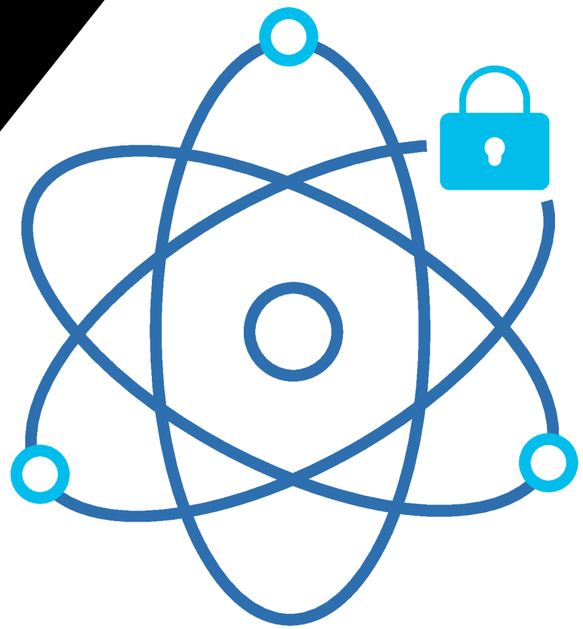

Post Quantum Cryptography in Voice/Video over IP

presented by Johan Pascal

February *4th, 2023*

linphone

open source VOIP project

Agenda

I. Context

II. ZRTP overview

III. Post Quantum Key Exchange Mechanism (KEM)

IV. ZRTP adaptation

V. Hybrid KEM

VI. Focus and Conclusion

I. CONTEXT

Quick intro

Linphone

- Is around since 2001
- Is available on GNU/Linux, android, iOS, Windows, Mac
- Uses SIP standards for audio, video and instant messaging
- Secure group messaging using a Signal protocol derivative

Linphone's team also provides

- Flexisip, an open source SIP Proxy
- A free SIP service sip.linphone.org

Media stream encryption

Media Stream encryption: SRTP

- Authenticated Encryption
- AES128,192,256 - Counter Mode or GCM
- RFCs 3711, 6188, 7714
- Requires an external key management

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SRTP key management

- SDES (RFC4568): key exchanged in SDP
  - SIP proxy can decrypt media streams
- DTLS-SRTP (RFC5764): key exchanged during a DTLS handshake
  - Requires PKI
- ZRTP (RFC6189): key exchange based on (EC)DH
  - No trusted third party required but vocal short authentication string (SAS) comparison

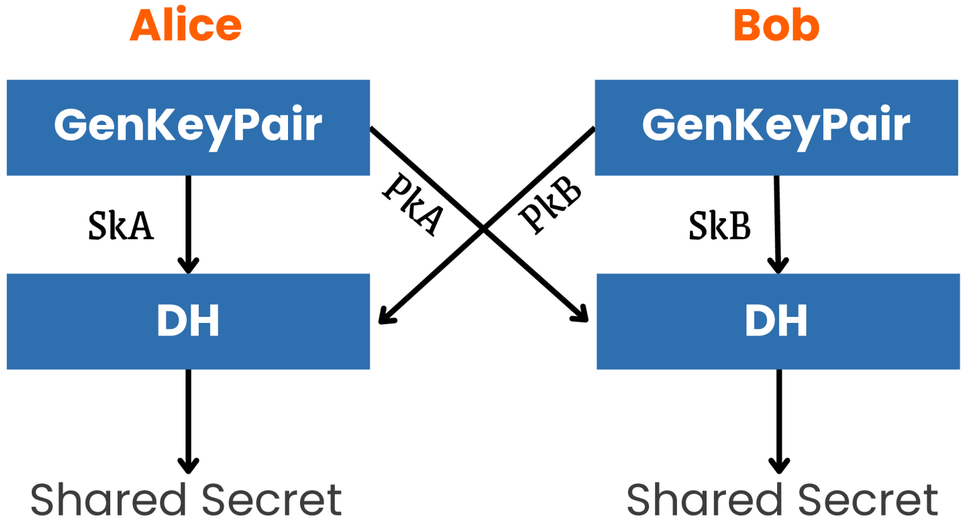
II. ZRTP OVERVIEW

ZRTP overview

- RFC6189, April 2011
- handshake performed on the media stream (over UDP)
- Provides key continuity feature and MitM attack detection
- Based on Diffie-Hellman key exchange

Diffie-Hellman

- *SecretKey, PublicKey = GenKeyPair()*
- *SharedSecret = DH(SelfSecretKey, PeerPublicKey)*



ZRTP overview

Diffie-Hellman

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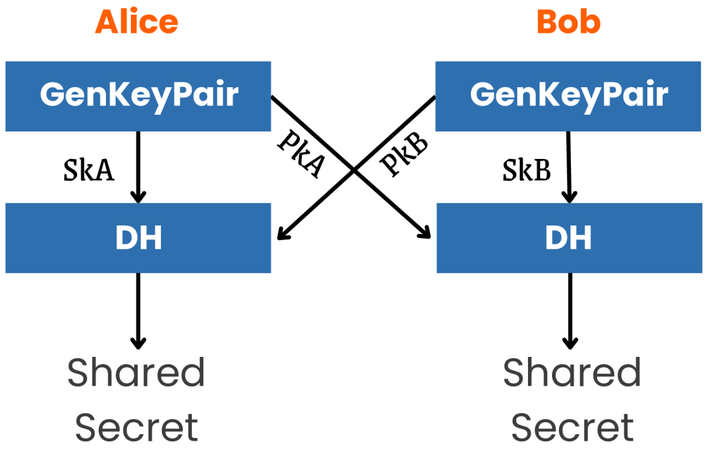
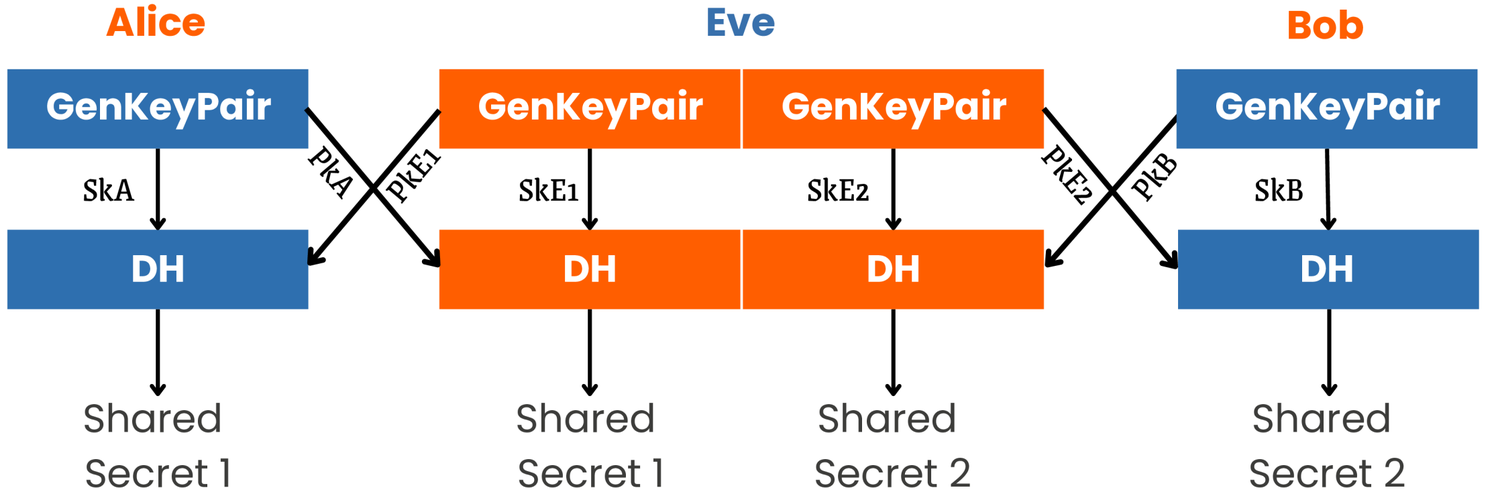
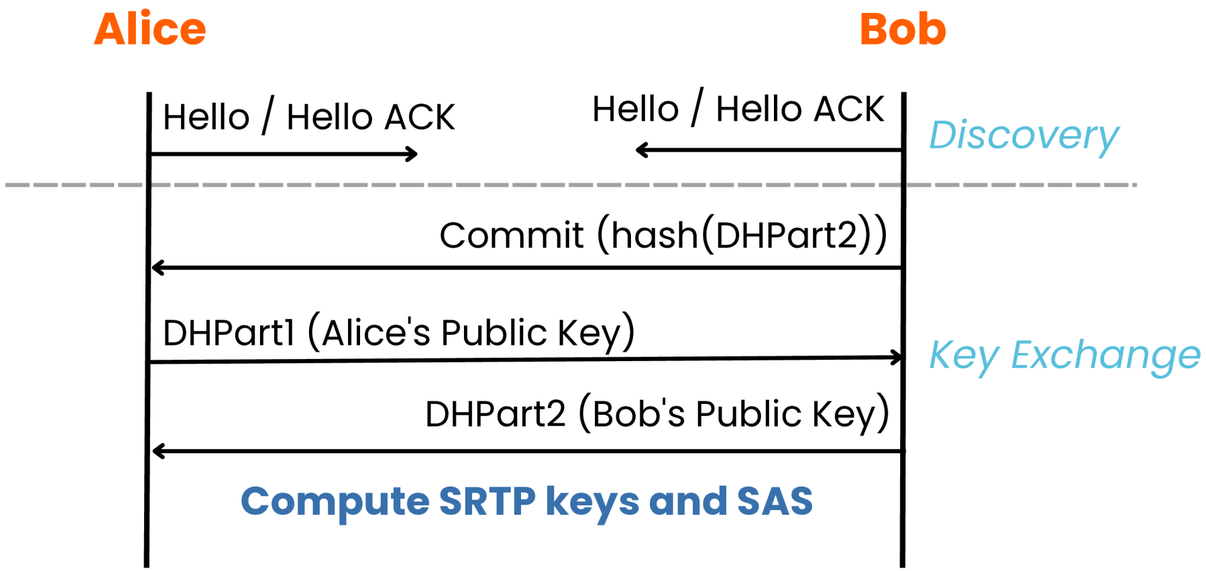


Diffie-Hellman is vulnerable to Man-in-the-Middle (MitM) Attack



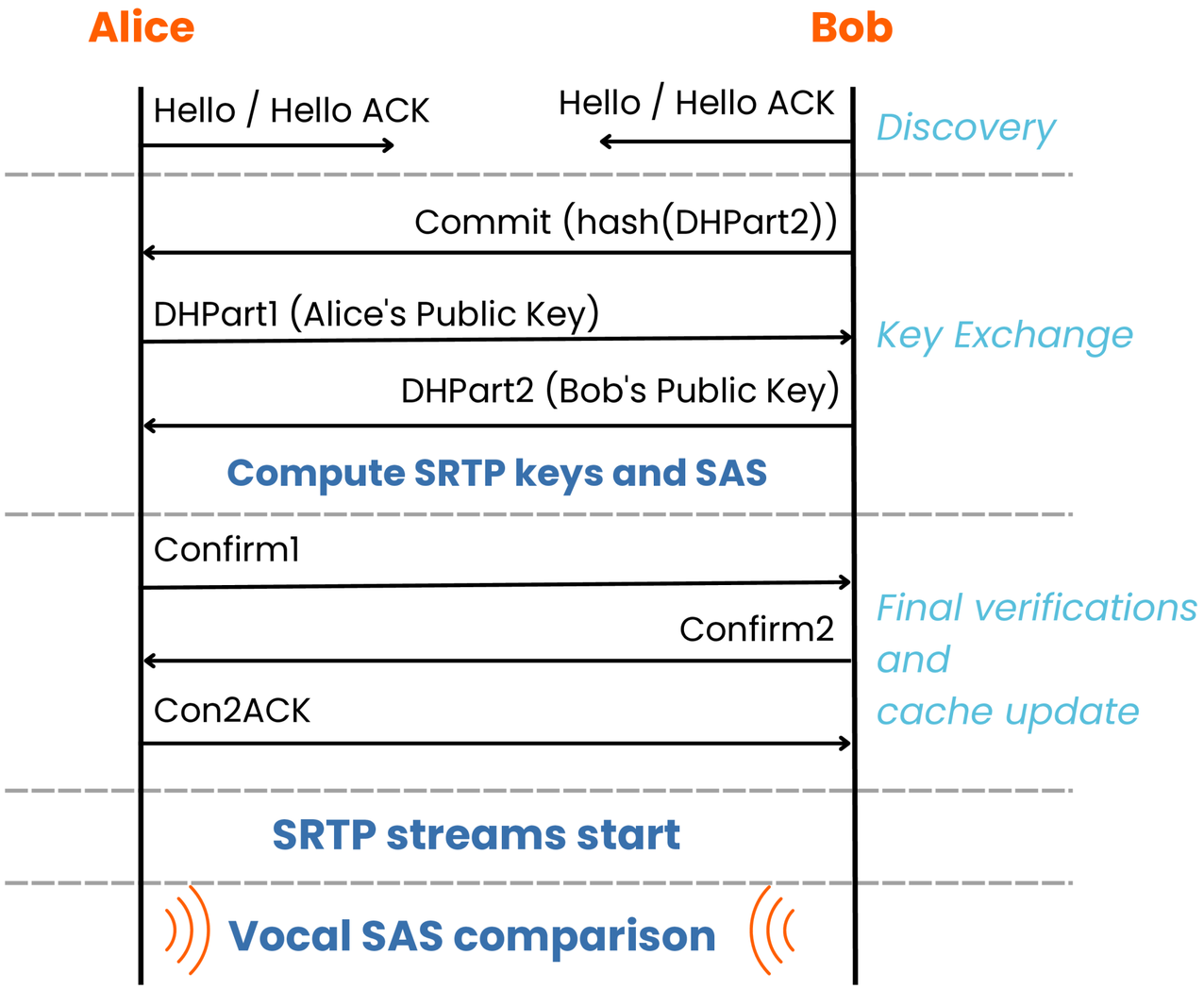
ZRTP handshake



Compute SRTP keys and SAS

- Derive s0 from DH result and transcript:
  - Hello, Commit and DHParts packets
- Derive SRTP keys from s0
- Derive SAS from s0 : 20 bits (4 characters)

ZRTP handshake



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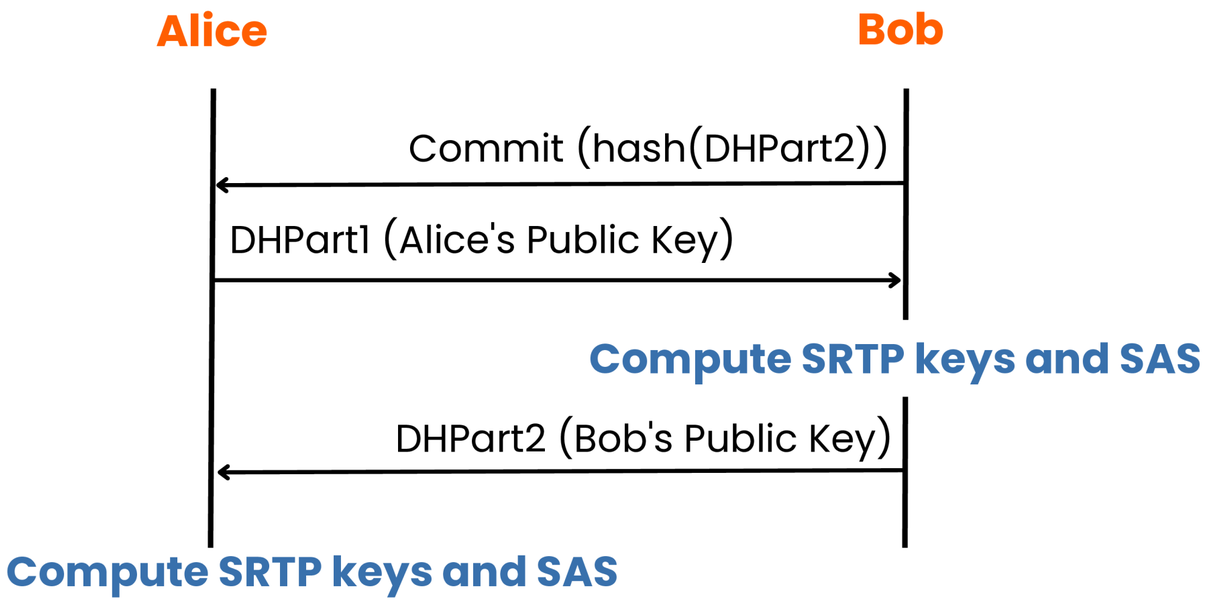
Vocal SAS comparison

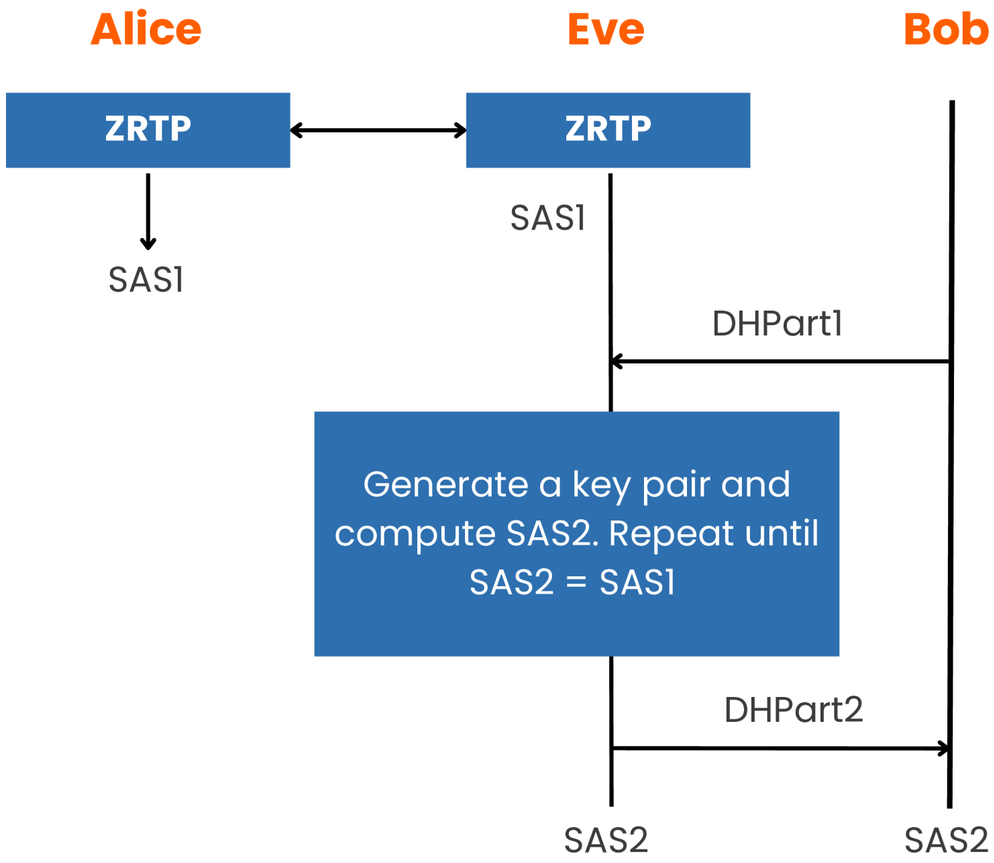
Detect MitM attack:

- Alice and Bob must assert they are using the same public keys
- Effective but not practical: each party reads its own public key to the other
- SAS value is short (4 characters) and based on both parties public keys

Commit Packet Role



SAS collision attack



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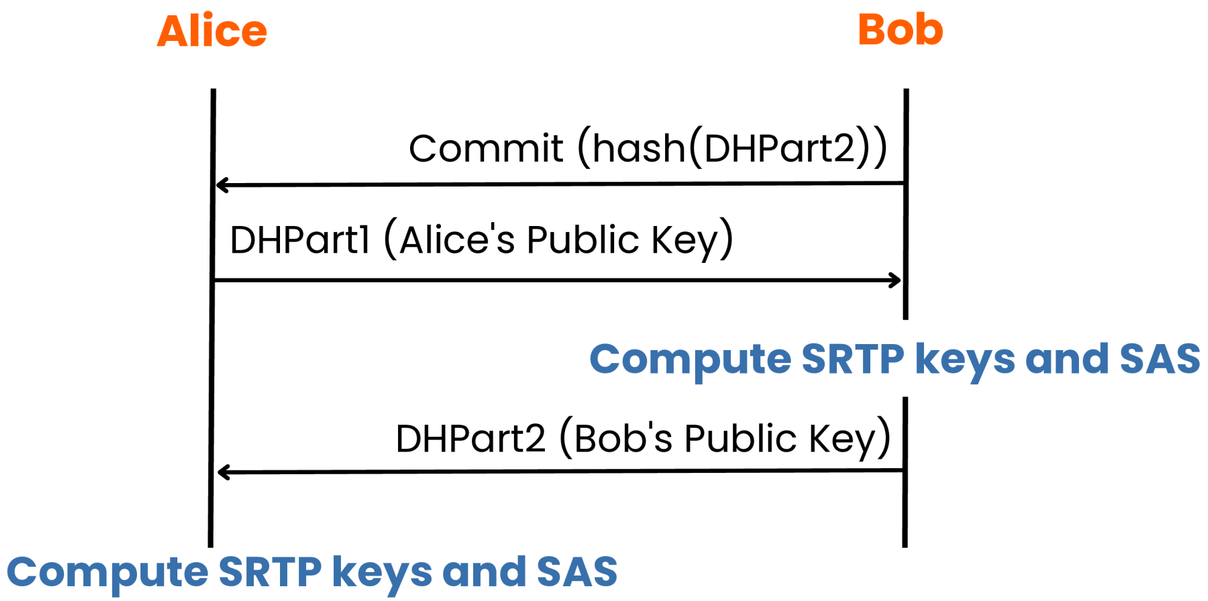
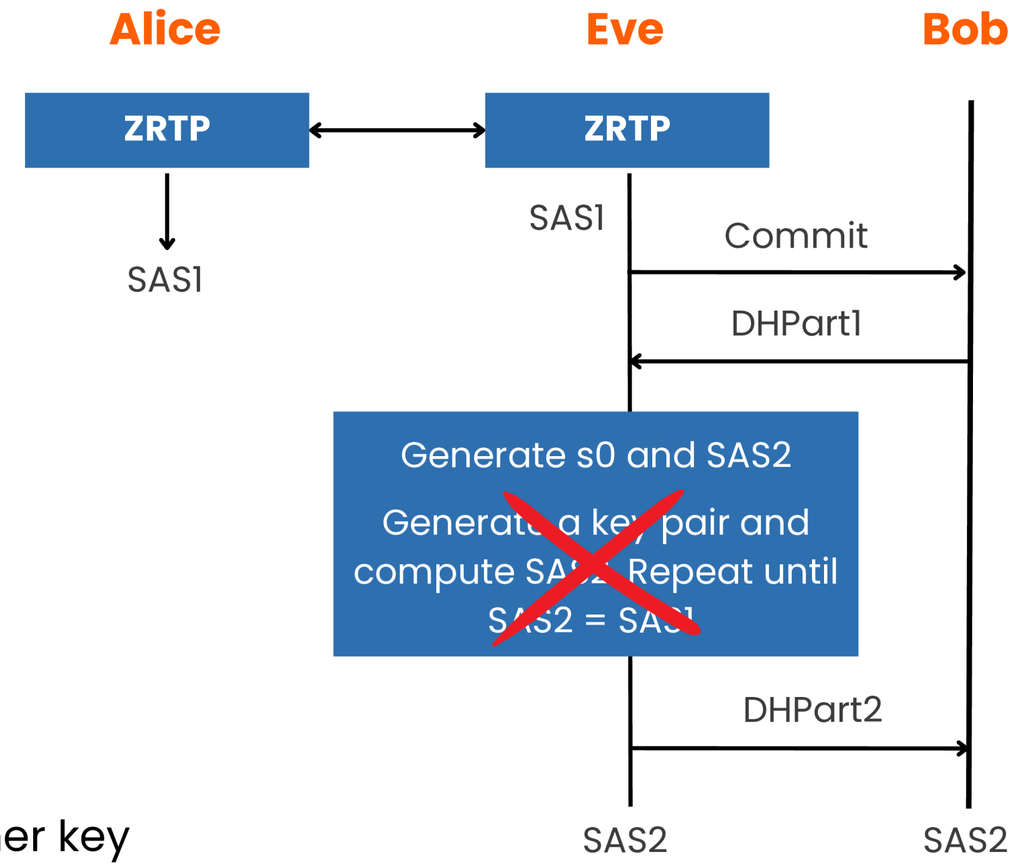


- Bob commits to use a public key without revealing it
- Alice cannot compute the shared secret before sending her key
- Bob cannot change his key to select a s0 and thus a SAS

SAS collision attack

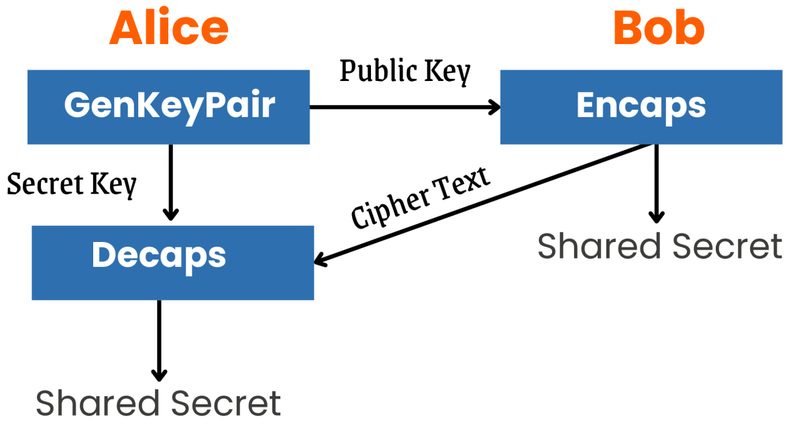


III. POST QUANTUM KEY EXCHANGE (KEM)

Key Encapsulation Mechanism (KEM) interface

NIST requests Post Quantum key exchange algorithms to use KEM interface :

- SecretKey, PublicKey = GenKeyPair()
- SharedSecret, CipherText = encaps(PublicKey)
- SharedSecret = decaps(CipherText, SecretKey)



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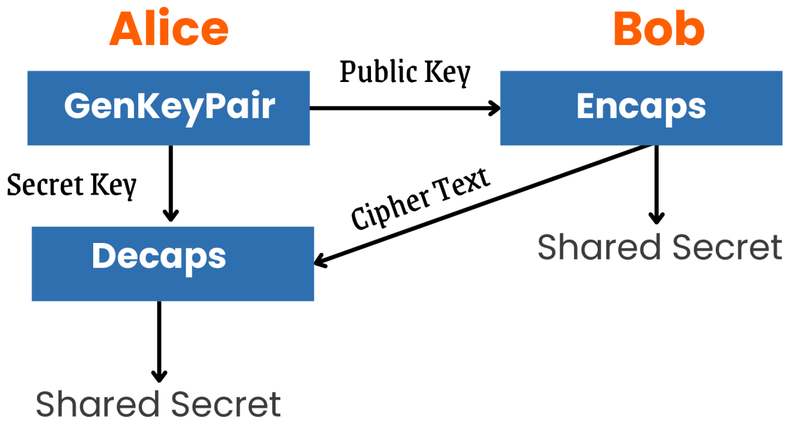

KEM is not Diffie-Hellman :

- Not symmetric
- Shared Secret can be selected by one party

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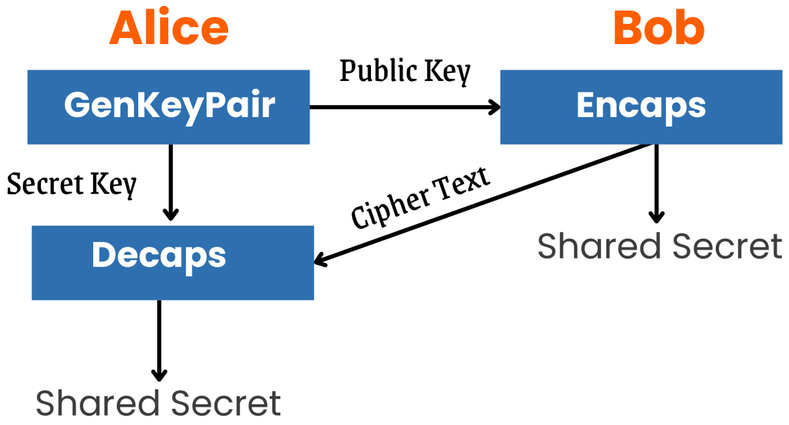
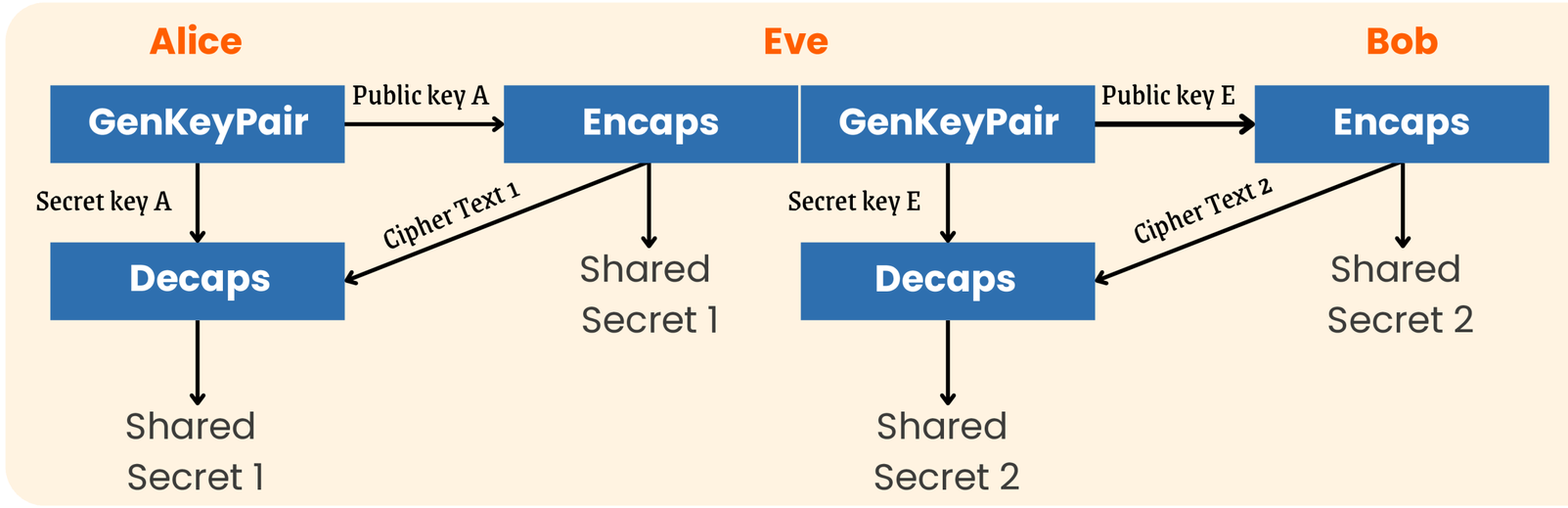


KEM too is vulnerable to Man-in-the-Middle (MitM) Attack



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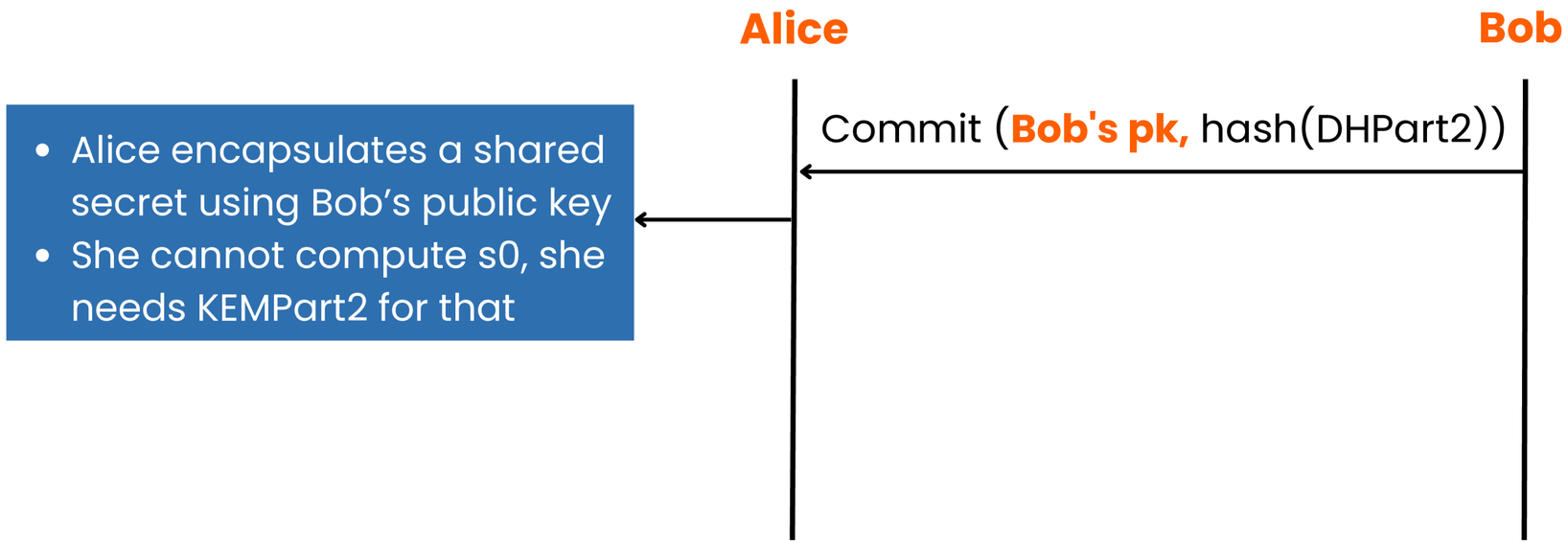
IV. ZRTP ADAPTATION

ZRTP KEM handshake

- s0 is derived from KEM shared secret and a transcript including:
  - Commit, KEMPart1 and KEMPart2 packets
- SRTP keys and SAS are derived from s0



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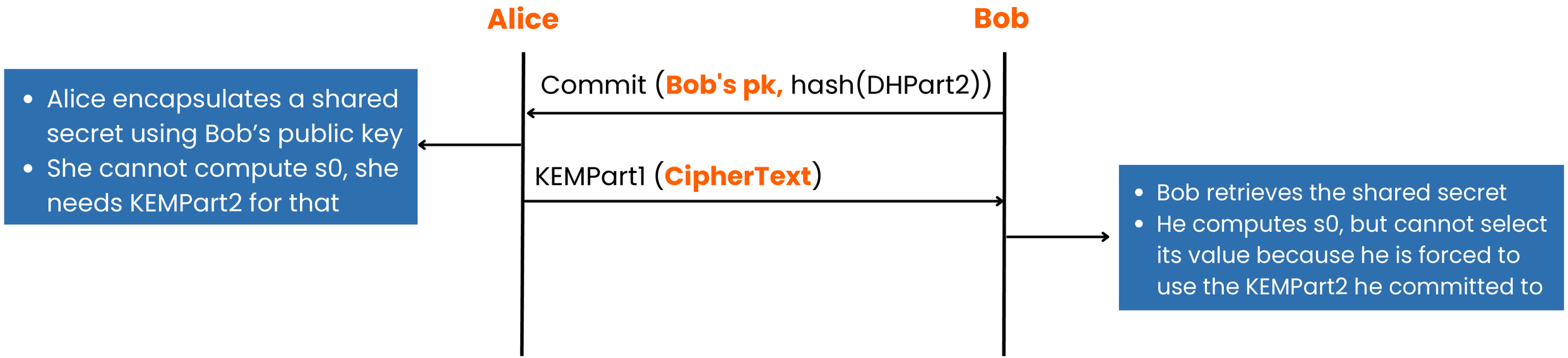

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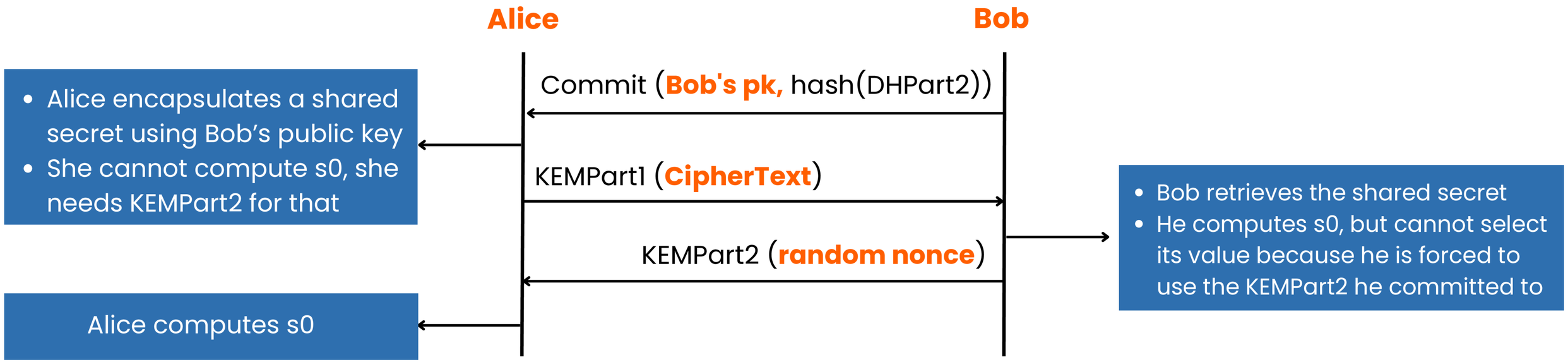


V. HYBRID KEM

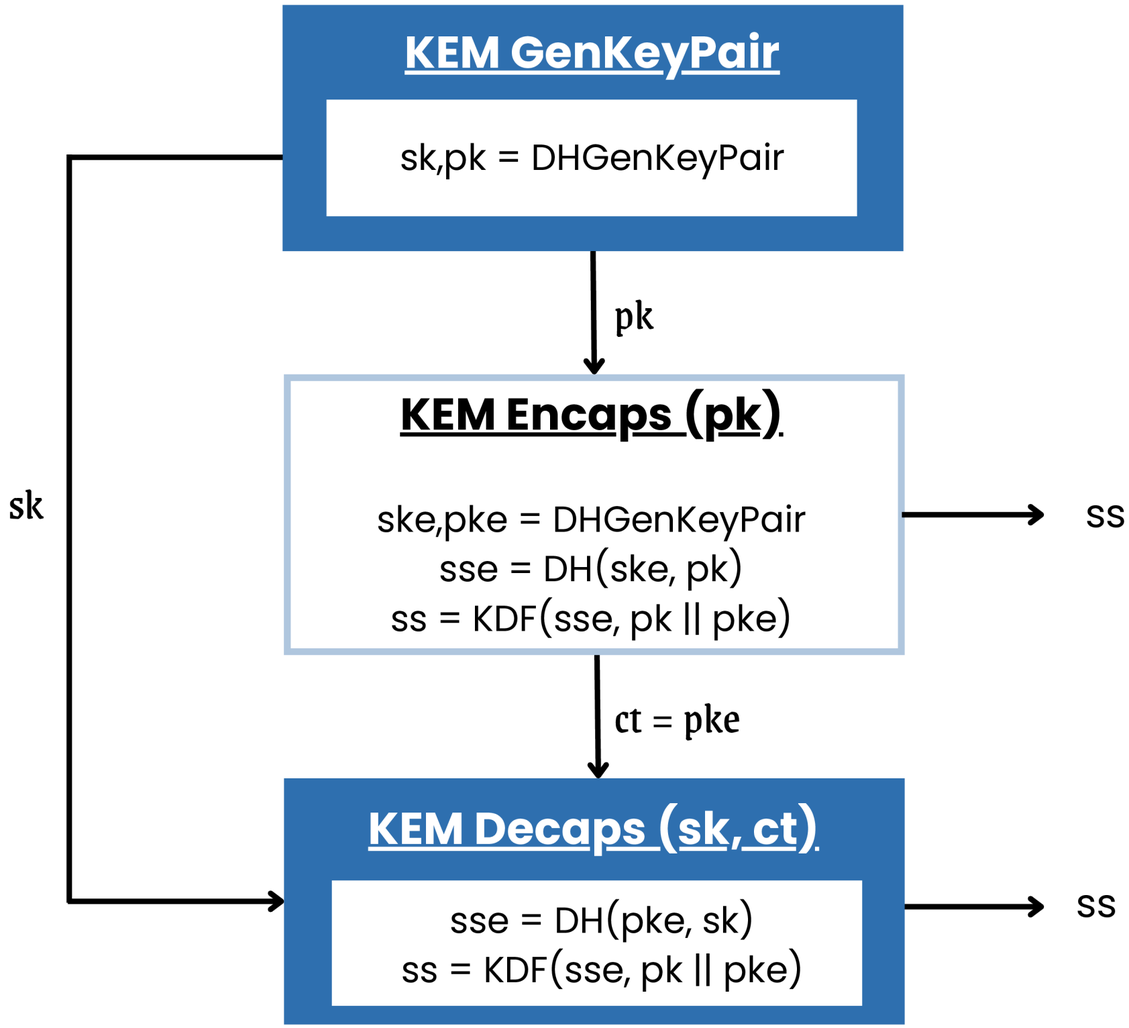
Hybrid key exchange : combine Post Quantum and traditional algorithm

- Post Quantum cryptography is relatively new and weakness may still be found (SIKE is a good example of the unexpected happening…)
- Perform one (or several) Post Quantum key exchange to protect against quantum computer
- and keep using (EC)DH key exchange so current security level is not downgraded

For ZRTP protocol simplicity

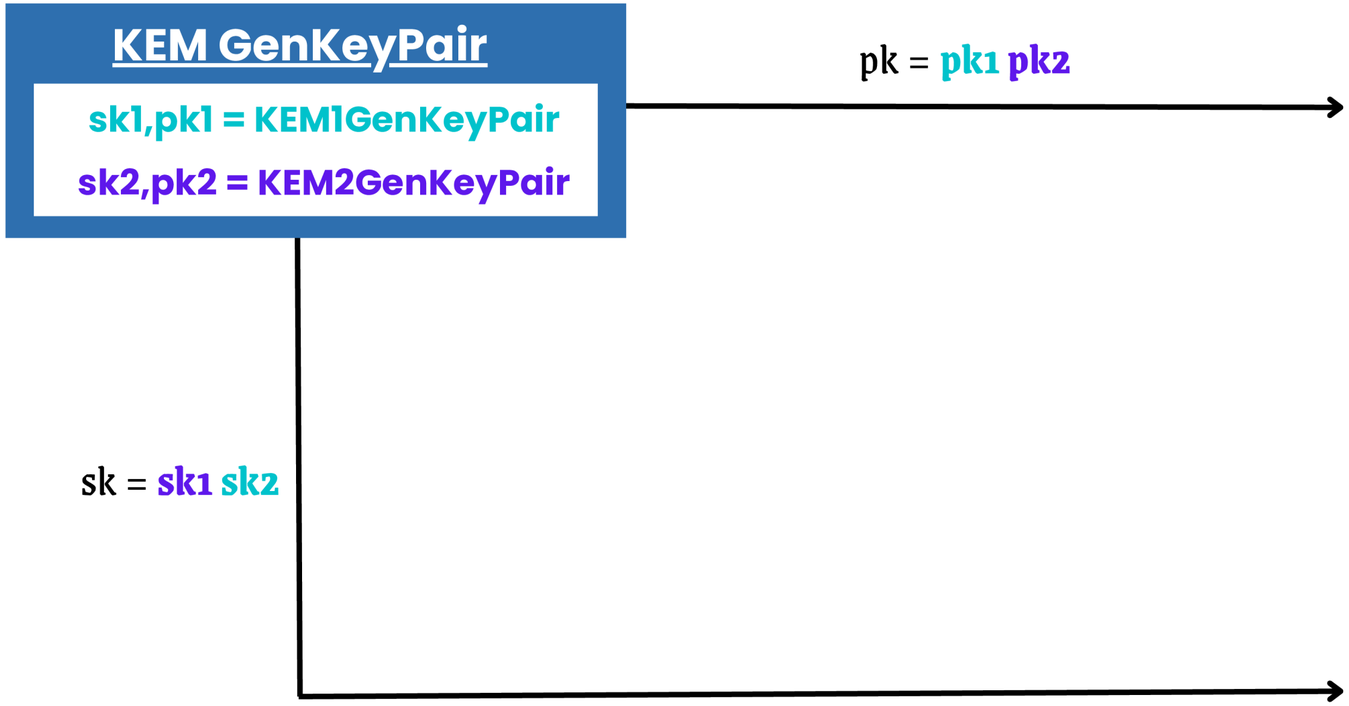
- The (EC)DH key exchange is performed as a KEM
- (EC)DH based and PQC KEM are combined into one KEM

Build a KEM from Diffie-Hellman



Combine two(or more) KEM

N. Bindel and al. - Hybrid Key Encapsulation Mechanisms and Authenticated Key Exchange



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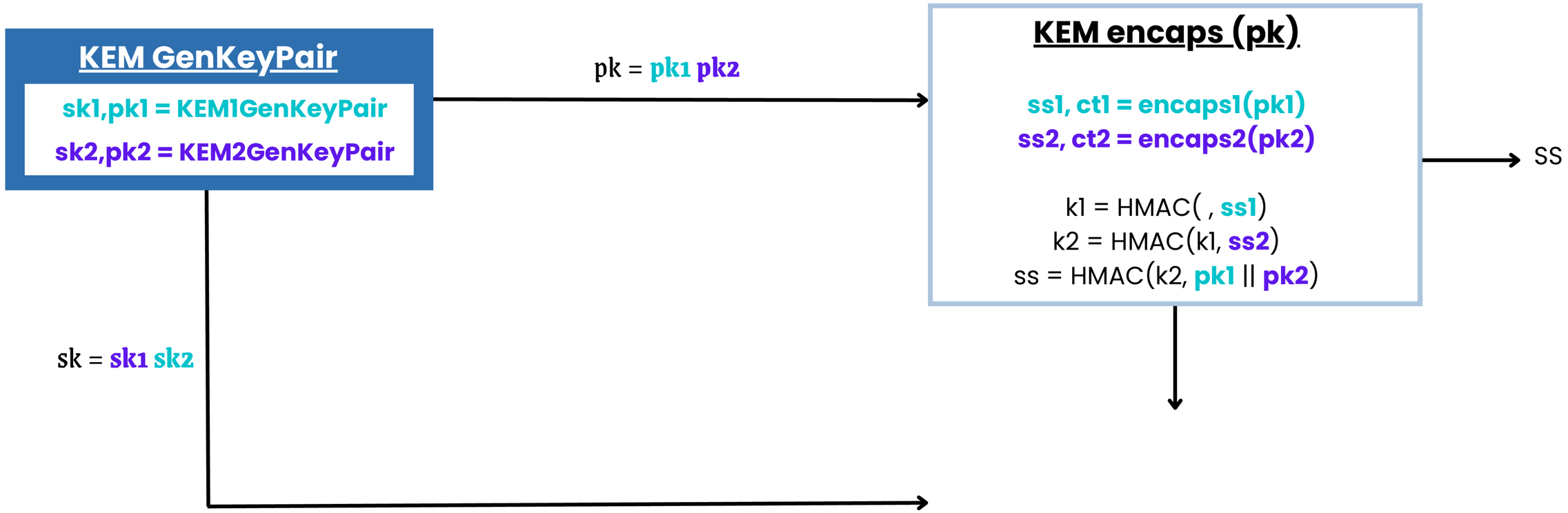

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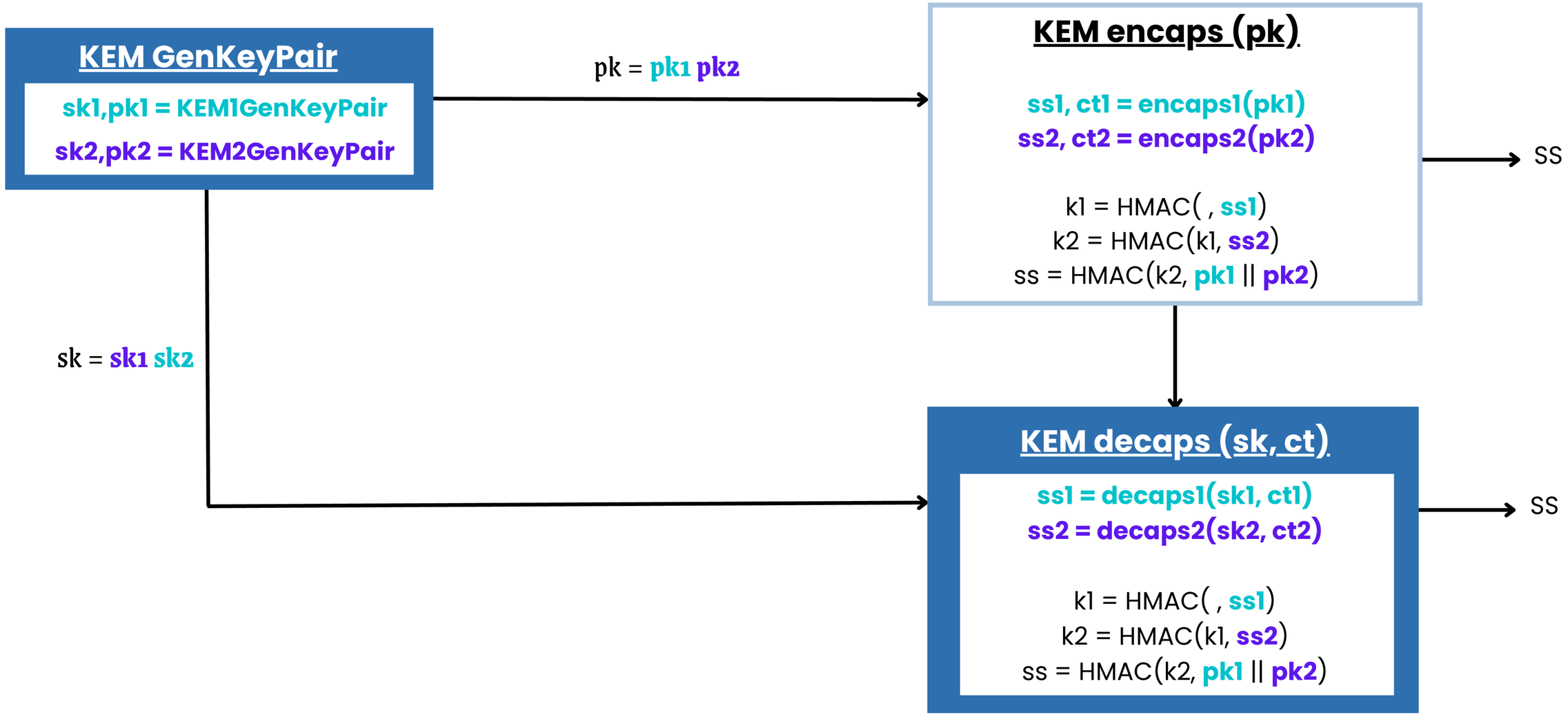


VI. FOCUS AND CONCLUSION

ZRTP handshake is performed in the media stream on UDP

- Typical MTU: 1500 bytes
- Diffie-Hellman public key size: from 32 (X25519) to 384 (DH3072) bytes
- Kyber public key or cipher text : up to 1568 bytes
- HQC cipher text: up to 14 kB

Fragment the ZRTP Commit and KEMPart1 packet

- ZRTP packet header modified to support fragmentation
- Fragmentation is opportunistic to keep interoperability with older version

Crypto libraries

- Liboqs : Kyber, HQC. More PQ KEM available.
- Libdecaf and mbedtls: X25519, X448, HMAC functions

Hybrid KEM

- Provides : ECDH-based KEM for X25519 and X448
- Can combine with Kyber (512, 768 and 1024), HQC(128, 192, 256)
- Can combine more than 2 KEM
- In a dedicated module (under GPLv3) so any project can use it

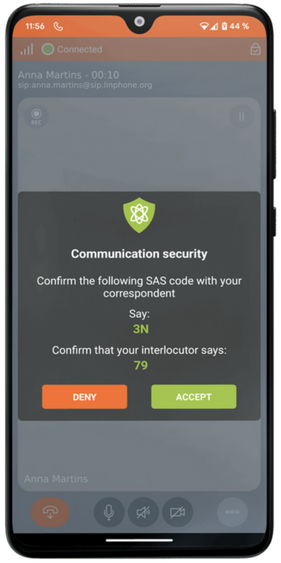
ZRTP implementation

- Deployed with a preset of hybrid KEM available:
  - X25519/Kyber512, X25519/HQC128, X25519/Kyber512/HQC128
  - X448/Kyber1024, X448/HQC256, X448/Kyber1024/HQC256
- Is fully compatible with older version

Audio Call

ZRTP handshake

Compute SRTP key and SAS



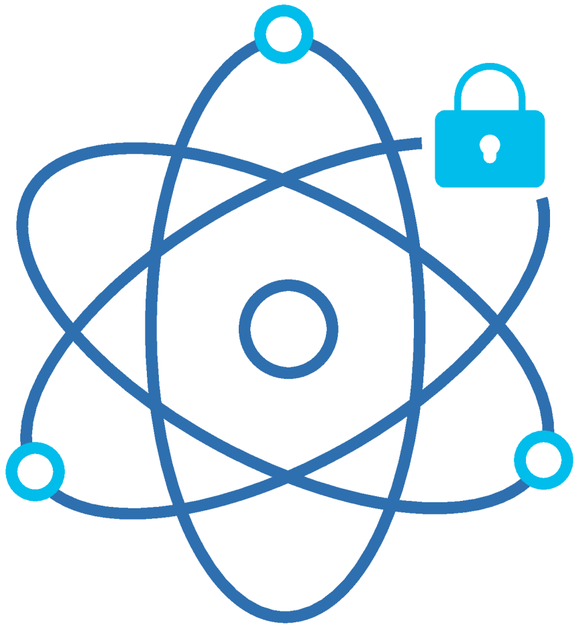
Compare SAS

Once in call history

Check what type of security :

Useful links

- **Linphone website**: https://www.linphone.org
- **Post Quantum Cryptography in Linphone**: https://www.linphone.org/sites/default/files/pqcrypto_integration-3_0.pdf
- **PostQuantumCryptoEngine module**: https://gitlab.linphone.org/BC/public/postquantumcryptoengine
- **ZRTP implementation**: https://gitlab.linphone.org/BC/public/bzrtp
- **N. Bindel and al. - Hybrid Key Encapsulation Mechanisms and Authenticated Key Exchange**: https://eprint.iacr.org/2018/903.pdf



Thank you!

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Do you have any questions ?

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