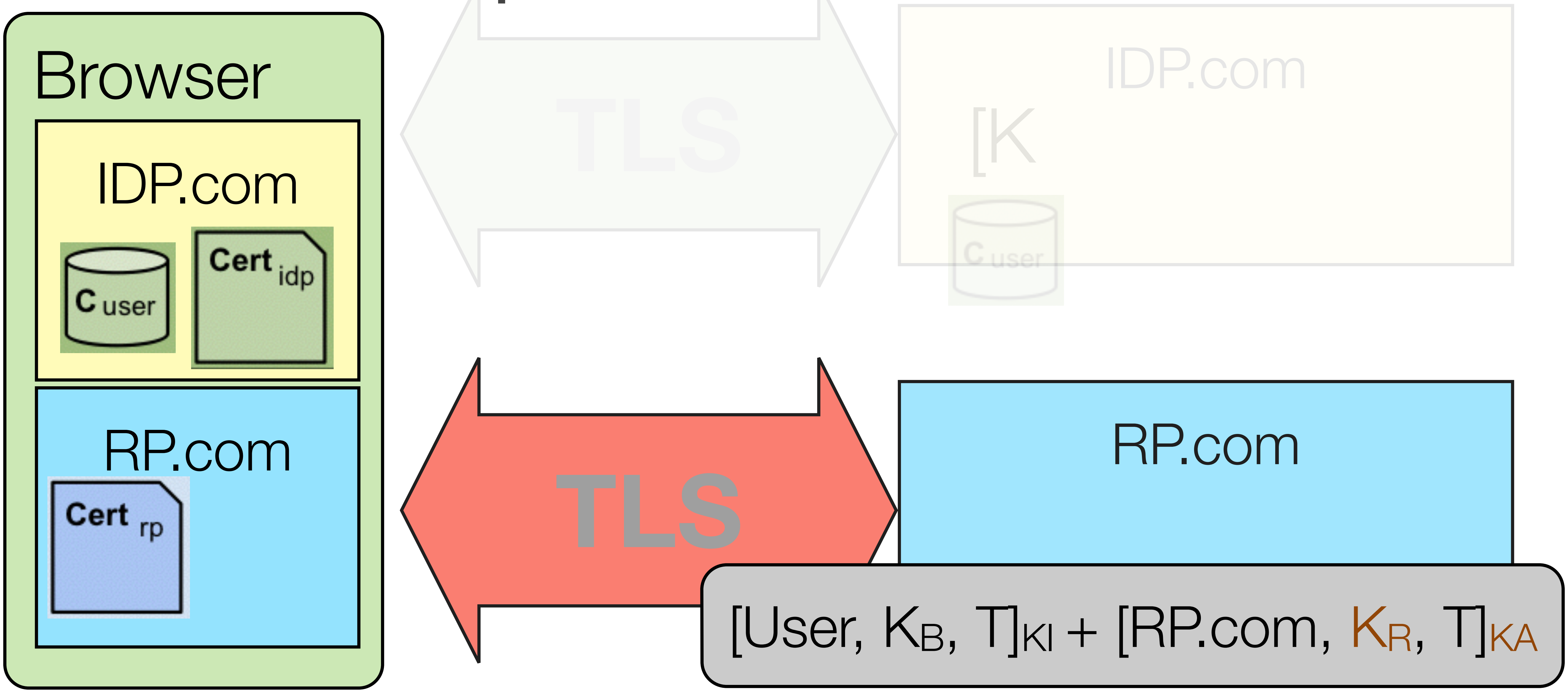
Attack #3

- Attacker between browser and RP
- Attacker impersonates browser



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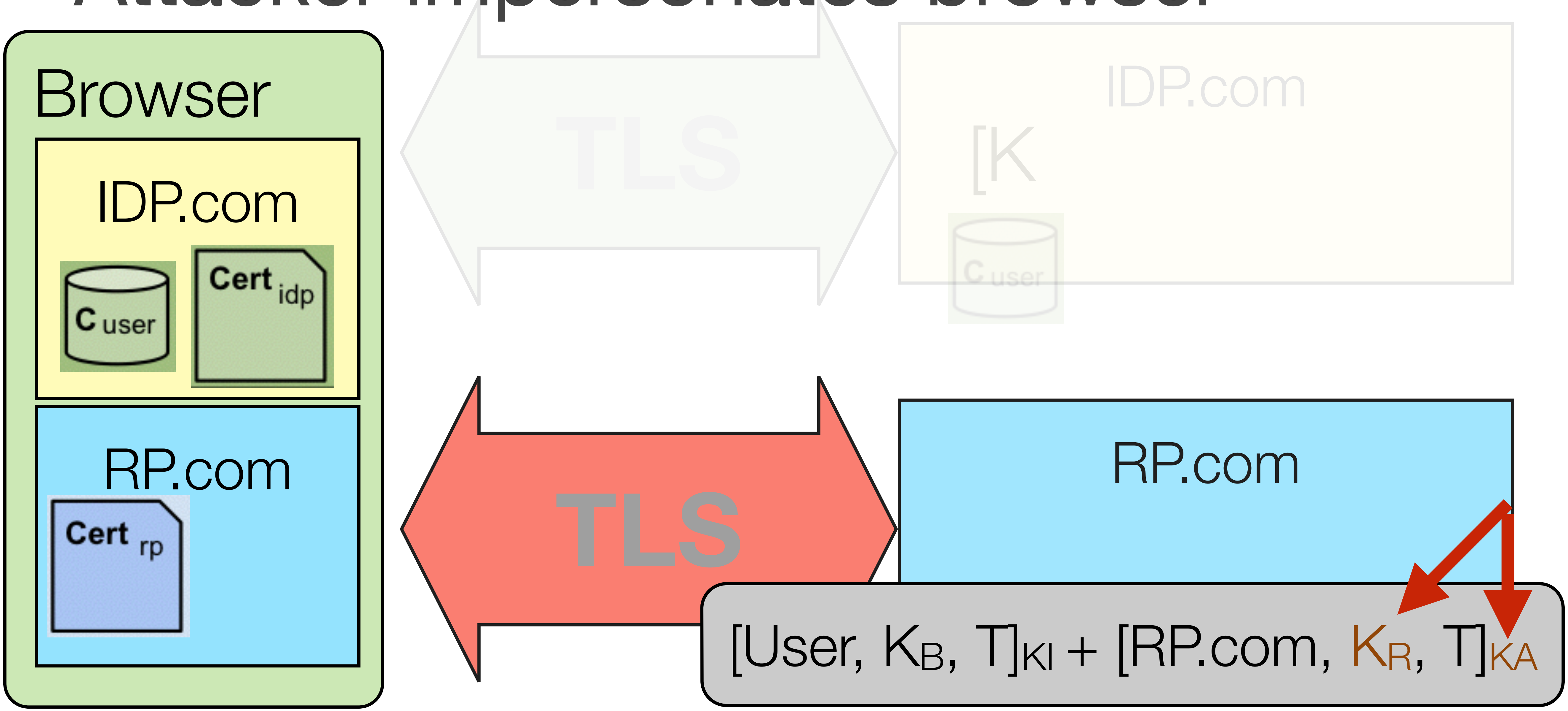

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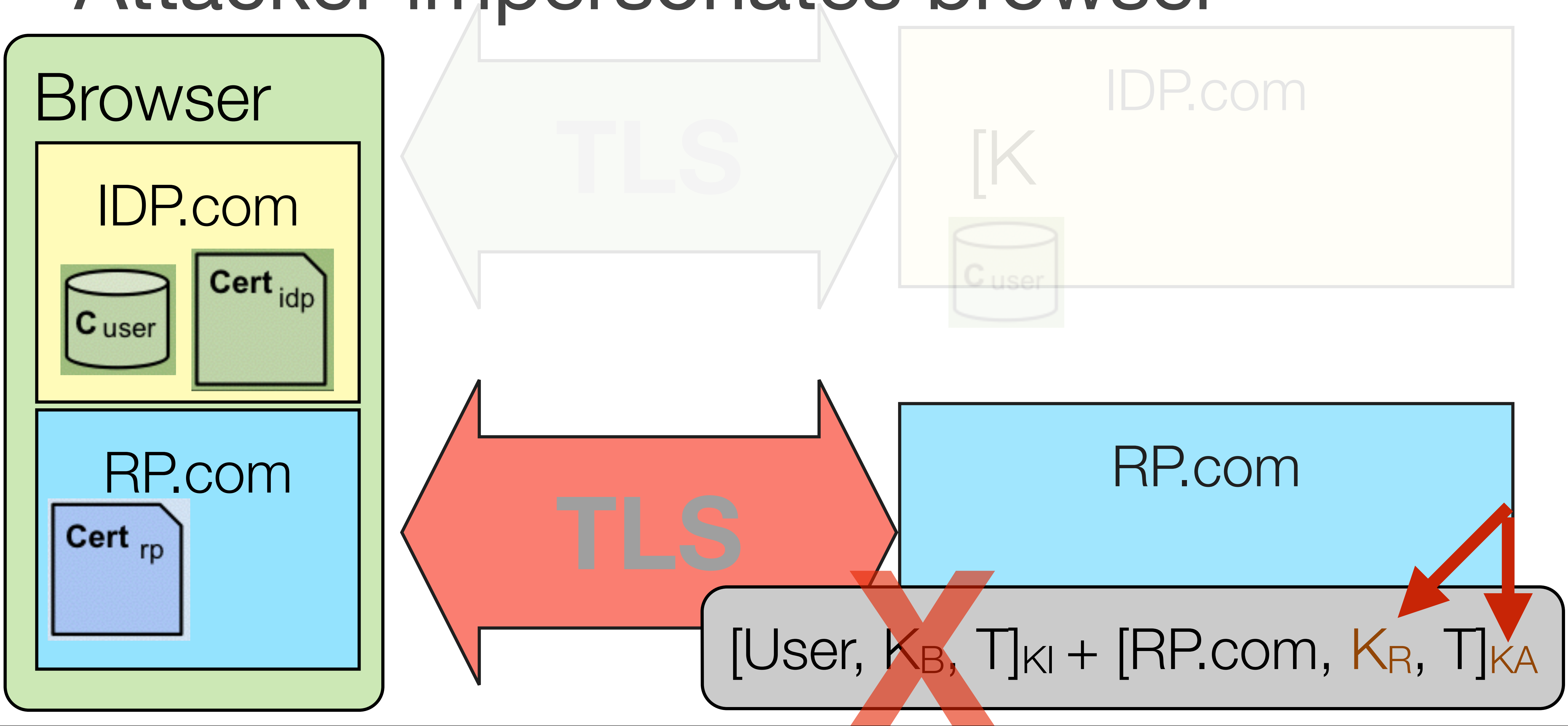
- Attacker between browser and RP
- Attacker impersonates browser



Protocol implementation

- Proof of concept IDP and RP implementations for Persona-OBC-Local
- Both written in Python
  - Use Nexus Authorization Logic proof checker to verify assertions
- BAN logic formalization of both protocols
  - Local and Central variants

Conclusion

- Two persona extensions
  - Better MITM protection for identity assertions
  - Leverage channel between IDP and user to create channel between user and RP
  - RP uses a different key than IDP to communicate with the user (for privacy)

Questions?

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