IT-Security Seminar
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PQC Wireguard as a new VPN

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Wireguard[9]

- Handshake every two minutes
- Handshake based on Diffie-Hellman
- Uses pre-Quantumn ciphers

Rosenpass[7][3]

- Post-quantum Encryption/Decryption in the wild!
- Spiritual Successor to PQ Wireguard
- Why? Because store now, decrypt later.

Huh?[4]

Encryption using AES-CBC with a 256-bit key with "CS1" ciphertext stealing.

```
int encrypt(const unsigned char *key, const unsigned char *iv,
            const unsigned char *msg, size_t msg_len, unsigned char *out)
{
    /*
     * This assumes that key size is 32 bytes and the iv is 16 bytes.
     * For ciphertext stealing mode the length of the ciphertext "out" will be
     * the same size as the plaintext size "msg_len".
     * The "msg_len" can be any size >= 16.
     */
    int ret = 0, encrypt = 1, outlen, len;
    EVP_CIPHER_CTX *ctx = NULL;
    EVP_CIPHER *cipher = NULL;
    OSSL_PARAM params[2];

    ctx = EVP_CIPHER_CTX_new();
    cipher = EVP_CIPHER_fetch(NULL, "AES-256-CBC-CTS", NULL);
    if (ctx == NULL || cipher == NULL)
        goto err;

    /*
     * The default is "CS1" so this is not really needed,
     * but would be needed to set either "CS2" or "CS3".
     */
    params[0] = OSSL_PARAM_construct_utf8_string(OSSL_CIPHER_PARAM_CTS_MODE,
                                                 "CS1", 0);
    params[1] = OSSL_PARAM_construct_end();

    if (!EVP_CipherInit_ex2(ctx, cipher, key, iv, encrypt, params))
        goto err;

    /* NOTE: CTS mode does not support multiple calls to EVP_CipherUpdate() */
    if (!EVP_CipherUpdate(ctx, out, &outlen, msg, msg_len))
        goto err;
     if (!EVP_CipherFinal_ex(ctx, out + outlen, &len))
        goto err;
    ret = 1;
err:
    EVP_CIPHER_free(cipher);
    EVP_CIPHER_CTX_free(ctx);
    return ret;
}
```

Get Siked![6][1]

ars TECHNICA

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COULDA BEEN A CONTENDER —

Post-quantum encryption contender is taken out by single-core PC and 1 hour

Leave it to mathematicians to muck up what looked like an impressive new algorithm.

DAN GOODIN - 8/2/2022, 2:31 PM

Getty Images

Enlarge

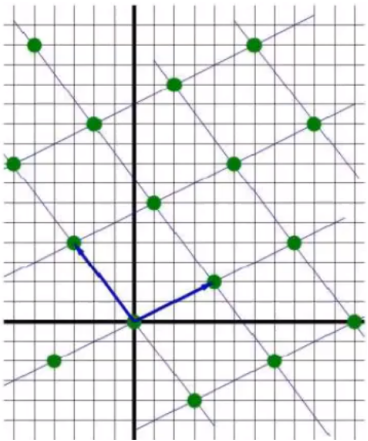
In the US government's ongoing campaign to protect data in the age of quantum computers, a new and powerful attack that used a single traditional computer to completely break a fourth-round candidate highlights the risks involved in standardizing the next generation of encryption algorithms.

Which Ciphers does Rosenpass use?

- **Classic McEliece** for Authentication and confidentiality
  (linear code based)
- **Kyber** for Forward Secrecy
  (lattice based)
- notably both are NIST[1] PQC Standardization Round 3 Finalists[5]

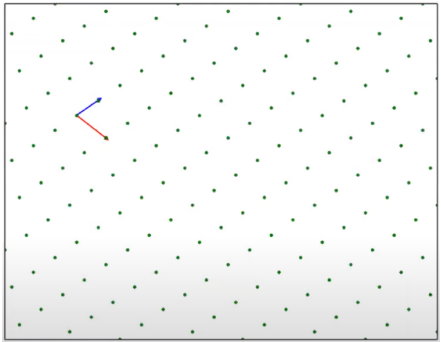
[1] „National Institute of Standards and Technology“ – NIST

Kyber
Lattices & Basis

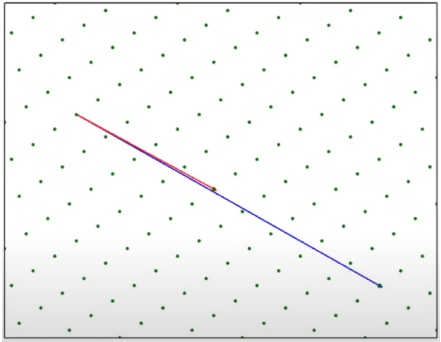


$$L = z_1 b_1 + z_2 b_2 = \begin{bmatrix} 4 & -3 \\ 2 & 4 \end{bmatrix} \cdot \begin{bmatrix} z_1 \\ z_2 \end{bmatrix}$$

Kyber
Lattices – CVP[2]



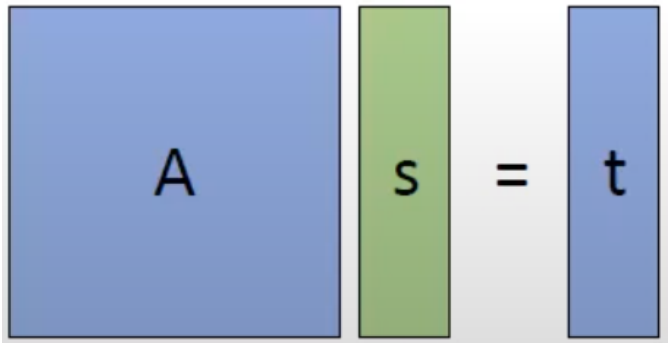
Good Basis!



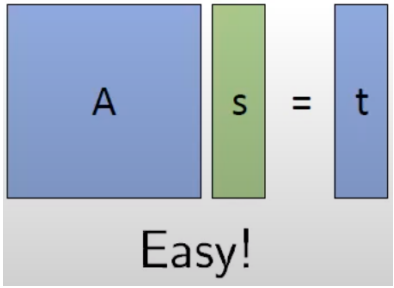
Bad Basis!

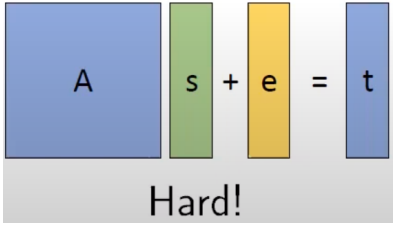
[2] „Closest vector problem“ – CVP

Kyber
LWE



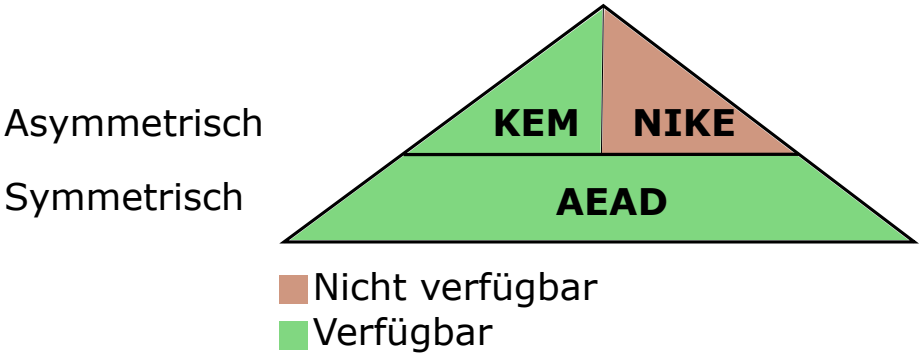
Kyber
LWE[3]





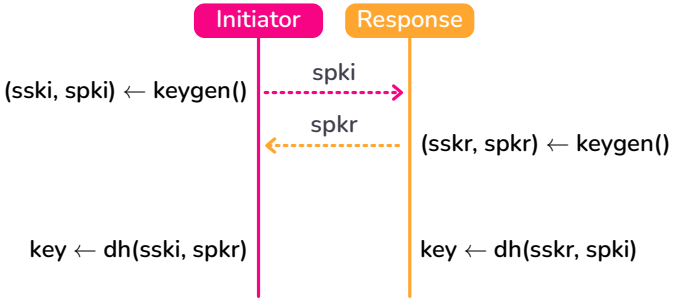
[3] „Learning with Errors“ – LWE

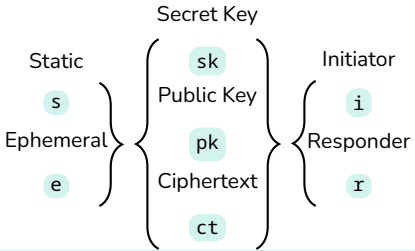
Ciphers available PQC[4]



[4] „Post-quantum cryptography“ – PQC

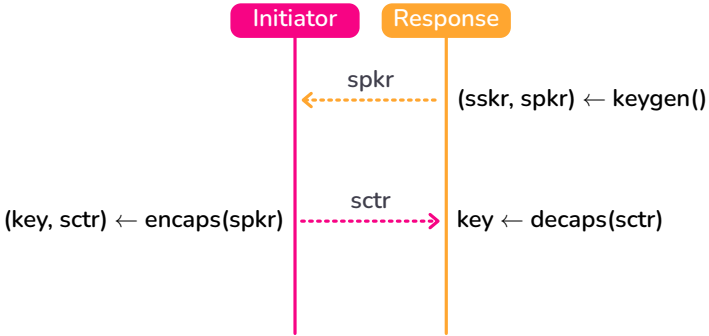
NIKE[5]

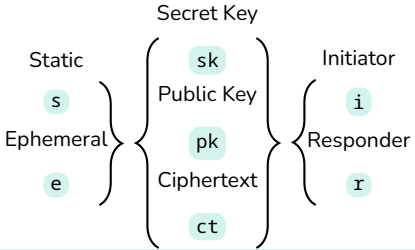




[5] „Non-Interactive Key Exchange“ – NIKE

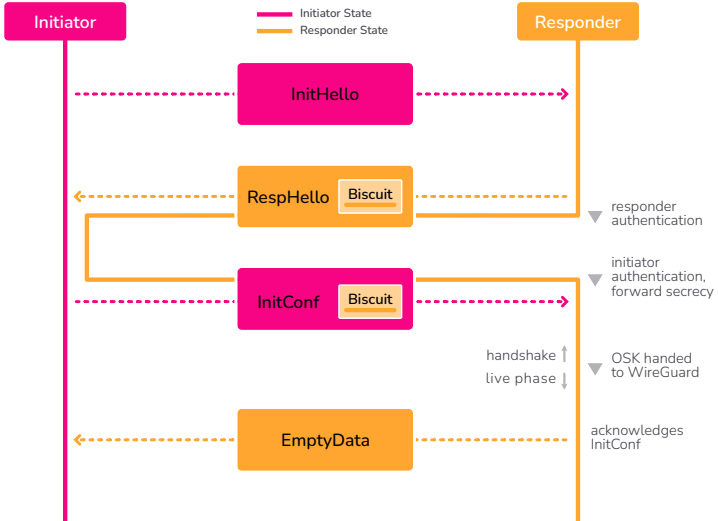
KEM[6] [2]



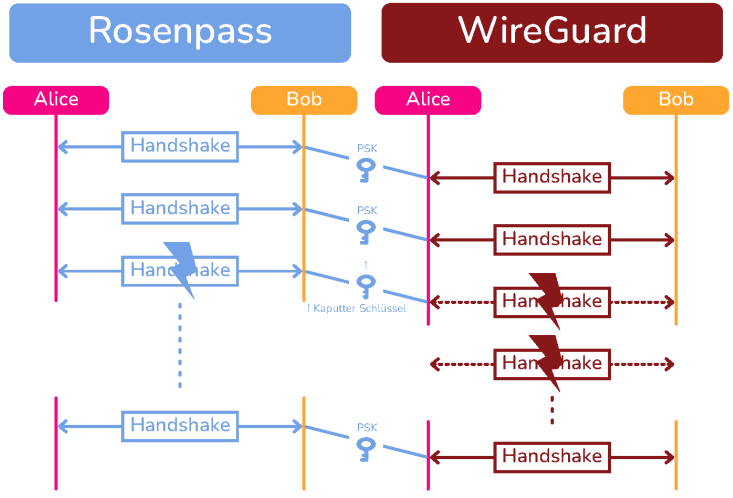


6 „Key-Encapsulation Method“ – KEM

Rosenpass Key Exchange



Wireguard Integration[8]




ROSENPASS

Sources

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[2] Diana Ghinea u. a. *Hybrid Post-Quantum Signatures in Hardware Security Keys*. Cryptology ePrint Archive, Paper 2022/1225. https://eprint.iacr.org/2022/1225. 2022. URL: https://eprint.iacr.org/2022/1225.

[3] Andreas Hülsing u. a. *Post-quantum WireGuard*. Cryptology ePrint Archive, Paper 2020/379. https://eprint.iacr.org/2020/379. 2020. URL: https://eprint.iacr.org/2020/379.

[4] *OpenSSL Documentation*. [Accessed 10.03.2024]. URL: https://www.openssl.org/docs/man3.2/man3/EVP_EncryptInit_ex.html.

[5] *Post-Quantum Cryptography Standardization*. [Accessed 10.03.2024]. URL: https://csrc.nist.gov/Projects/post-quantum-cryptography/post-quantum-cryptography-standardization.

[6] *Post-quantum encryption contender is taken out by single-core PC and 1 hour*. [Accessed 10.03.2024]. URL: https://arstechnica.com/information-technology/2022/08/sike-once-a-post-quantum-encryption-contender-is-koed-in-nist-smackdown/.

[7] *Rosenpass Whitepaper*. [Accessed 10.03.2024]. 2023. URL: https://rosenpass.eu/whitepaper.pdf.

[8] Douglas Stebila und Michele Mosca. *Post-Quantum Key Exchange for the Internet and the Open Quantum Safe Project*. Cryptology ePrint Archive, Paper 2016/1017. https://eprint.iacr.org/2016/1017. 2016. URL: https://eprint.iacr.org/2016/1017.

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Question 1:

- Do you think Rosenpass has a future if PQ Ciphers establish themselves?
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- Hint: ’Technical Dept’

Question 2:

- The Rosenpass developers may allow you to choose your own ciphers in the future. Why would they **not** enable this?
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- The Rosenpass developers may allow you to choose your own ciphers in the future. Why would they **not** enable this?
- Hint: They definitely won't allow for **dynamic negotiation** of ciphers between initiator and responder.

Question 3:

- Despite this, why would Administrators ’choose’ to pick different cipers?
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- Hint: National Institute of Standards and Technology (NIST)