Håck ma's 2024, Schloss in Ottenschlag
2024-08-29

How to build post-quantum cryptographic protocols and why wall clocks are not to be trusted.

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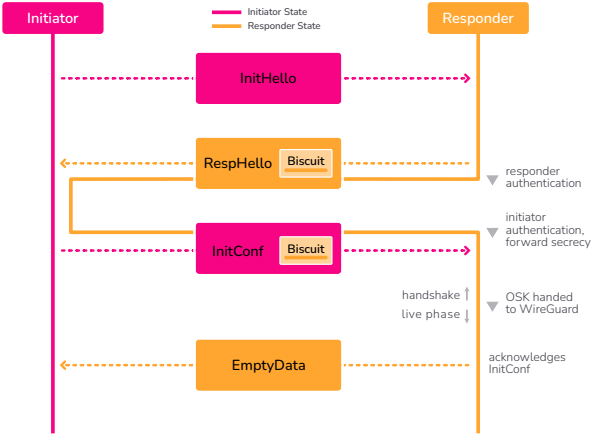
with support from Alice Bowman, Marei Peischl, and Lisa Schmidt
https://rosenpass.eu

This is the Plan

1. **Introducing Rosenpass,** briefly.
2. **The design of Rosenpass** and basics about post-quantum protocols.
3. **Hybrid Security** how it can be done and how we do it.
4. **ChronoTrigger Attack** and not trusting wall clocks.
5. **Protocol proofs** – big old rant!

Introducing Rosenpass, briefly

- A post-quantum secure key exchange **protocol** based on the paper Post-Quantum WireGuard[PQWG]
- An open-source Rust **implementation** of that protocol, already in use
- A way to secure WireGuard setups against quantum attacks
- A **post-quantum secure VPN**
- A governance **organization** to facilitate development, maintenance and adoption of said protocol



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The design of Rosenpass

and how to build post-quantum protocols

In the following slides, you will learn...

...that most cryprographic applications today are susceptible against attacks from quantum computers.

...that this is not fundamental to cryptography, but that pre-quantum protocols are simply a more efficient.

...that – cryptographically speaking – the difference between pre-quantum and post-quantum crypto is about a subtle difference in function interface.

Glossary: Post-quantum security

Pre-quantum Cryptography is...

...susceptible to attacks from quantum computers.

- Specifically, to *Shor's Algorithm*
- Quite fast
- Widely widely trusted

Post-quantum cryptography is...

...not susceptible to attacks from quantum computers.

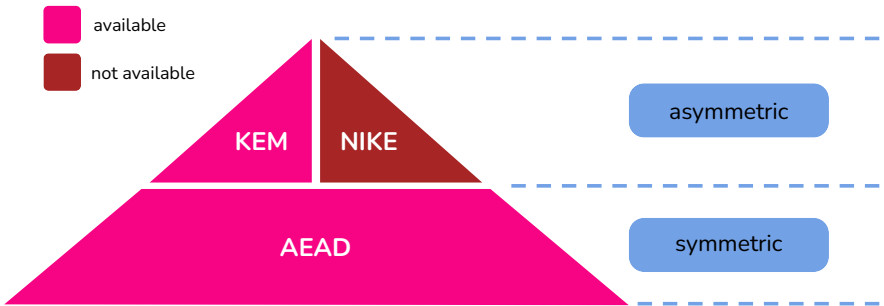
- generally less efficient.
- much bigger ciphertexts.
- less analyzed.

Hybrid cryptography combines...

...the combination of the previous two. It is...

- about as inefficient as post-quantum cryptography.
- not widely adopted, which is a major problem.

What post-quantum got



NIKEs and KEMs

Key Encapsulation Method

```
fn Kem::encaps(Pk) -> (Shk, Ct);
fn Kem::decaps(Pk, Ct) -> Shk;

(shk, ct) = encaps(pk);
assert!(decaps(sk, ct) = shk)
```

Think of it a encrypting a key and sending it to the partner.

- Secrecy
- Implicit authentication of recipient (assuming they have the shared key, they must also have their secret key)

Non Interactive Key Exchange

```
fn nike(sk: Sk, pk: Pk) -> Shk;

assert!(nike(sk1, pk2) = nike(sk2, pk1));
```

Aka. Diffie-Hellman. I don't know a good analogy, but ote how the keypairs are *crossing over* to each other.

- Secrecy
- Mutual authentication (for each party: assuming they have the shared key, they must also have their secret key)

NIKEs and KEMs: Key exchange

Key Encapsulation Method

Responder Authentication: Initiator encapsulates key under the responder public key.

Initiator Authentication: Responder encapsulates key under the initiator public key.

Forward-secrecy: In case the secret keys get stolen, either party generates a temporary and has the other party encapsulate a secret under that keypair.

How to do this properly? See

Non Interactive Key Exchange

Responder Authentication: Static-static NIKE since NIKE gives mutual authentication.

Initiator Authentication: Static-static NIKE since NIKE gives mutual authentication.

Forward-secrecy: Another nike, involving a temporary keypair.

How to do this properly? See the Noise Protocol Framework.

NIKEs and KEMs

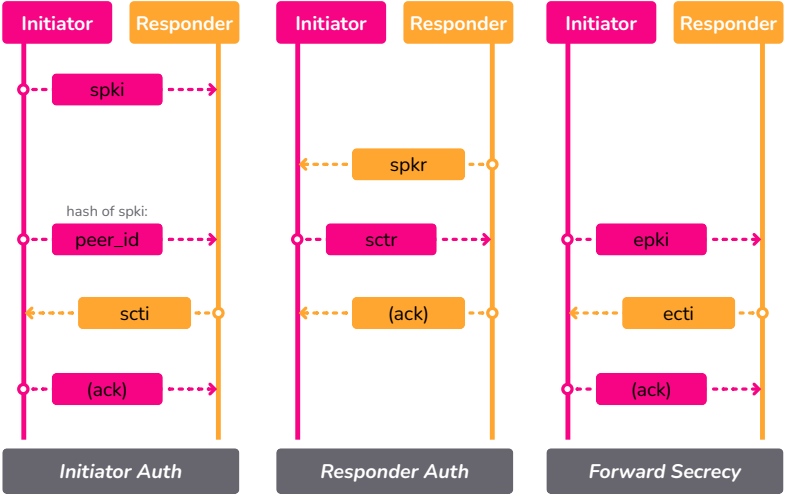
Key Encapsulation Method

```
trait Kem {
  // Secret, Public, Symmetric, Ciphertext
  type Sk; type Pk; type Shk; type Ct;
  fn genkey() -> (Sk, Pk);
  fn encaps(pk: Pk) -> (Shk, Ct);
  fn decaps(sk: Pk, ct: Ct) -> Shk;
}
#[test]
fn test<K: Kem>() {
  let (sk, pk) = K::genkey();
  let (shk1, ct) = K::encaps(pk);
  let shk2 = K::decaps(sk, ct);
  assert_eq!(shk1, shk2);
}
```

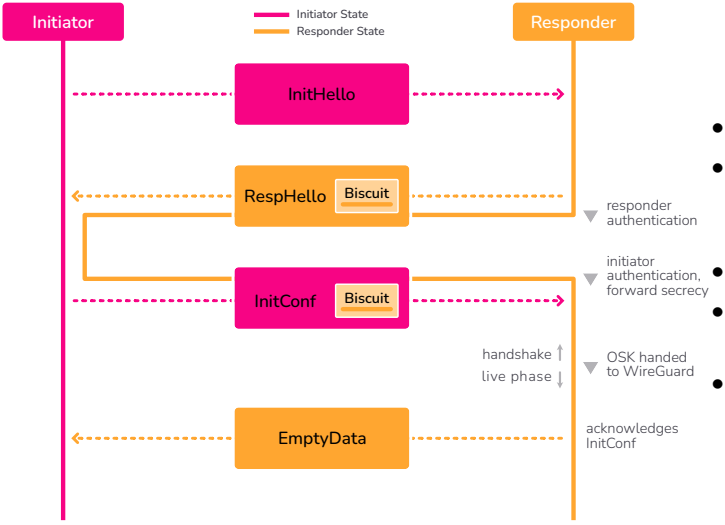
Non Interactive Key Exchange

```
trait Nike {
  // Secret, Public, Symmetric
  type Sk; type Pk; type Shk;
  fn genkey() -> (Sk, Pk);
  fn nike(sk: Sk, pk: Pk) -> Shk;
}
#[test]
fn test<N: Nike>() {
  let (sk1, pk1) = N::genkey();
  let (sk2, pk2) = N::genkey();
  let ct1 = N::nike(sk1, pk2);
  let ct2 = N::nike(sk2, pk1);
  assert_eq!(ct1, ct2);
}
```

Rosenpass Kex Exchange Parts

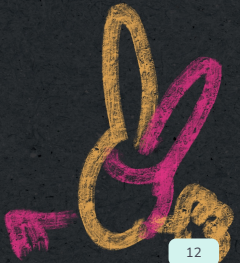


Rosenpass Protocol Features



- Authenticated key exchange
- Three KEM operations interleaved to achieve mutual authentication and forward secrecy
- No use of signatures
- First package (InitHello) is unauthenticated
- Stateless responder to avoid disruption attacks

Hybridization



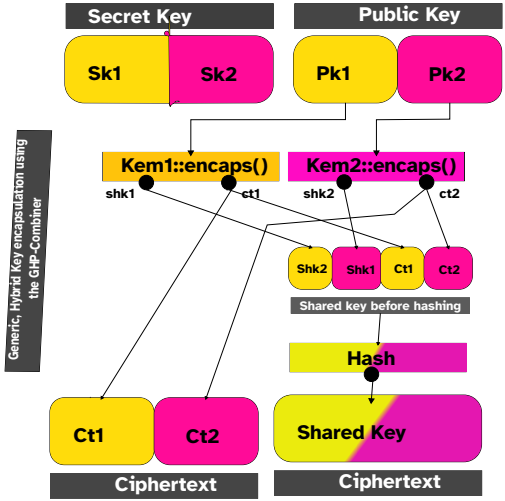
In the following slides, you will learn...

...that hybrid, practical, post-quantum cryptography is built by combining pre-quantum and post-quantum primitives.

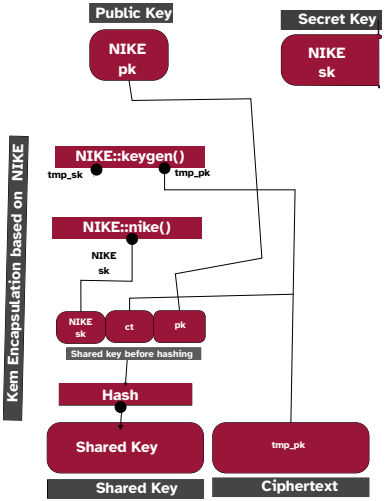
...that key encapsulation methods can be combined, rendering a protocol like Rosenpass useful in pre-quantum as well as post-quantum settings.

...why combining protocols like WireGuard and Rosenpass directly is still useful to enable code-reuse and to avoid loosing trust in established systems like WireGuard.

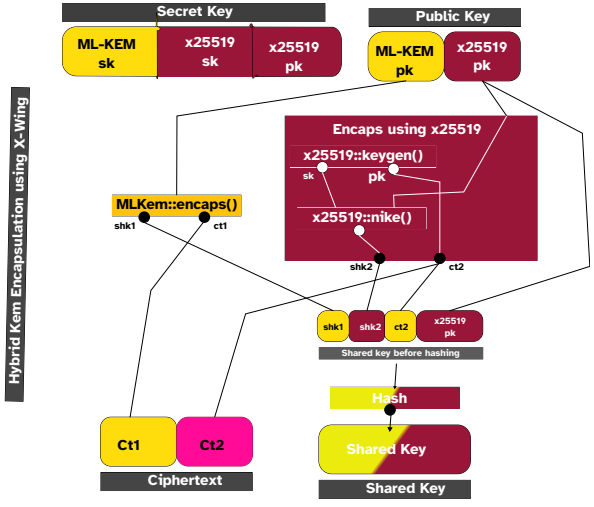
Combining two KEMs with the GHP-Combiner



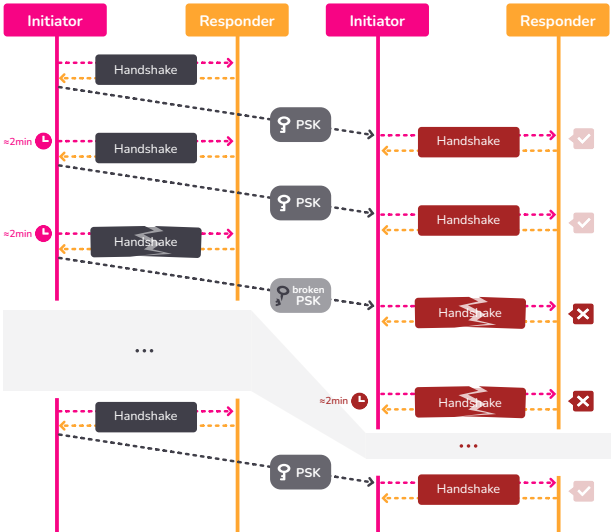
Turning a NIKE into a KEM



X-Wing


Secret Key
ML-KEM sk
x25519 sk
x25519 pk
Public Key
ML-KEM pk
x25519 pk
Hybrid Kem Encapsulation using X-Wing
Encaps using x25519
x25519::keygen()
sk
pk
x25519::nike()
MLKem::encaps()
shk1
ct1
shk2
ct2
shk1
shk2
ct2
x25519 pk
Shared key before hashing
Hash
Ct1
Ct2
Ciphertext
Shared Key
Shared Key

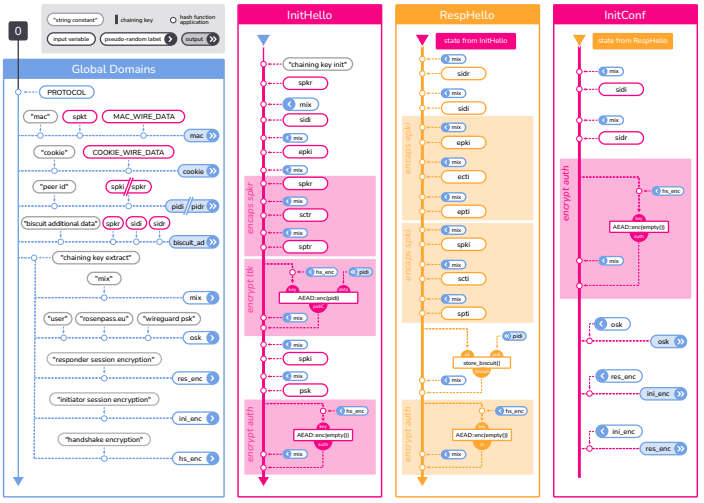
Rosenpass & WireGuard Hybridization



Full Protocol Reference in the Whitepaper

Initiator Code			Responder Code			Comments
		1 InitHello { sidi, epki, sctr, pidiC, auth } 2				
IHI1	**ck** ← thash("chaining key init", spkr)		**ck** ← thash("chaining key init", spkr)	IHR1		Initialize the chaining key, and bind to the responder's public key.
IHI2	**sidi** ← random_session_id();					The session ID is used to associate packets with the handshake state.
IHI3	**eski, epki** ← EKEM::keygen();					Generate fresh ephemeral keys, for forward secrecy.
IHI4	mix(sidi, epki);		mix(sidi, epki)	IHR4		InitHello includes sidi and epki as part of the protocol transcript, and so we mix them into the chaining key to prevent tampering.
IHI5	**sctr** ← encaps_and_mix<SKEM>(spkr);		decaps_and_mix<SKEM>(sskr, spkr, ct1)	IHR5		Key encapsulation using the responder's public key. Mixes public key, shared secret, and ciphertext into the chaining key, and authenticates the responder.
IHI6	**pidiC** ← encrypt_and_mix(pidi);		**spki, psk** ← lookup_peer(decrypt_and_mix(pidiC))	IHR6		Tell the responder who the initiator is by transmitting the peer ID.
IHI7	mix(spki, psk);		mix(spki, psk);	IHR7		Ensure the responder has the correct view on spki. Mix in the PSK as optional static symmetric key, with epki and spkr serving as nonces.
IHI8	**auth** ← encrypt_and_mix(empty())		decrypt_and_mix(auth)	IHR8		Add a message authentication code to ensure both participants agree on the session state and protocol transcript at this point.
		4 RespHello { sidr, sidi, ecti, scti, biscuit, auth } 3				
RHI1			**sidr** ← random_session_id()	RHR1		Responder generates a session ID.
RHI2	**ck** ← lookup_session(sidi);			RHR2		Initiator looks up their session state using the session ID they generated.
RHI3	mix(sidr, sidi);		mix(sidr, sidi);	RHR3		Mix both session IDs as part of the protocol transcript.
RHI4	decaps_and_mix<SKEM>(eski, epki, ecti);		**ecti** ← encaps_and_mix<SKEM>(epki);	RHR4		Key encapsulation using the ephemeral key, to provide forward secrecy.
RHI5	decaps_and_mix<SKEM>(sski, spki, scti);		**scti** ← encaps_and_mix<SKEM>(spki);	RHR5		Key encapsulation using the initiator's static key, to authenticate the initiator, and non-forward-secret confidentiality.
RHI6	mix(biscuit)		**biscuit** ← store_biscuit();	RHR6		The responder transmits their state to the initiator in an encrypted container to avoid having to store state.
RHI7	decrypt_and_mix(auth)		**auth** ← encrypt_and_mix(empty());	RHR7		Add a message authentication code for the same reason as above.
		5 InitConf { sidi, sidr, biscuit, auth } 6				
ICI1			**biscuit_no** ← load_biscuit(biscuit);	ICR1		Responder loads their biscuit. This restores the state from after RHR6.
ICI2			encrypt_and_mix(empty());	ICR2		Responder recomputes RHR7, since this step was performed after biscuit encoding.
ICI3	mix(sidi, sidr);		mix(sidi, sidr);	ICR3		Mix both session IDs as part of the protocol transcript.
ICI4	**auth** ← encrypt_and_mix(empty);		decrypt_and_mix(auth);	ICR4		Message authentication code for the same reason as above, which in particular ensures that both participants agree on the final chaining key.
ICI5			assert(biscuit_no > biscuit_used);	ICR5		Biscuit replay detection.
ICI6			**biscuit_used** ← biscuit_no;	ICR6		Biscuit replay detection.
ICI7	enter_live();		enter_live();	ICR7		Derive the transmission keys, and the output shared key for use as WireGuard's PSK.

Rosenpass Key Derivation Chain



Trials ~ Attacks found

ChronoTrigger

In the following slides, you will learn...

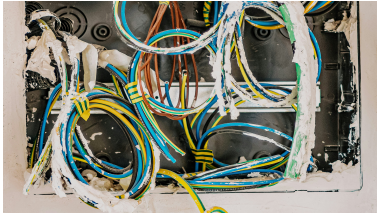
...that denial of service can happen on the level of cryptography protocols!

...that the wall clock is not to be trusted.

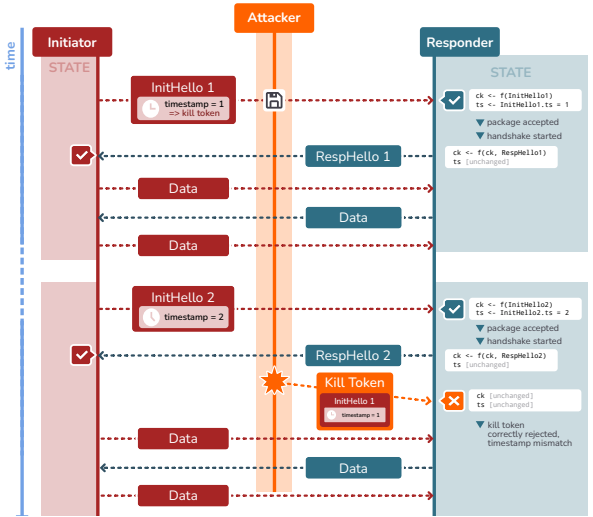
...how to accept replay attacks and face them without fear!

What are State Disruption Attacks?

Protocol level DOS



Retransmission Protection in WireGuard



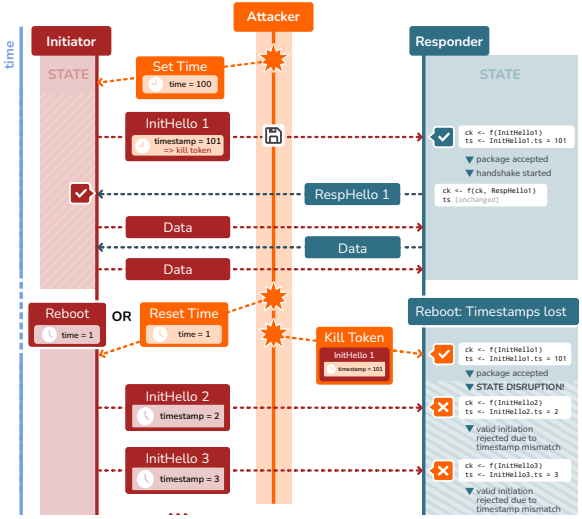
- Replay attacks thwarted by counter
- Counter is based on real-time clock
- Responder is semi-stateful (one retransmission at program start may be accepted, but this does not affect protocol security)

⇒ WG requires *either* reliable real-time clock *or* stateful initiator

⇒ Adversary can attempt replay, but this cannot interrupt a valid handshake by the initiator

! Assumption of reliable system time is invalid in practice!

ChronoTrigger Attack



A. Preparation phase:

1. **Attacker** sets *initiator system time* to a future value
2. **Attacker** records *InitHello* as *KillToken* while both peers are performing a valid handshake

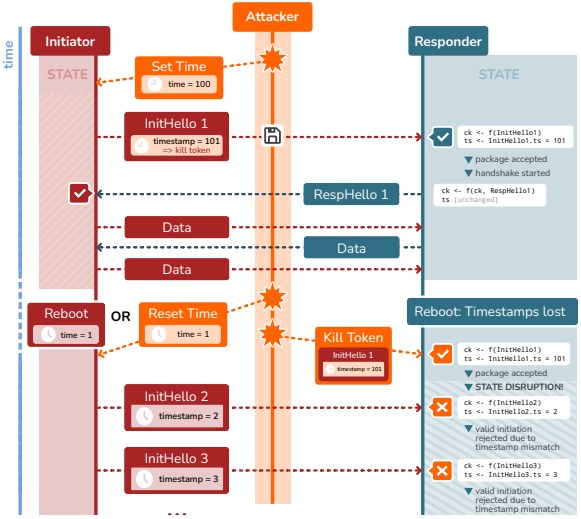
... both peers are being reset ...

B. Delayed execution phase:

1. **Attacker** sends *KillToken* to responder, setting their timestamp to a future value

⇒ Initiation now fails again due to timestamp mismatch

ChronoTrigger Attack

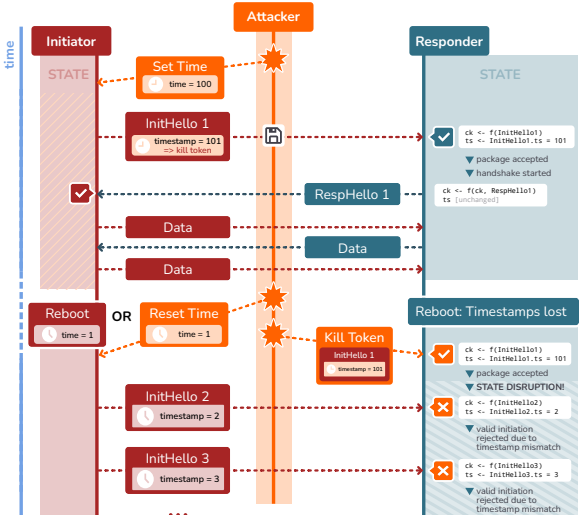


Gaining access to system time:

- Network Time Protocol is insecure, Mitigations are of limited use

⇒ Break NTP *once*; kill token lasts forever

ChronoTrigger Attack



Attacker gains

- Extremely cheap protocol-level DOS

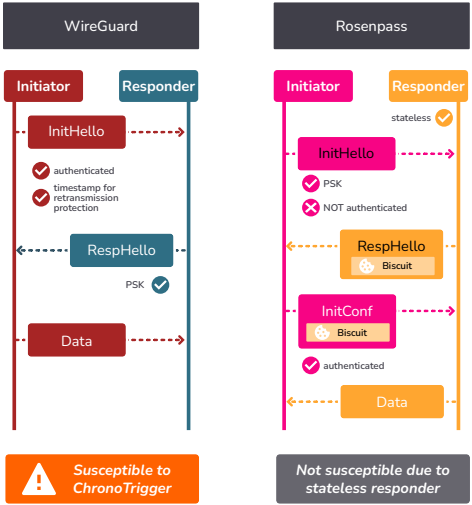
Preparation phase, attacker needs:

- Eavesdropping of initiator packets
- Access to system time

Delayed execution, attacker needs:

- No access beyond message transmission to responder

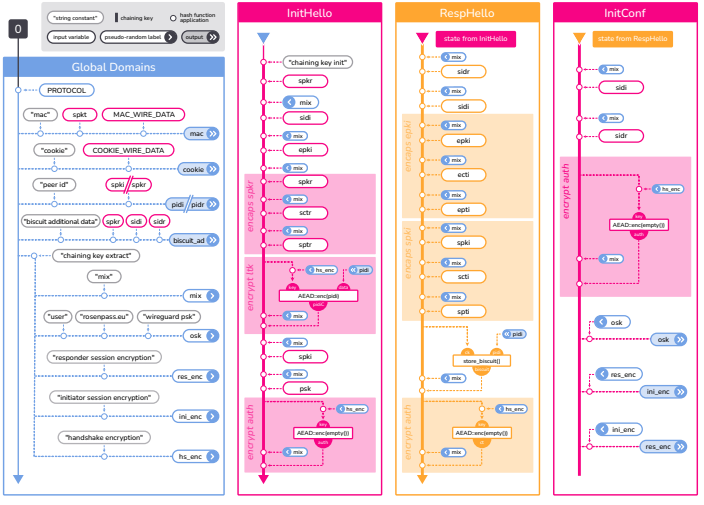
ChronoTrigger: Changes in Rosenpass



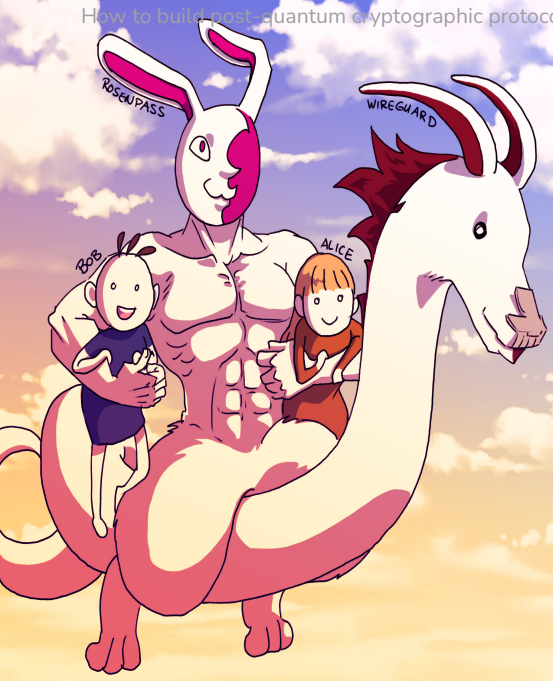
- InitHello is unauthenticated because responder still needs to encapsulate secret with initiator key
- Since InitHello is unauthenticated, retransmission protection is impossible
- Responder state is moved into a cookie called *Biscuit*; this renders the responder stateless
- Retransmission of InitHello is now easily possible, but does not lead to a state disruption attack

⇒ Stateless responder prevents ChronoTrigger attack

Rosenpass Key Derivation Chain: Spot the Biscuit



Rosenpass Protocol Messages: Spot the Biscuit



Tribulations ~ Tooling

Oh These Proof Tools

Vive la Révolution! Against the

Bourgeoisie of Proof Assistants!

In the following slides, you will hear...

> Everything had a name, and each name gave birth to a new thought.
>
> Helen Keller (1880-1968) in The Day Language Came into My Life

Symbolic Modeling of Rosenpass

```
~/p/rosenpass  dev/karo/rwpqc-slides ?  nix build .#packages.x86_64-linux.
rosenpass-proverif-proof> unpacking sources
rosenpass-proverif-proof> unpacking source archive /nix/store/cznyv4ibwlzbh257v6
rosenpass-proverif-proof> source root is source
rosenpass-proverif-proof> patching sources
rosenpass-proverif-proof> configuring
rosenpass-proverif-proof> no configure script, doing nothing
rosenpass-proverif-proof> building
rosenpass-proverif-proof> no Makefile, doing nothing
rosenpass-proverif-proof> installing
rosenpass-proverif-proof> $ metaverif analysis/01_secrecy.entry.mpv -color -html
-rosenpass-proverif-proof
rosenpass-proverif-proof> $ metaverif analysis/02_availability.entry.mpv -color
ym6dv-rosenpass-proverif-proof
rosenpass-proverif-proof> $ wait -f 34
rosenpass-proverif-proof> $ cpp -P -I/build/source/analysis analysis/01_secrecy.
y.i.pv
rosenpass-proverif-proof> $ cpp -P -I/build/source/analysis analysis/02_availabi
ility.entry.i.pv
rosenpass-proverif-proof> $ awk -f marzipan/marzipan.awk target/proverif/01_secr
rosenpass-proverif-proof> $ awk -f marzipan/marzipan.awk target/proverif/02_avai
rosenpass-proverif-proof> 4s ✔ state coherence, initiator: Initiator accepting a
ed the associated InitHello message
rosenpass-proverif-proof> 35s ✔ state coherence, responder: Responder accepting
ted the associated RespHello message
rosenpass-proverif-proof> 0s ✔ secrecy: Adv can not learn shared secret key
rosenpass-proverif-proof> 0s ✔ secrecy: There is no way for an attacker to learn
rosenpass-proverif-proof> 0s ✔ secrecy: The adversary can learn a trusted kem pk
rosenpass-proverif-proof> 0s ✔ secrecy: Attacker knowledge of a shared key impli
rosenpass-proverif-proof> 31s ✔ secrecy: Attacker knowledge of a kem sk implies
```

- Symbolic modeling using ProVerif
- Proofs treated as part of the codebase
- Uses a model internally that is based on a fairly comprehensive Maximum Exposure Attacks (MEX) variant
- Covers non-interruptability (resistance to disruption attacks)
- Mechanized proof in the computational model is an open issue

Problematic Parts of Pen-and-Paper Proofs

Bellare and Rogaway: [BR06]
many “essentially unverifiable” proofs, “crisis of rigor”

Halevi: [Hal05]
some reasons are social, but “our proofs are truly complex”

Joseph Jaeger: [ProTeCS 2024, Workshop at Eurocrypt]
technical and social reasons why and for whom do we write proofs?

We’d like to add:
pen-and-paper proofs are hard to maintain, update, reuse
especially for 3rd parties

Can proofs become part of a continuous engineering effort?

Friction & Frustration for the Working Cryptographer

Tooling

- Syntax highlighting, favorite editor
- Engineering for large models: syntax rewriting, syntactic sugar, macros
- Comfortable tooling to inspect intermediate games (CryptoVerif)

Documentation: Often incomplete; step from example to research too big

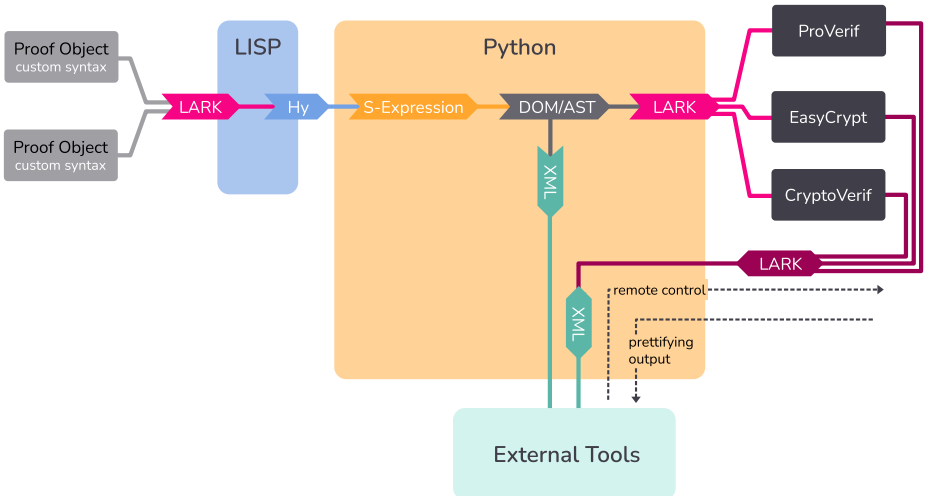
Output: hard to understand for non-experts

Input Language: Unintuitive? Inaccessible? Mixed signals!

Proof Language: not enough flexibility and leeway compared to pen-and-paper

- hand-waving, unsafe blocks
- support for incremental process

Rosenpass going Rube-Goldberg



Idea: Build a framework around existing tools

Keep expressivity and preciseness

Generate and parse their languages

Open them up to ecosystems in Python, Lisp, XML

Epilogue

Epilogue

Rosenpass

- Post-quantum secure AKE
- Same security as WireGuard
- Improved state disruption resistance
- Transfers key to WireGuard for hybrid security

rosenpass.eu

About Protocols

- It is possible to treat NIKEs as KEMs with DHKEM
- The GHP-Combiner can be used to combine multiple KEMs
- X-Wing makes this easy
- Wall clocks are not to be trusted

Talk To Us

- Adding syntax rewriting to the tool belt of mechanized verification in cryptography
- Using broker architectures to write more secure system applications
- Using microvms to write more secure applications
- More use-cases for rosenpass

Appendix — Here Be Dragons

Bibliography

[PQWG]: https://eprint.iacr.org/2020/379

Graphics attribution

- https://unsplash.com/photos/brown-rabbit-Efj0HGPdPKs
- https://unsplash.com/photos/barista-in-apron-with-hands-in-the-pockets-standing-near-the-roaster-machine-Y5qjv6Dj4w4
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- https://unsplash.com/photos/white-rabbit-on-green-grass-u_kMWN-BWyU

Random slides — The dragon just ate you!

Rosenpass and WireGuard: Advanced Security

Limited Stealth:

- Protocol should not respond without pre-auth.
- Proof of IP ownership (cookie mechanism) prevents full stealth
- Adv. needs to know responder public key

Limited Identity Hiding:

- Adversary cannot recognize peers unless their public key is known
- This is incomplete!

CPU DOS mitigation:

- Attacker should not easily trigger public key operations
- Preventing CPU exhaustion using network amplification
- Proof of IP ownership

Triumphs ~ Secrecy & Non-Interruptability

Modeling of Rosenpass

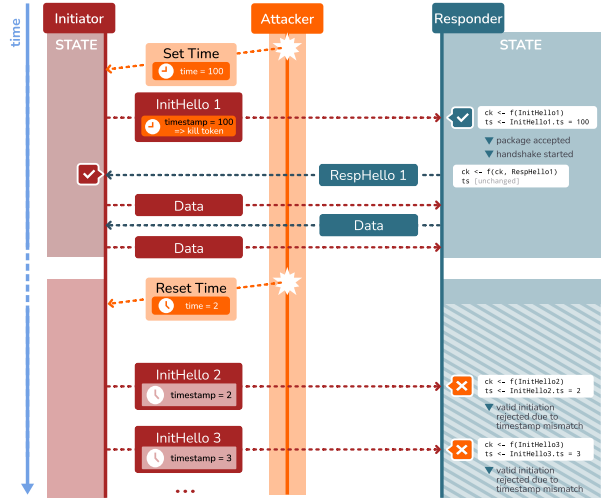
Using ProVerif

Non-Interruptability: More Formally

For every pair of traces $\texttt{tmin}, \texttt{tmax}$ where trace $\texttt{tmax}$ can be formed by insertion of messages/oracle calls into $\texttt{tmin}$, the result of $\texttt{tmin}$ and $\texttt{tmax}$ should remain the same.

- Let $\texttt{Result}$ be the set of possible protocol results
- Let $\texttt{Trace}$ be the set of possible protocol traces
- Let $\texttt{res}(\texttt{t}) : \texttt{Trace} \to \texttt{Result}$ determine the protocol result given $\texttt{t} : \texttt{Trace}$
- Let $\texttt{t1} \supseteq \texttt{t2} : \texttt{Trace} \to \texttt{Trace} \to \texttt{Prop}$ denote that $\texttt{t2}$ can be formed by insertion of elements into $\texttt{t1}$
- $\forall(\texttt{tmin}, \texttt{tmax}) : \texttt{Trace} \times \texttt{Trace}; \texttt{tmin} \supseteq \texttt{tmax} \to \texttt{res}(\texttt{tmin}) = \texttt{res}(\texttt{tmax})$

ChronoTrigger Attack: Immediate Execution



A. Preparation phase:

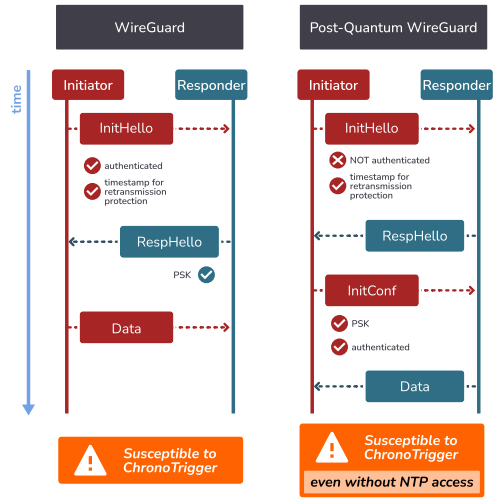
1. **Attacker** sets *initiator system time* to a future value
2. **Attacker** waits while both peers are performing a valid handshake

B. Direct execution phase:

1. **Attacker** lets system time on initiator reset

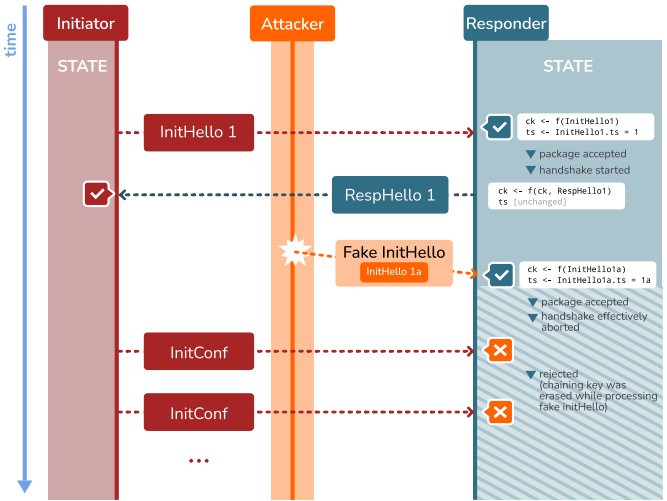
=> Initiation now fails due to counter mismatch

ChronoTrigger: Changes in Post-Quantum WG



- *InitHello* is unauthenticated
- Retransmission counter is kept
- PQWG assumes a pre-shared key to authenticate InitHello instead (the authors recommend deriving the PSK from both public keys)
- PSK evaluated twice, during InitHello *and* InitConf processing

ChronoTigger against Post-Quantum WireGuard



No PSK/Public keys as PSK

- Attacker needs access to public keys
- The attack is trivial (attacker just forges *InitHello*)

With PSK

- Replay attack with NTP access from classic WireGuard still applies

Trials ~ Attacks found

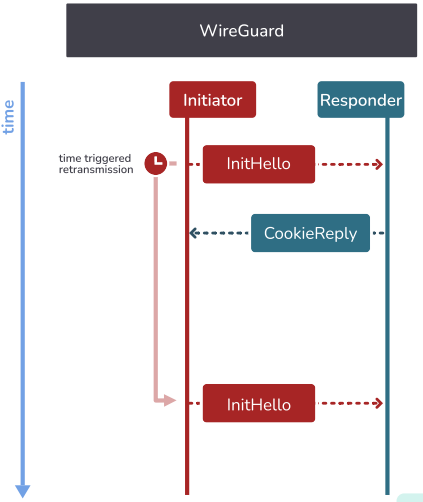
CookieCutter

CookieCutter Attack

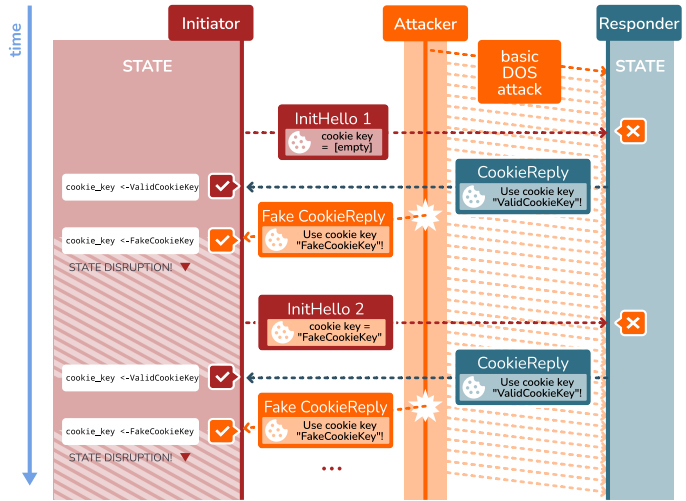
ROSENPASS

I am under load. Prove that you are not using IP address impersonation before I process your handshake!
This message contains a *cookie key*. Use it to prove that you can receive messages sent to your address when retransmitting your *InitHello* packet.

A WireGuard CookieReply, ca. 2014



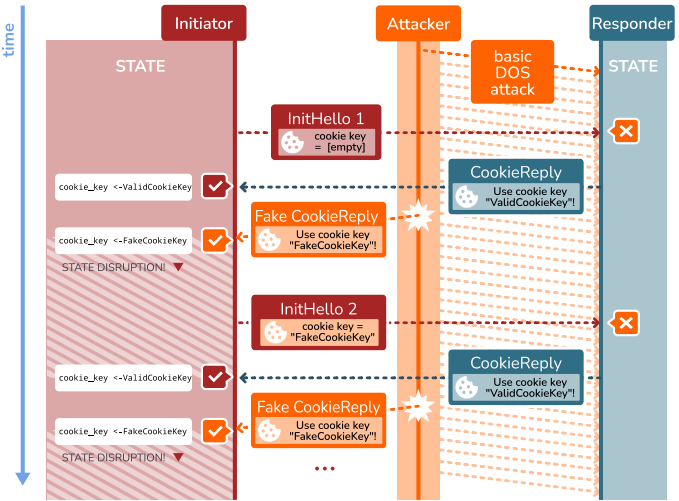
CookieCutter Attack



1. **Attacker** begins continuous DOS attack against responder
2. **Initiator** begins handshake, sends *InitHello*
3. **Responder** replies with *CookieReply*
   > **CookieReply:** I am under load. Prove you are not using an IP spoofing attack with this *cookie key*.
4. **Initiator** Initiator stores cookie key and waits for their retransmission timer
5. **Attacker** forges a cookie reply with a fake *cookie key*
6. **Initiator** Initiator overwrites the valid cookie key with the fake one

... Repeat ad nauseam

CookieCutter Attack



Attacker gains:

- Cheap protocol-level DOS

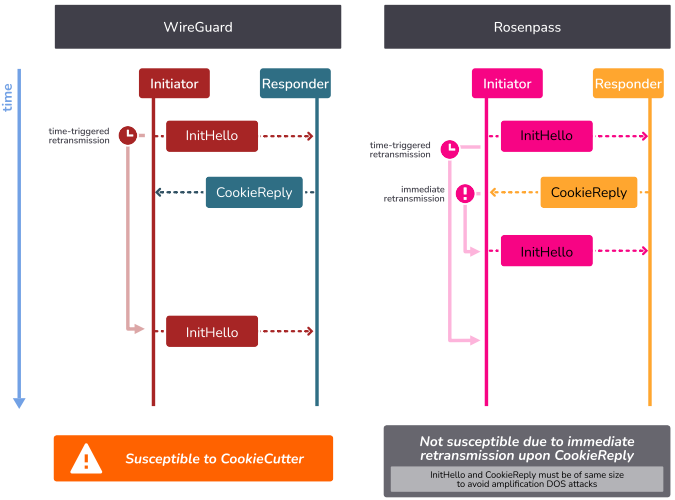
Attacker needs:

- Knowledge of public keys
- Good timing

Role switching:

- WireGuard sometimes uses role switching
- To account for that, the attack can be performed against both peers

CookieCutter: Post-Quantum WG & Rosenpass



Post-Quantum WireGuard

- No change.

Rosenpass

- Immediate retransmission of *InitHello* upon receiving *CookieReply*
- *CookieReply* and *InitHello* must be of same size to prevent DOS amplication attacks

⇒ Rosenpass is protected from CookieCutter attacks

Trials ~ Advanced Security Properties

Knock Patterns

Rosenpass and WireGuard: Advanced Security

CPU DOS mitigation:

- No change on the protocol level.
- 😐 Slightly worsened in practice because PQ operations are more expensive than elliptic curves

Limited Stealth:

- No change in Rosenpass, but we should have **full stealth**!

⇒ Remove cookie mechanism?

😐 This would affect the CPU DOS mitigation too much.

Limited Identity Hiding:

- No change in Rosenpass, but we should have **full identity hiding**!

⇒ Do not use pre-authentication with public key?

😐 This would affect the CPU DOS mitigation, possibly too much.

Choose Two: Stealth, Identity Hiding, CPU DOS Mit.

CPU DOS Protection
asymmetric functions are not called unless pre-auth has succeeded

KNOCK PATTERNS
proof of IP ownership
interactive proof of work

KNOCK PATTERNS
initiator public key
responder public keys
weaker + more performant form of authentication (e.g. EC-based NIKE)

WireGuard

Stealth
no interactive pre-auth allowed

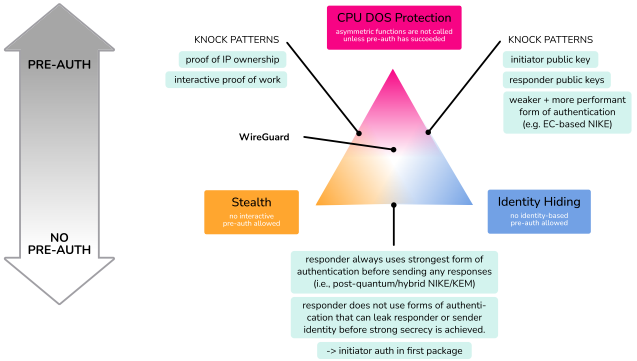
Identity Hiding
no identity-based pre-auth allowed

responder always uses strongest form of authentication before sending any responses (i.e., post-quantum/hybrid NIKE/KEM)

responder does not use forms of authenti-cation that can leak responder or sender identity before strong secrecy is achieved.

-> initiator auth in first package

WireGuard and Rosenpass Trade-Offs



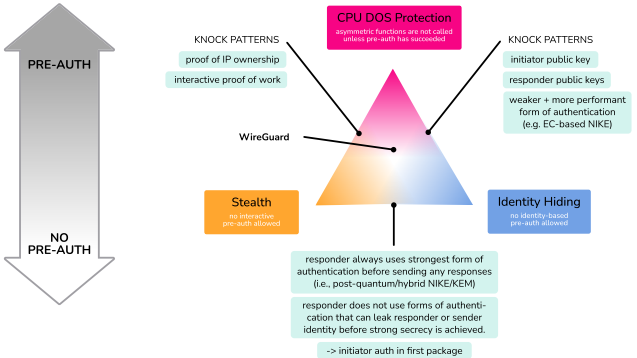
CPU DOS Mitigation:

- There is no clear optimum here.
- CPU DOS mitigation is never calling asymmetric crypto unless we know it succeeds (circular reasoning)

Stealth:

Identity hiding:

WireGuard and Rosenpass Trade-Offs



CPU DOS Mitigation:

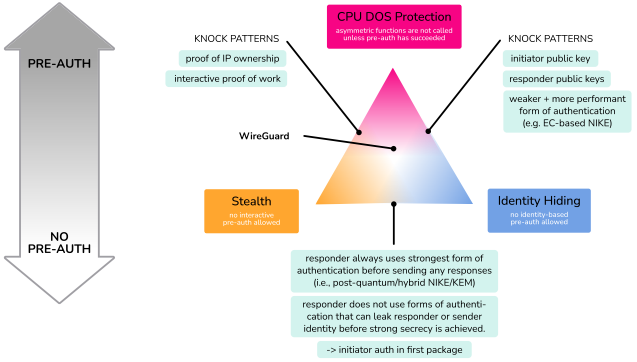
Stealth:

- Broken on DOS attacks assuming recipient is known

⇒ This seems acceptable

Identity hiding:

WireGuard and Rosenpass Trade-Offs



CPU DOS Mitigation:

Stealth:

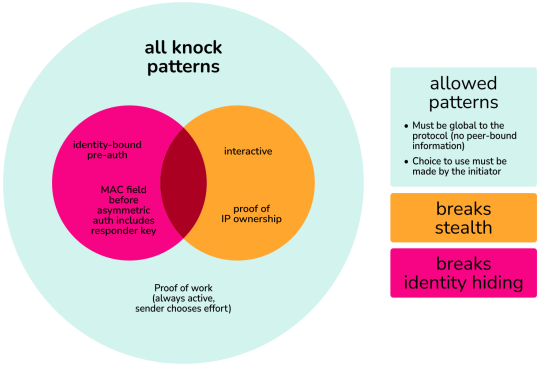
Identity hiding:

- Broken on knowledge of public keys

⇒ This seems inacceptable!

⇒ Investigate proper identity hiding without overly impacting stealth and CPU DOS mitig.

Knock Patterns



- We choose to think of WireGuard's and Rosenpass' pre-auth as "Knock Patterns"
- These knock patterns have severe trade-offs.
- Interactive knock pattern (cookie mechanism) breaks stealth
- Identity-based knock patterns (e.g., knowledge of public key) breaks identity hiding

⇒ Avoid identity-bound knock patterns
⇒ Minimize interactive knock patterns
⇒ Explore other (allowed) knock patterns

Tools to the Table!

Bellare and Rogaway [BR06], Halevi [Hal05]:
Call for “automated tools, that can help write and verify game-based proofs”

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We like these tools, they are good!

Tools to the Table!

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Do the tools *actually help*? And if yes, whom?

ProVerif, Tamarin, CryptoVerif, EasyCrypt:
We like these tools, they are good!

They mostly help the *formal verification experts* to:

- do analyses themselves, write papers
- develop proof methodologies, foundation work for formal methods

Epilogue

Conclusion

Rosenpass

- Post-quantum secure AKE
- Same security as WireGuard
- Improved state disruption resistance
- Transfers key to WireGuard for hybrid security

Protocol Findings

- **CookieCutter**: DOS exploiting WireGuard cookie mechanism
- **ChronoTrigger**: DOS exploiting insecure system time to attack WireGuard
- There is a **trade-off** between identity hiding, stealth, and CPU-exhaustion DOS protection

Talk To Us

- About why we should use Tamarin (or SAPIC+?) over ProVerif
- State disruption attacks
- Stealth and Identity hiding
- Adding syntax rewriting to the tool belt of mechanized verification in cryptography

rosenpass.eu

Rosenpass going Rube-Goldberg: The Details

- Embed cryptographic proof syntax in Lisp S-Expressions
- Translate Lisp code to Python using the Hy language (Lisp that compiles to Python)
- Translate S-Expression code to AST or DOM
- Translate AST or DOM to ProVerif/Tamarin/CryptoVerif/EasyCrypt code using the LARK code parser/generator
- Remote control ProVerif/Tamarin/CryptoVerif/EasyCrypt by
  - Parsing their command line output using LARK
  - (Possibly using the language server interface for more interactive features)
- Provide custom syntax using
  - Lisp Macros
  - Extending LARK-based syntax parsers (to add custom syntactic elements)
  - AST Rewriting for more complex adaption
- Integrate with external tools by exporting our AST as XML
  - XML is just a convenient grammar for trees
  - We do not need to support the full complexity of XML including XML style sheets and such things