Alexander Haar

Key exchange using an online trusted third party

Outline

- overview
- TTP protocol
- different insecure Variotions
- conclusion

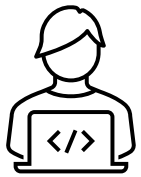
Overview

- TTP must play an active role in all exchanges
- efficient for clients
- heavy load on TTP
- usecase: corporate networks

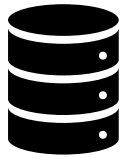
$\mathcal{K}_e$: Cipher key space

$\mathcal{K}_m$: MAC key space

Registration



Peter



TTP

(id_P)

$k_P \xleftarrow{R} (k_{enc,P},\ k_{mac,P}) \in \mathcal{K}_e \times \mathcal{K}_m$

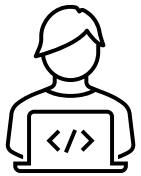
Stores only (id_P) for security reasons

(k_P)

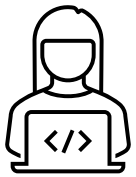
To Generate k_P again:

$k_P \leftarrow F(k_{TTP}, id_P)$

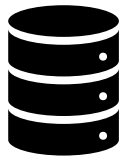
Key Exchange



Peter



Quinn



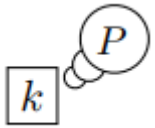
TTP

$r_P \xleftarrow{\$} \{0,1\}^*$

$r_Q \xleftarrow{\$} \{0,1\}^*$

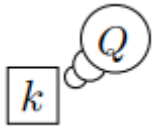
(id_P , r_P)

(r_P , r_Q , id_P, id_Q)



$c_Q := Enc_Q(k)$,
$t_Q := Mac_Q(id_P , r_P, r_Q, c_Q)$

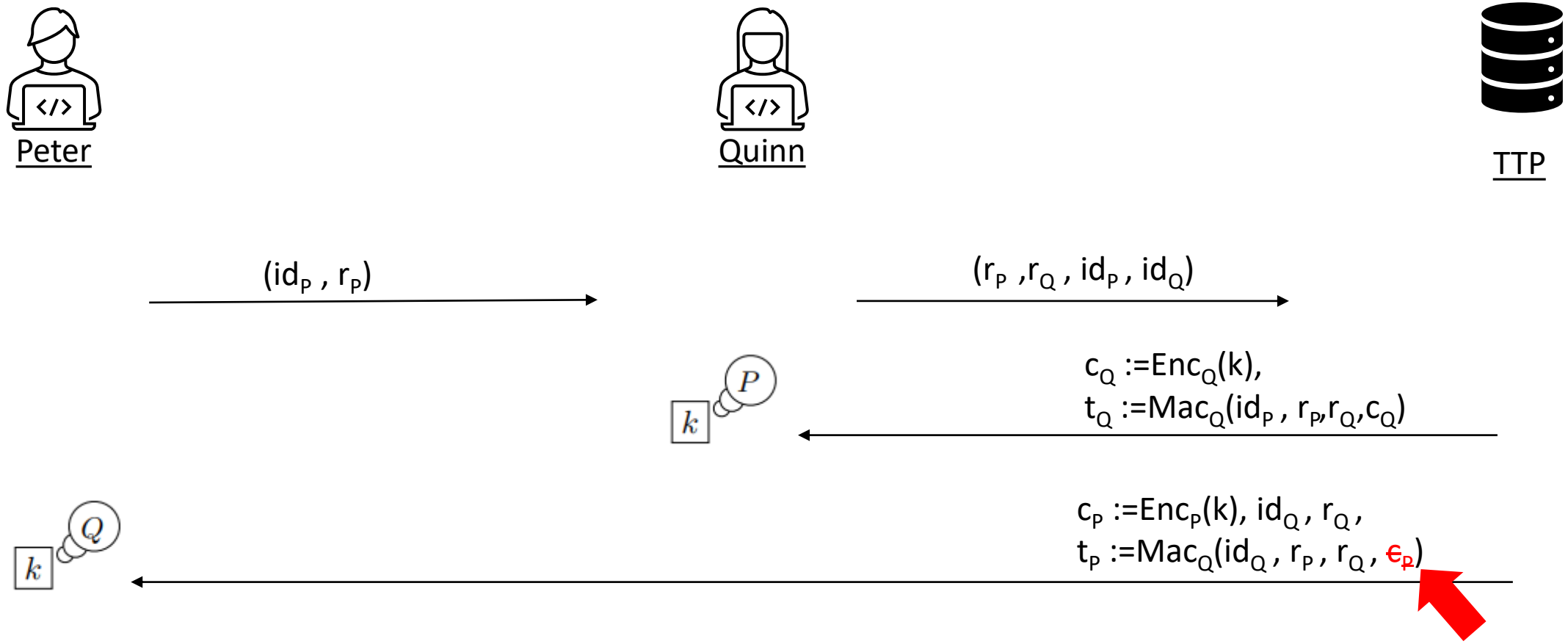
$c_P := Enc_P(k), id_Q , r_Q ,$
$t_P := Mac_Q(id_Q , r_P , r_Q , c_P)$



Insecure Variations

I. **key exposure attack**
II. replay attack
III. identity missbinding attack
IV. secure channel bindings attack

KEA – remove c_P from tag

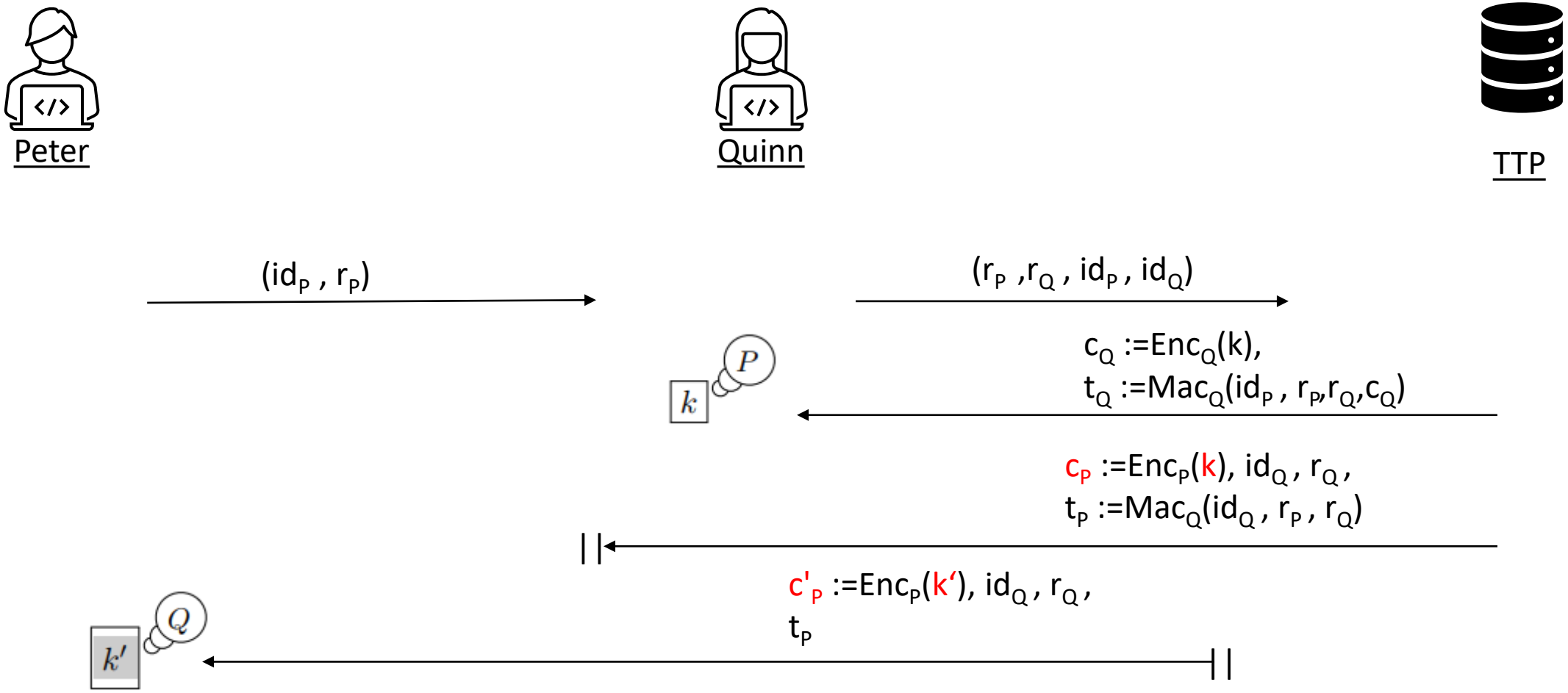


Key exposure attack

first step:

1. Adversary registers new user R
2. Initialize a conversation with Peter
3. Obtains $c_R := Enc_R(k')$ and decrypts it to obtain k´

KEA – second step



Key exposure attack

- adversary can now read every message from Peter
- same attack can be used against Quinn
  - Replace $\mathbf{c_Q}$ where $\mathbf{c'_Q} := Enc_Q(k')$

Insecure Variations

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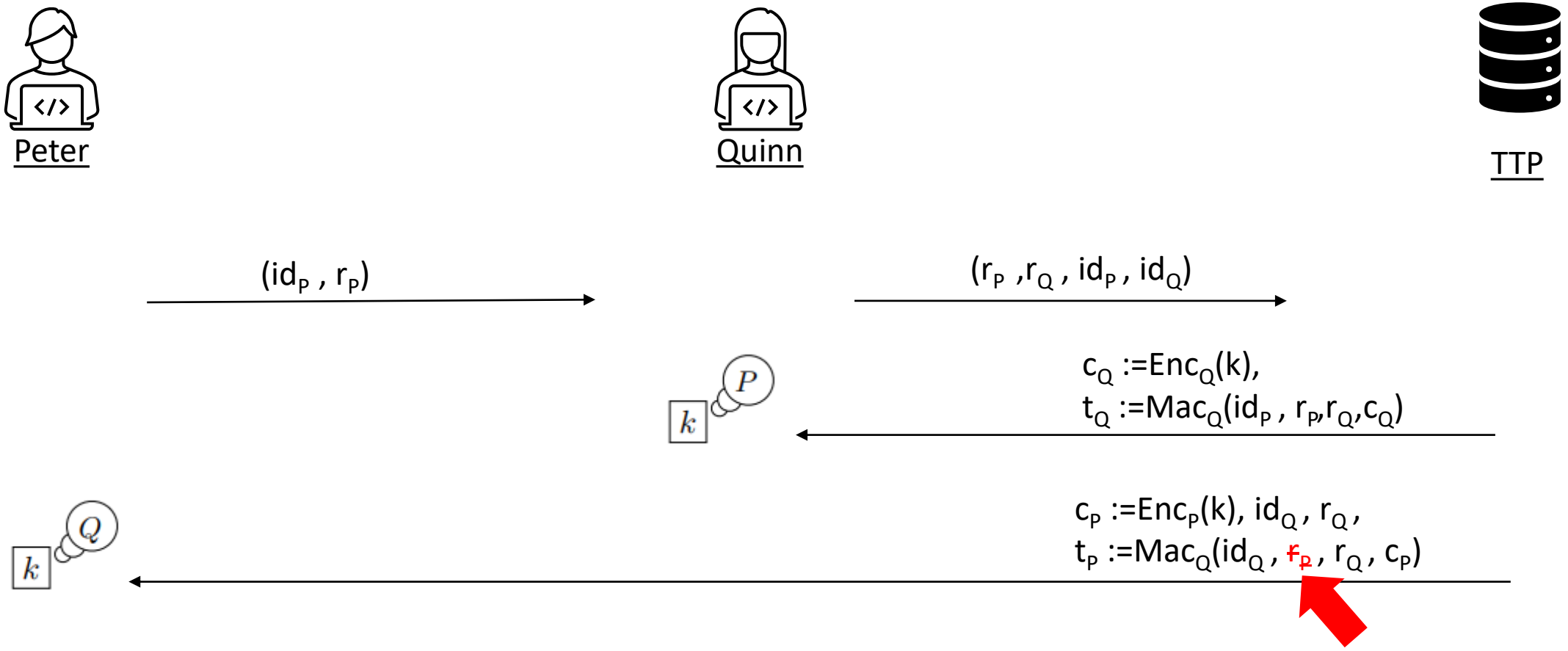
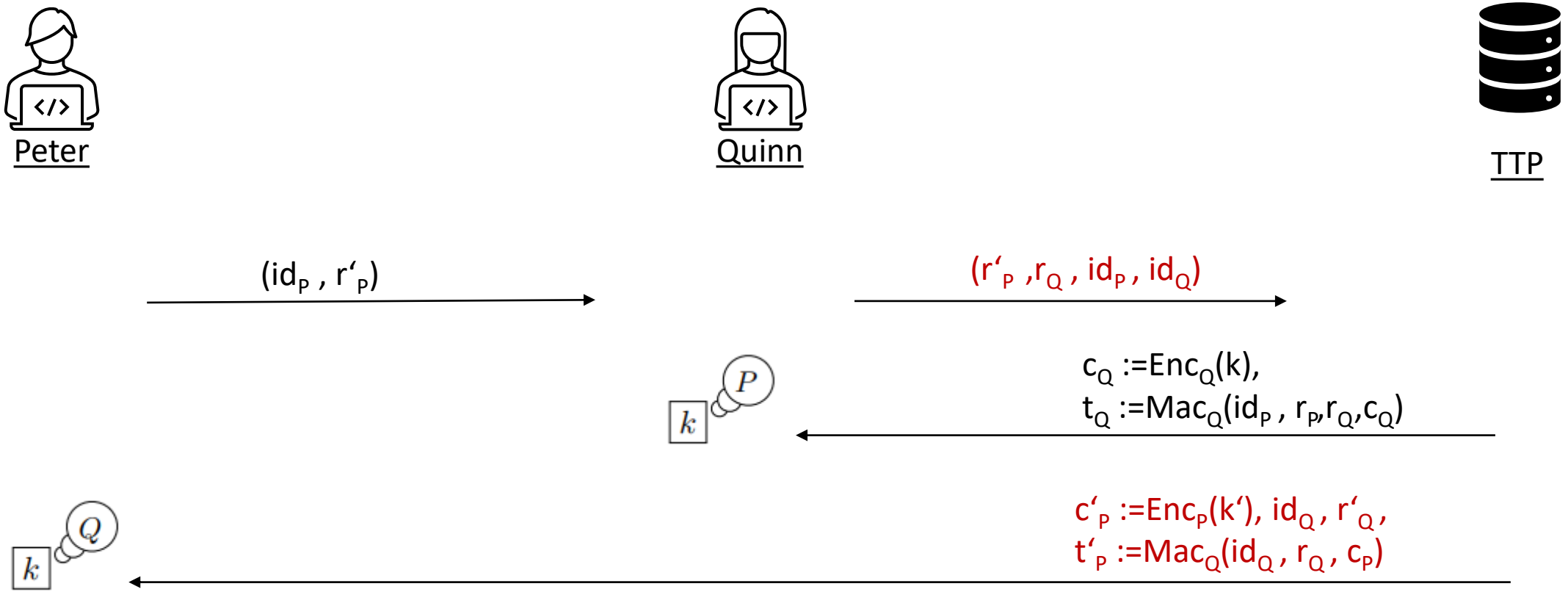
RA – remove r_P from tag



RA – remove r_P from tag



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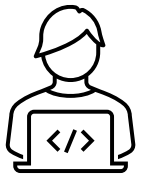
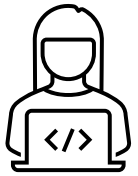


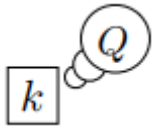
Peter



Quinn

(id_P , r_P)

||

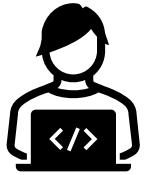


$c'_P := Enc_P(k'), id_Q , r'_Q ,$
$t'_P := Mac_Q(id_Q , r_Q , c_P)$

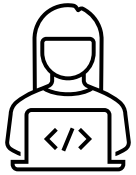
||

Peter thinks he is talking to Quinn
but he is holding the old session key k‘

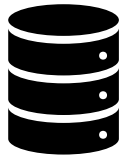
RA – attack on Quinn



Adversary



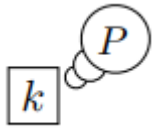
Quinn



TTP

(id_P , r'_P)

$(r'_P , r_Q , id_P , id_Q)$



$c_Q := Enc_Q(k)$,
$t_Q := Mac_Q(id_P , r'_P , c_Q)$
||

$c'_Q := Enc_Q(k')$,
$t'_Q := Mac_Q(id_P , r'_P , c_Q)$
||

Quinn thinks she is talking to Peter
but is holding the old session key k‘

Insecure Variations

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III. identity missbinding attack
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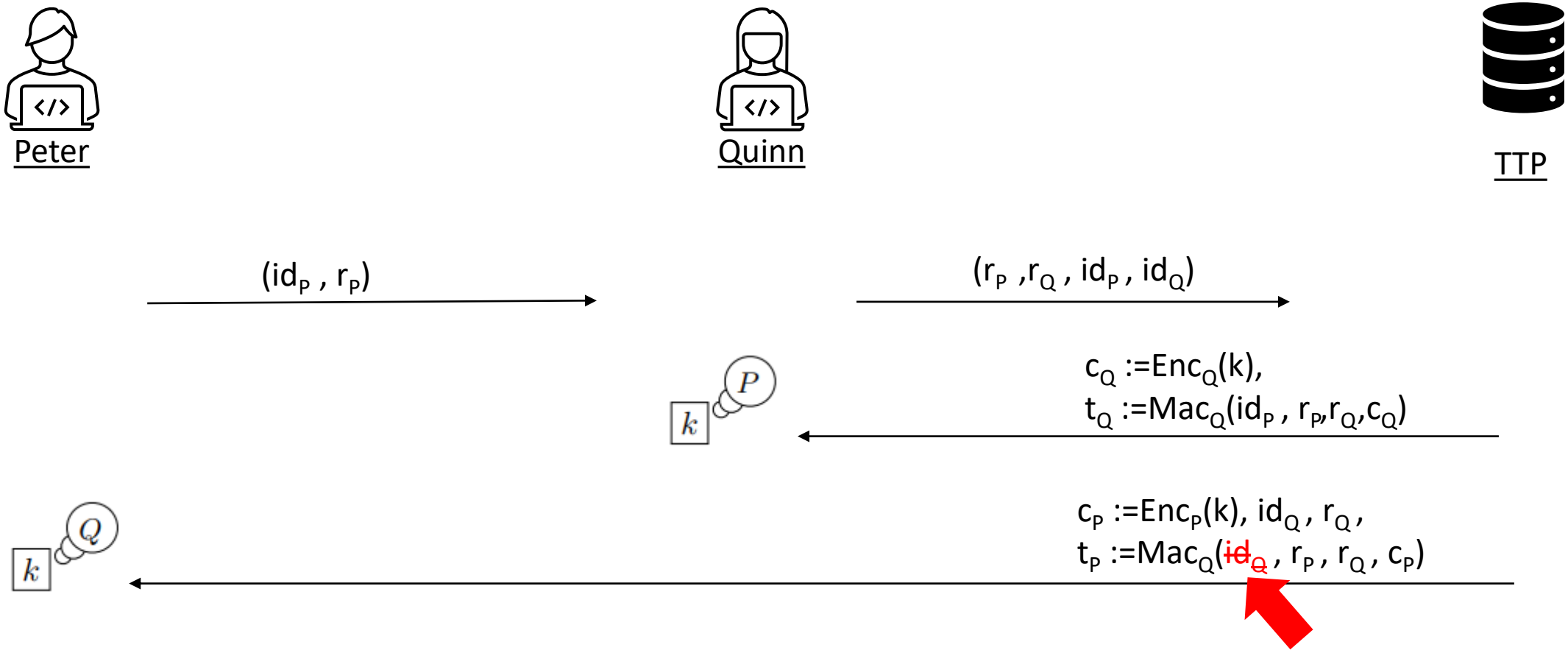
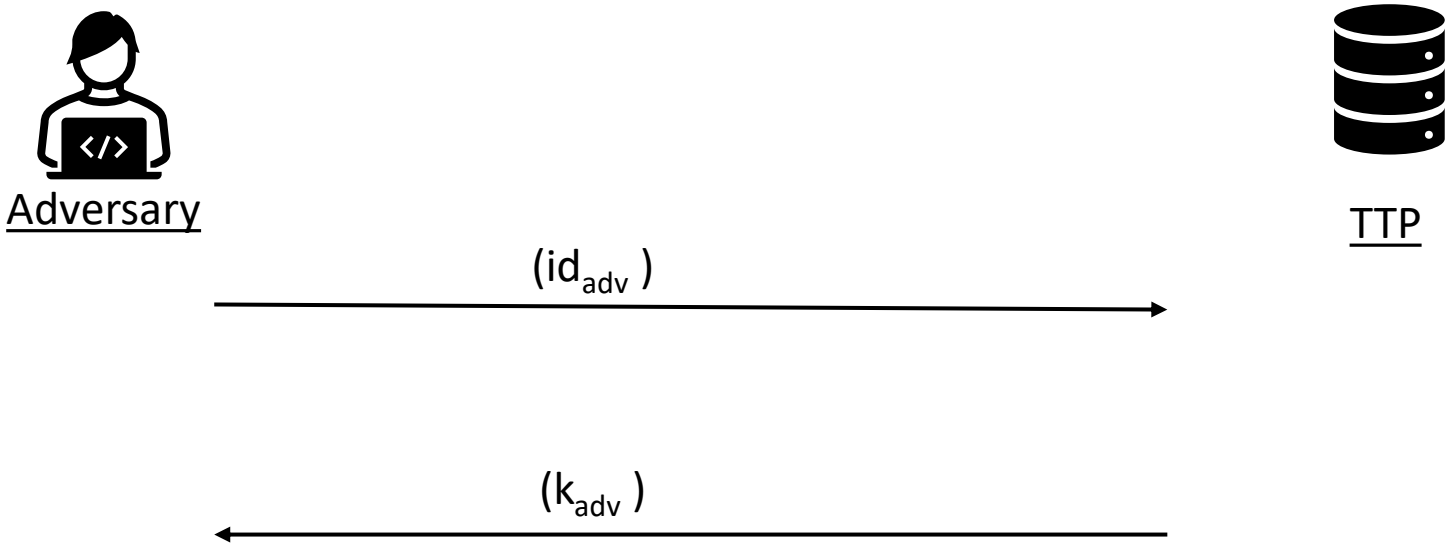
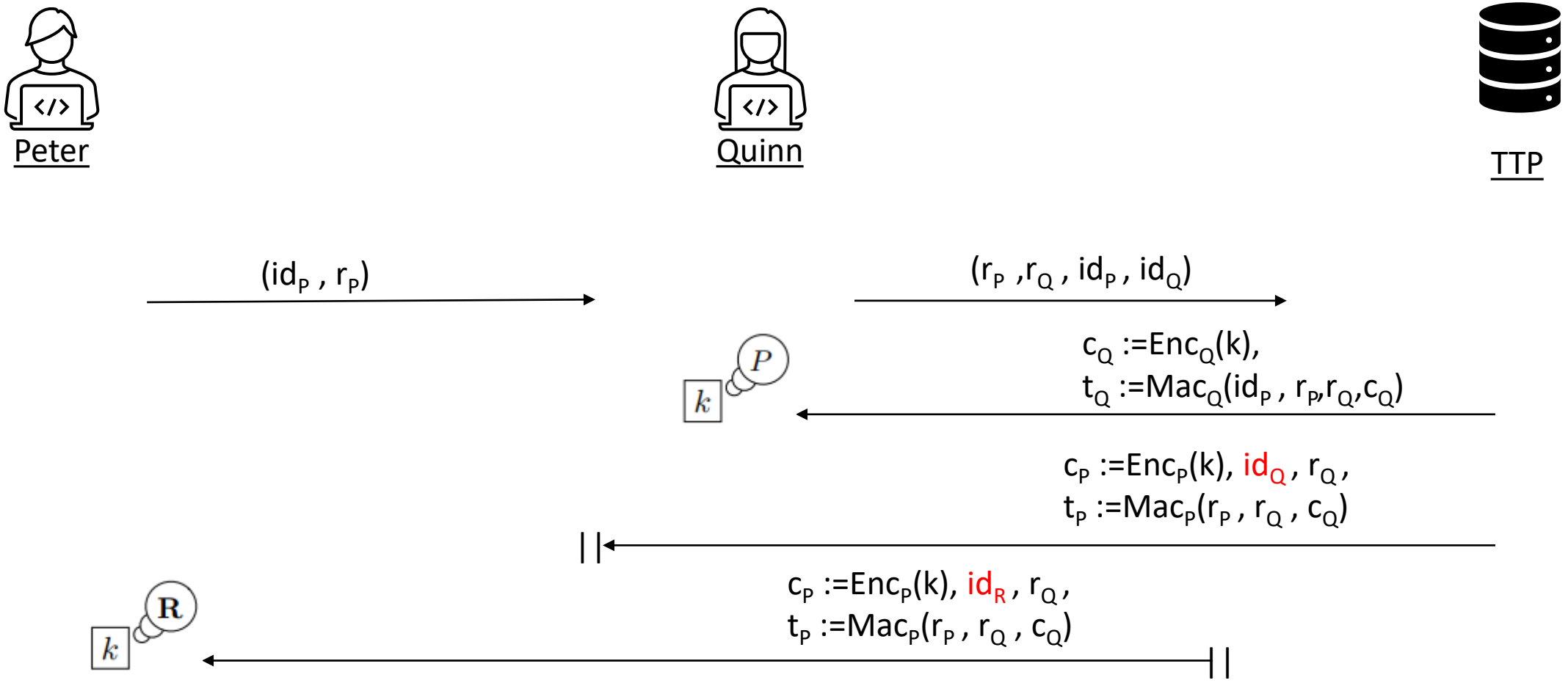
IMA – remove id_Q from tag



Adversary Registration



IMA – remove id_Q from tag

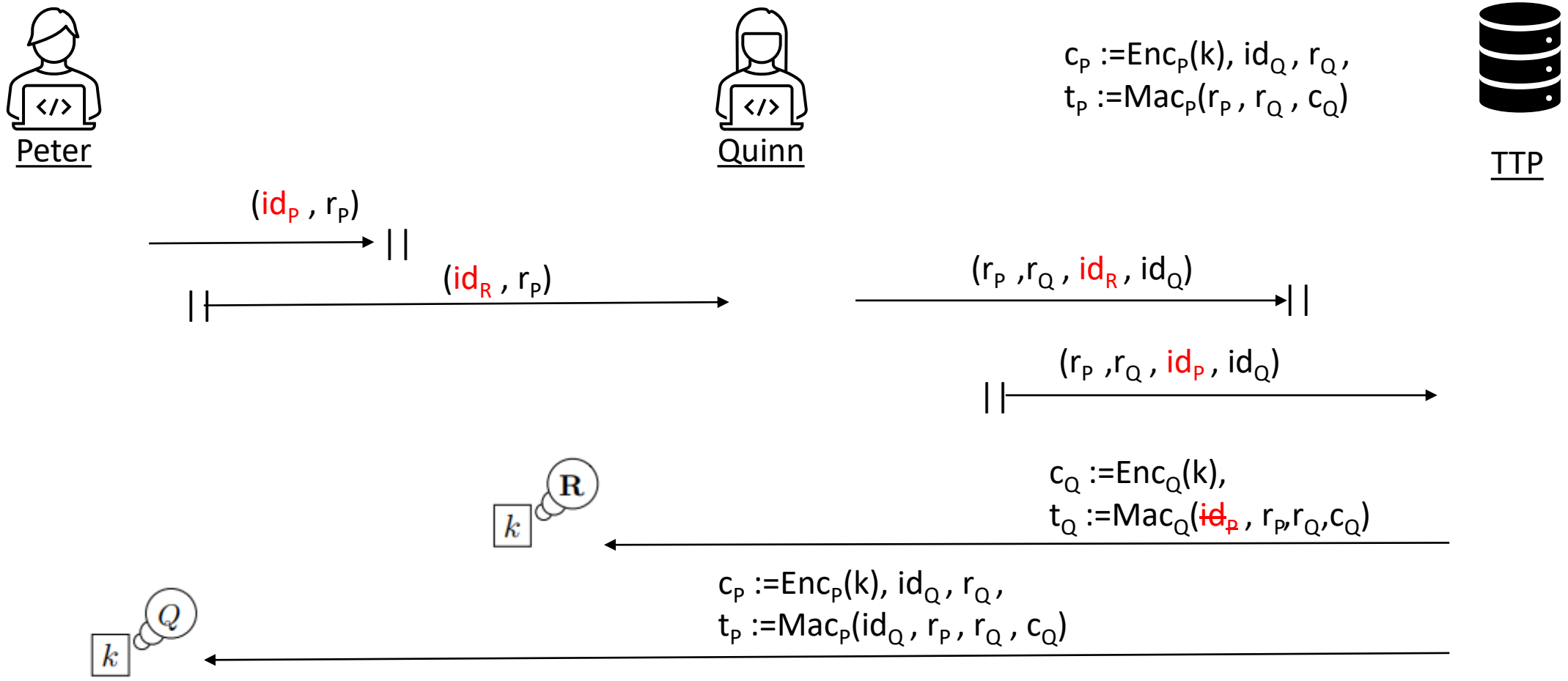


IMA – remove id_Q from tag

- both user share the same key k
- Adversary has no information on k

=> parties are misbound

IMA – attack on Quinn



Insecure Variations

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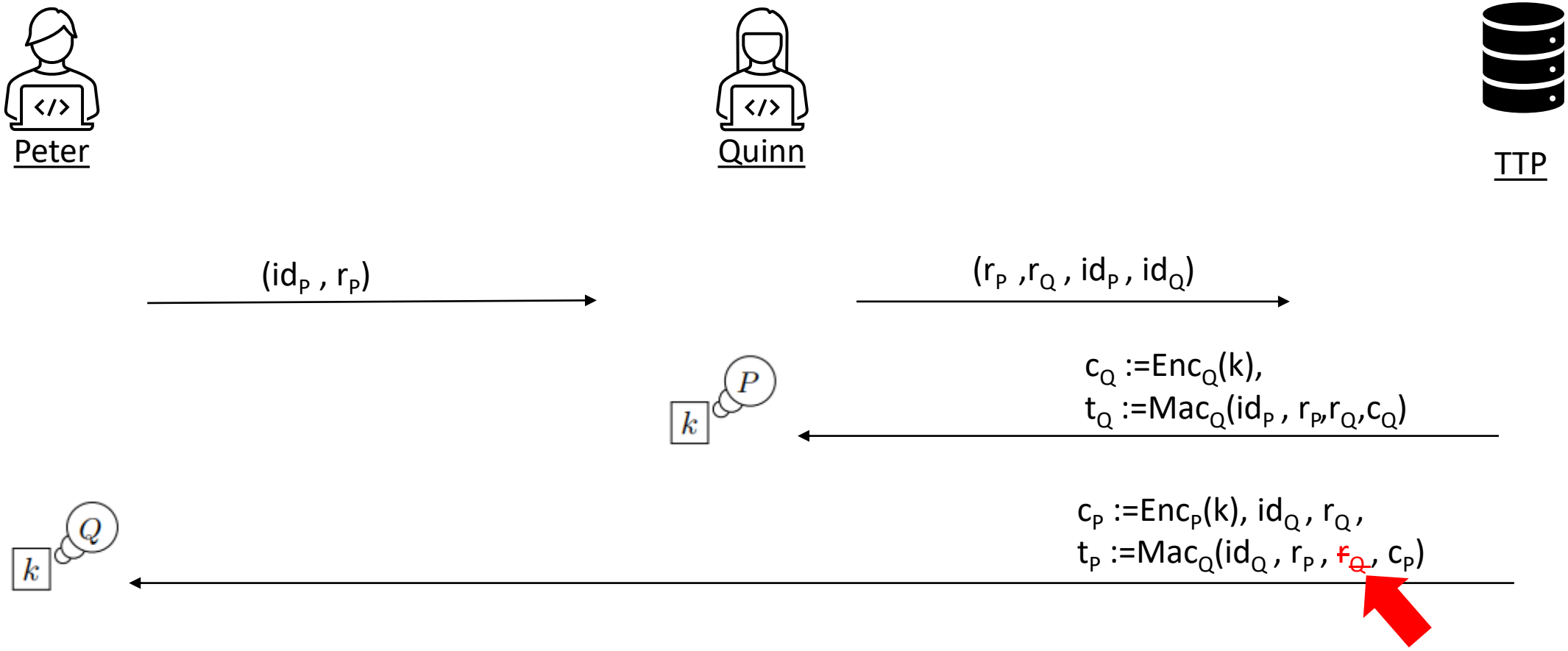
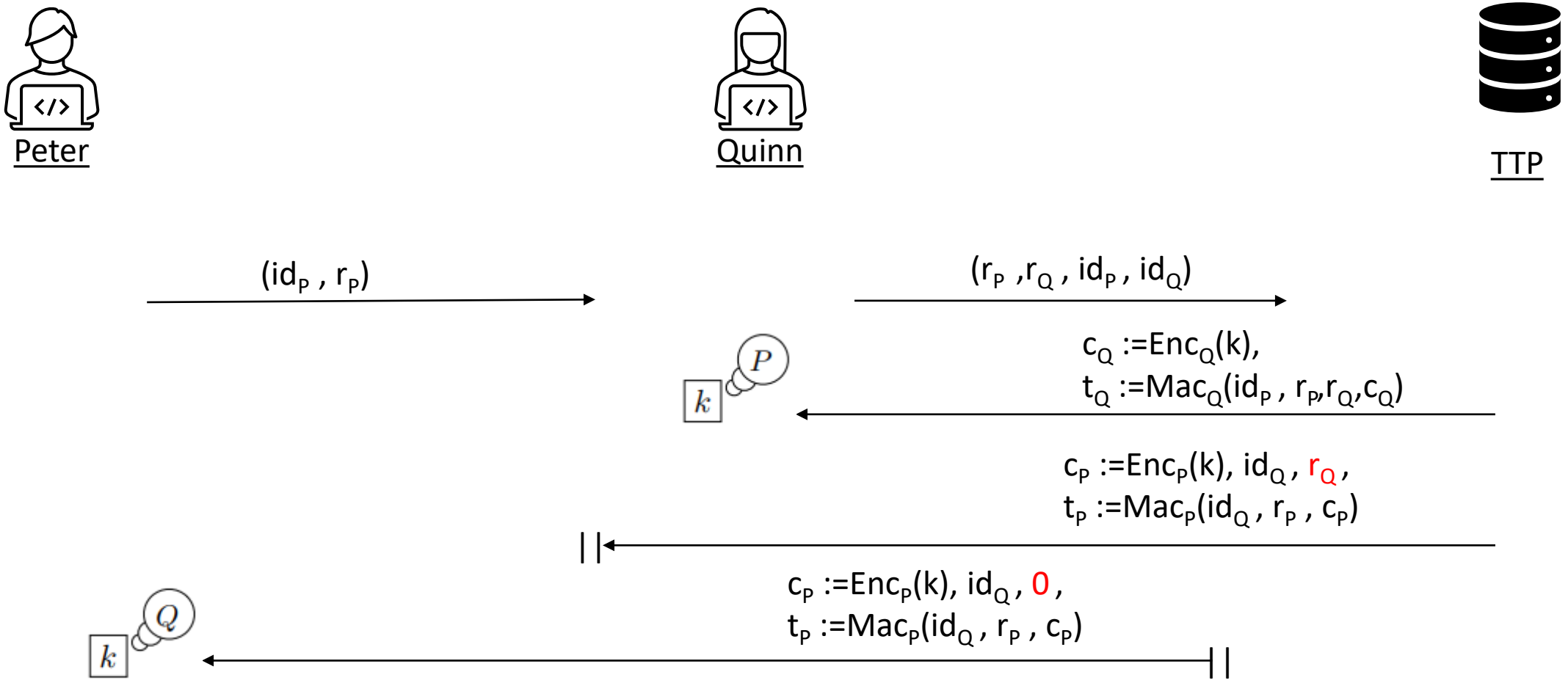
SCBA – remove r_Q from tag



SCBA – remove r_Q from tag



SCBA – remove r_Q from tag

- both sides agree on session key k
- k is unknown to the adversary
- disagree on their channel bindings

Conclusion

- TTP is a statically secure key exchange protocol
- can provide secure channel bindings
- Not PFS secure
  - If adv. learns either P's key, Q's key, or the TTP's key
  - All past sessions between P and Q are exposed

Ressource

- Dan Boneh and Victor Shoup „A Graduate Course in Applied Cryptography” Version 0.6, Jan 2023 https://crypto.stanford.edu/~dabo/cryptobook/BonehShoup_0_6.pdf