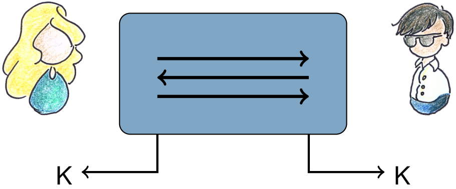
0-RTT Key Exchange with Full Forward Secrecy

Felix Günther

Technische Universität Darmstadt, Germany

joint work with Britta Hale, Tibor Jager, and Sebastian Lauer

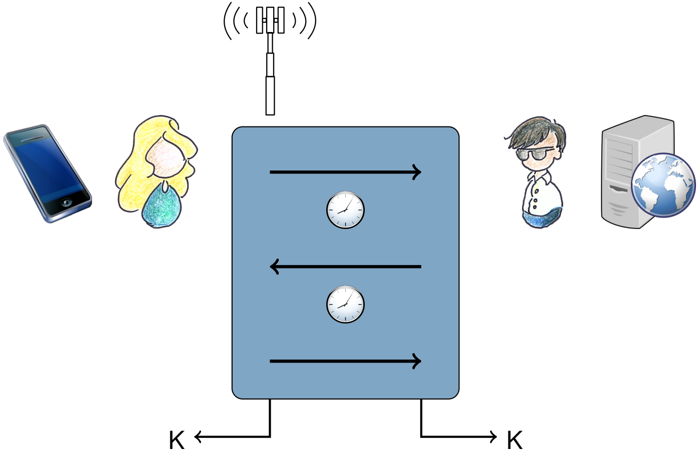
Key Exchange



drawings by *Giorgia Azzurra Marson*

Key Exchange

can be a bottleneck



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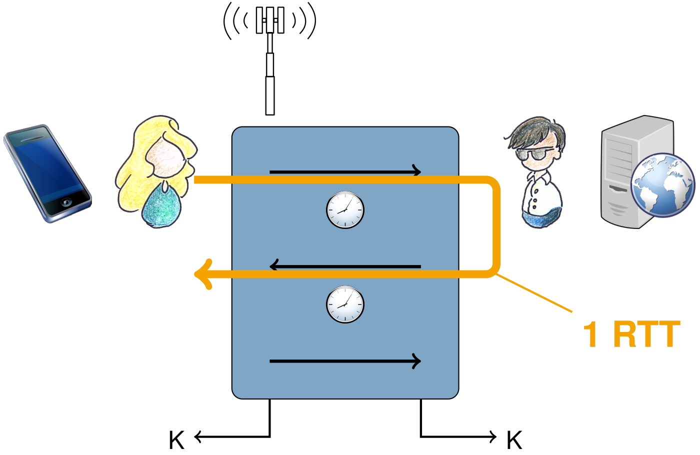

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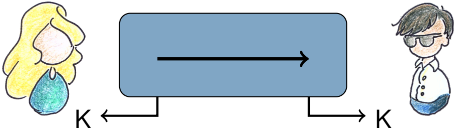
Solution: 0-RTT Key Exchange



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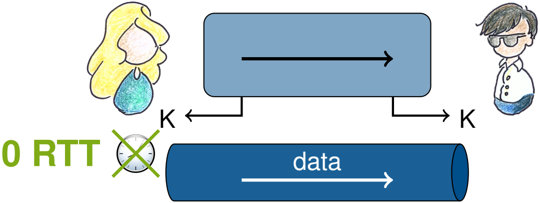

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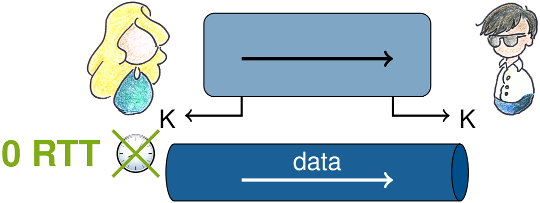
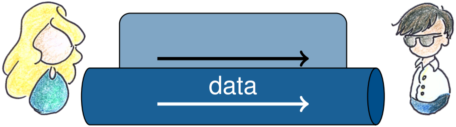


- theoretically not new
- in practice: **QUIC** (2013), **TLS 1.3** (2015+)

Problems with 0-RTT Key Exchange



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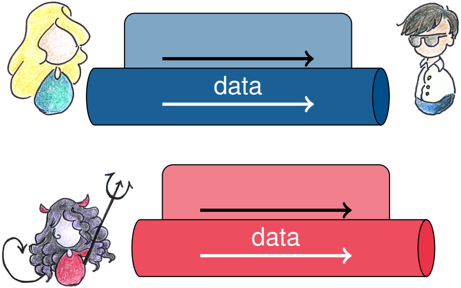

replays

(partially unavoidable)

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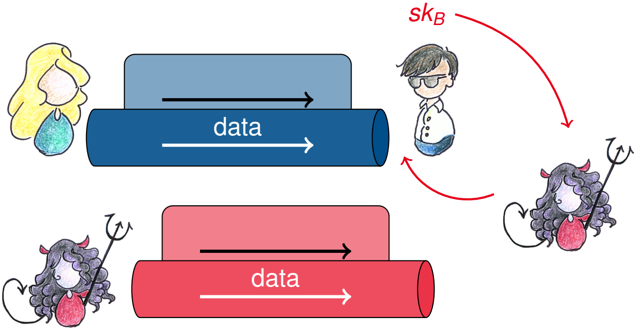

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no forward secrecy
(considered inherent)

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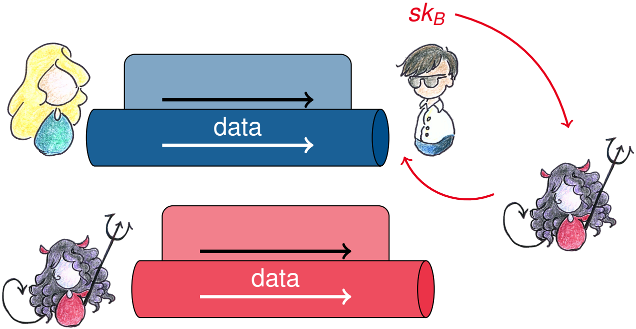

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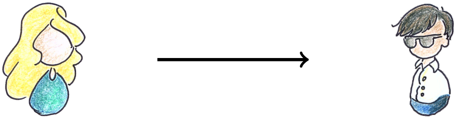
A Similar Scenario: Asynchronous Messaging

wants to send M



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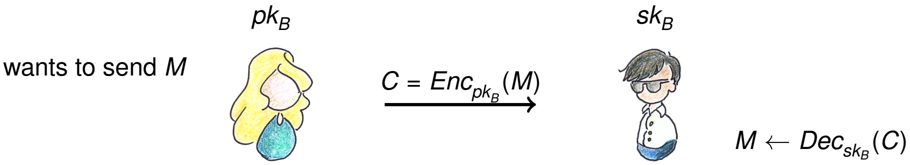

pk_B

wants to send M

$C = Enc_{pk_B}(M)$ $\xrightarrow{\quad}$

sk_B

$M \leftarrow Dec_{sk_B}(C)$

- public-key encryption

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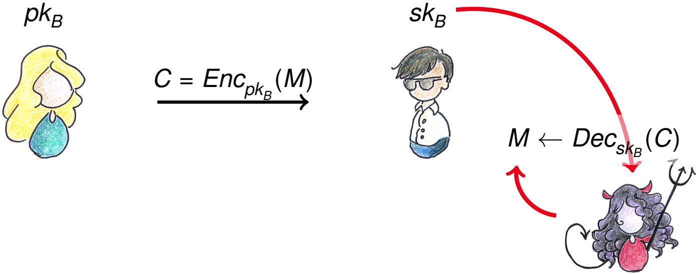

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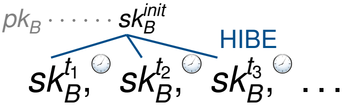
$pk_B \cdots\cdots sk_B^{init}$

HIBE

$sk_B^{t_1}, \; sk_B^{t_2}, \; sk_B^{t_3}, \; \ldots$

pk_B

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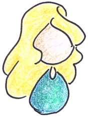

$\xrightarrow{C = Enc^{t_2}_{pk_B}(M)}$

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- public-key encryption with coarse **forward secrecy** (CHK'03)

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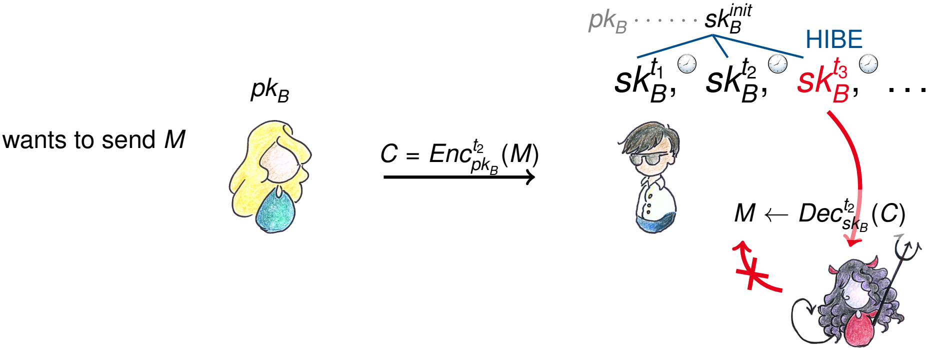

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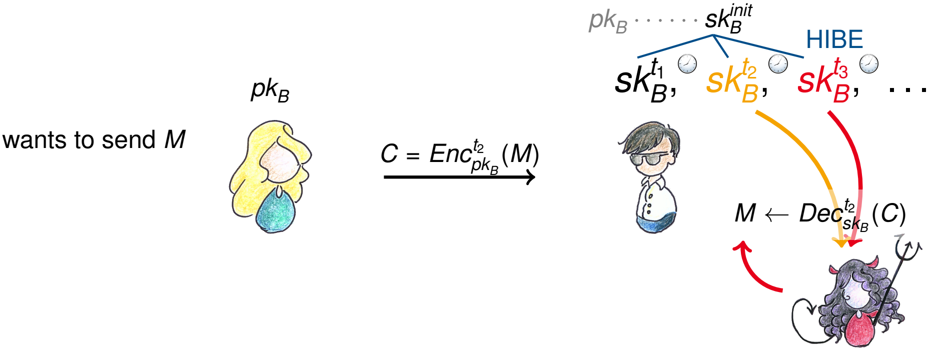

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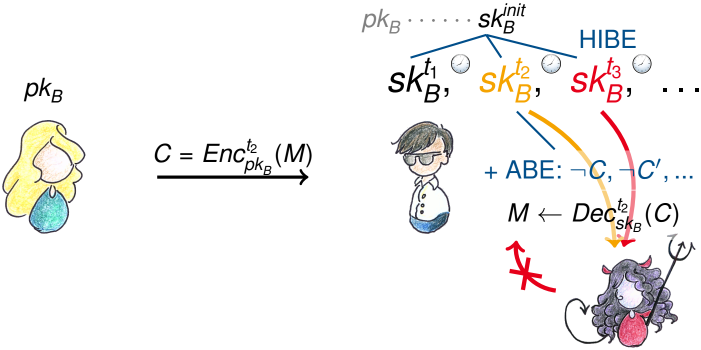

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- fine-grained **puncturable forward-secret encryption** (GM'15)

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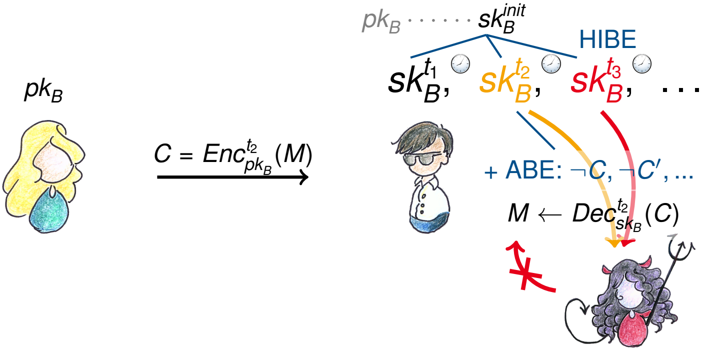

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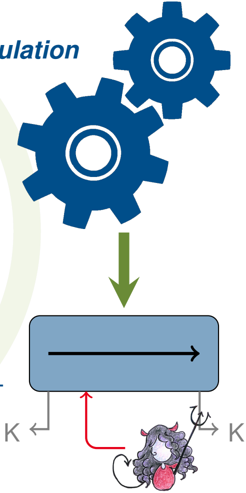
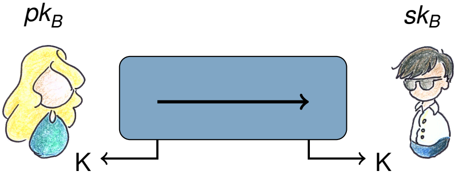
  - we build generically from any HIBKEM
  - can replace involved blend of HIBE+ABE [GM'15]
  - CCA-secure in the standard model
- **forward-secret 0-RTT key exchange**
  - we build from any PFSKEM
  - formalize key exchange security with forward-secret 0-RTT



Our Forward-Secret 0-RTT Key Exchange

In a Nutshell



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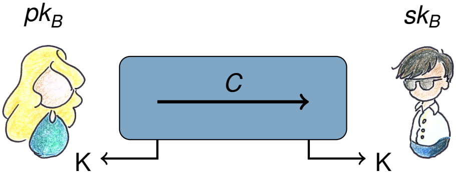

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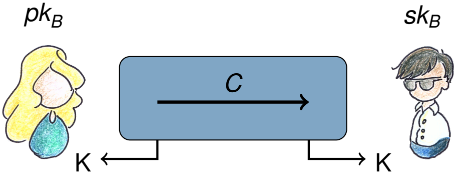

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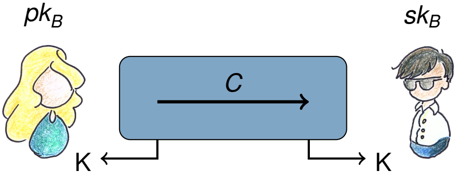

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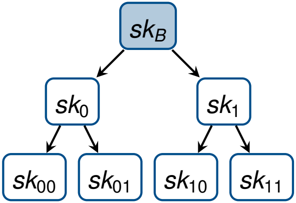

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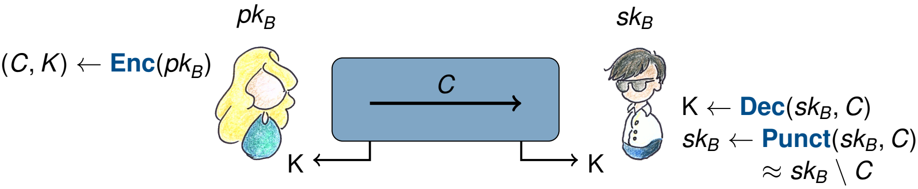

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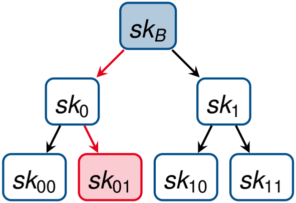

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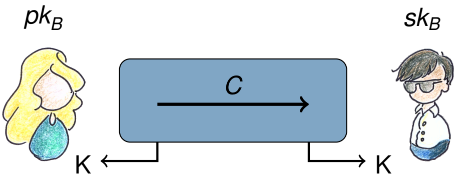

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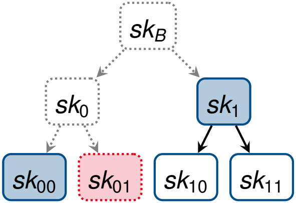

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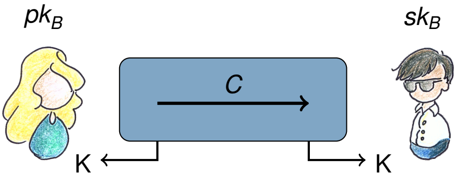

pk_B

sk_B

C

K

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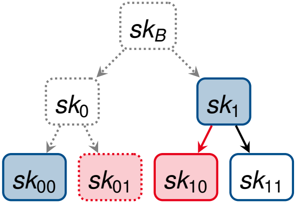

sk_B

sk_0

sk_1

sk_{00}

sk_{01}

sk_{10}

sk_{11}

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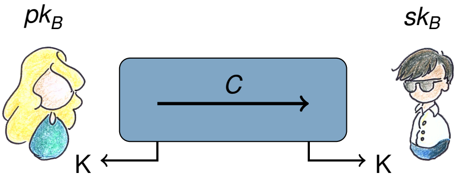

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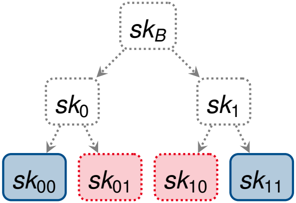

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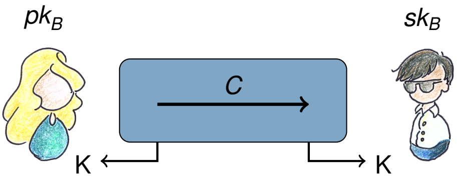

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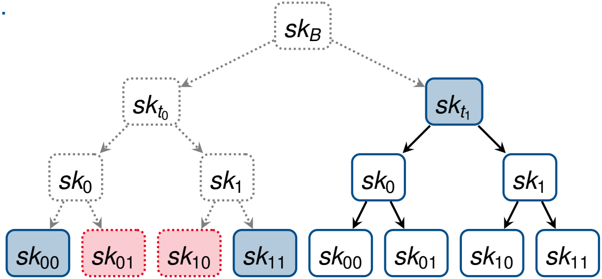
sync. time intervals $t_0, t_1, \ldots$



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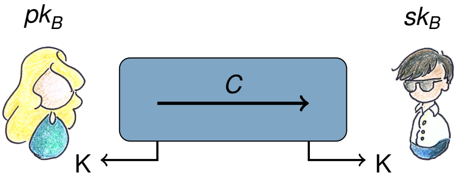

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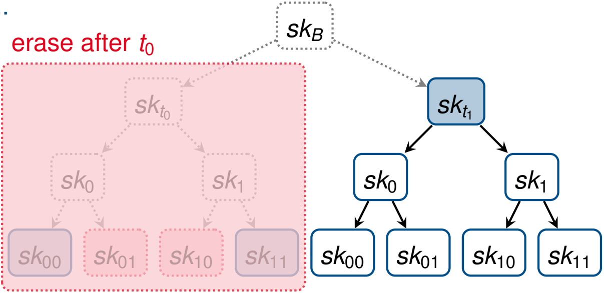

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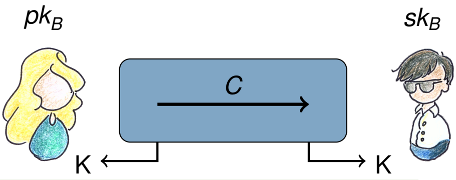

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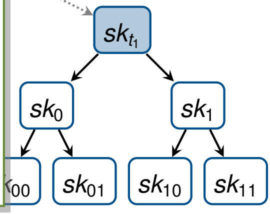
Evaluation



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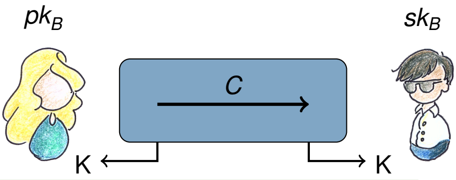

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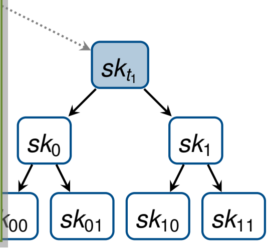
✓ full forward secrecy



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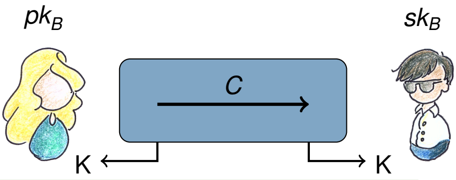

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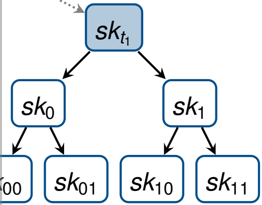

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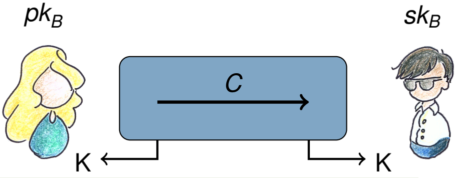

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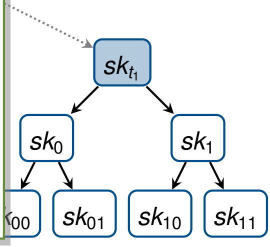

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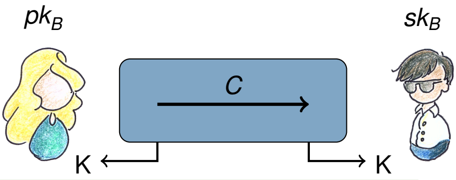

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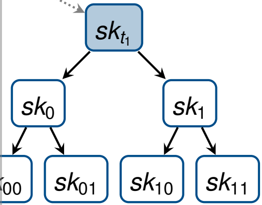
- time performance:
  ✓ **Enc** few ms



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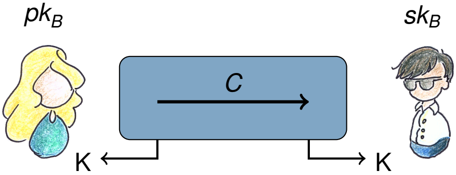

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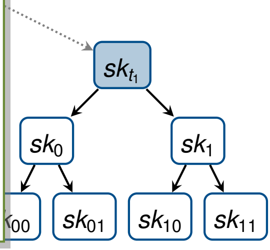
- time performance:

✓	**Enc**	few ms
?	**Dec**	few seconds



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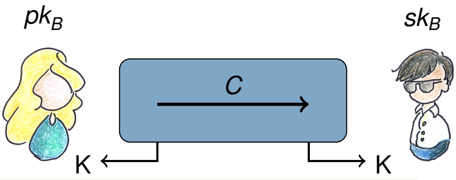

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Evaluation (initial, based on BKP'14 HIBE)

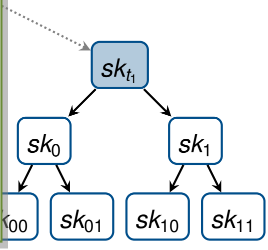
✓ full forward secrecy

✓ replay protection

- time performance:

✓	**Enc**	few ms
?	**Dec**	few seconds
✗	**Punct**	few minutes

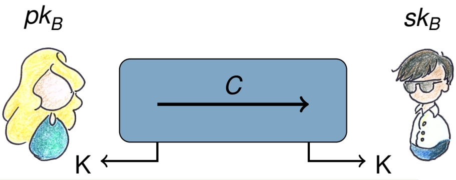
$\left.\right\}$ expensive delegation



Our Forward-Secret 0-RTT Key Exchange

In a Nutshell

$(C, K) \leftarrow \textbf{Enc}(pk_B)$



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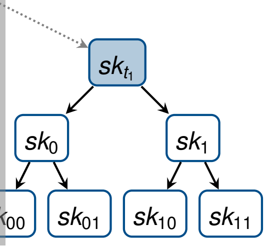
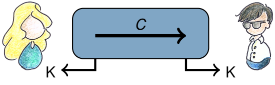
hope: need only **selective security**



Summary

Summary

- **Fully forward-secret 0-RTT key exchange exists!**



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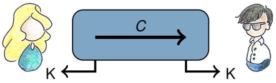

$K \leftarrow \textbf{Dec}(sk_B, C)$

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- Generic construction and security proof
  - very simple single-message protocol
  - building block: puncturable forward-secret key encapsulation
  - from any HIBKEM

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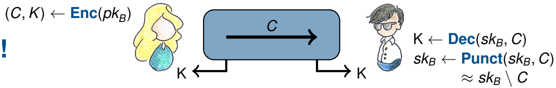

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C

K

K

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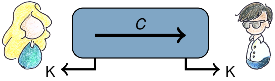

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Thank You!

mail@**felixguenther.info**

P.S. Britta and Felix plan on finishing their Ph.D. in the next year resp. months and interesting job offers are always welcome.