Post-Quantum

Cryptography Conference

Quantum-Safe Secure Boot: How hard can it be?

Secure boot is hard. Quantum-safe secure boot is even harder. It starts with the choice of a suitable algorithm. On the signature verification side, conflicting regulatory requirements on Post-Quantum/Traditional (PQ/T) hybrid mean there is no silver-bullet, while on the signature generation side, key management challenges and the lack of available end-to-end quantum-safe solutions further complicate the decision process. In this talk we highlight open issues at various stages of the secure boot lifecycle.

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Quantum-Safe Secure Boot

How hard can it be?

Dr. Axel Y. Poschman

Speaker: about me

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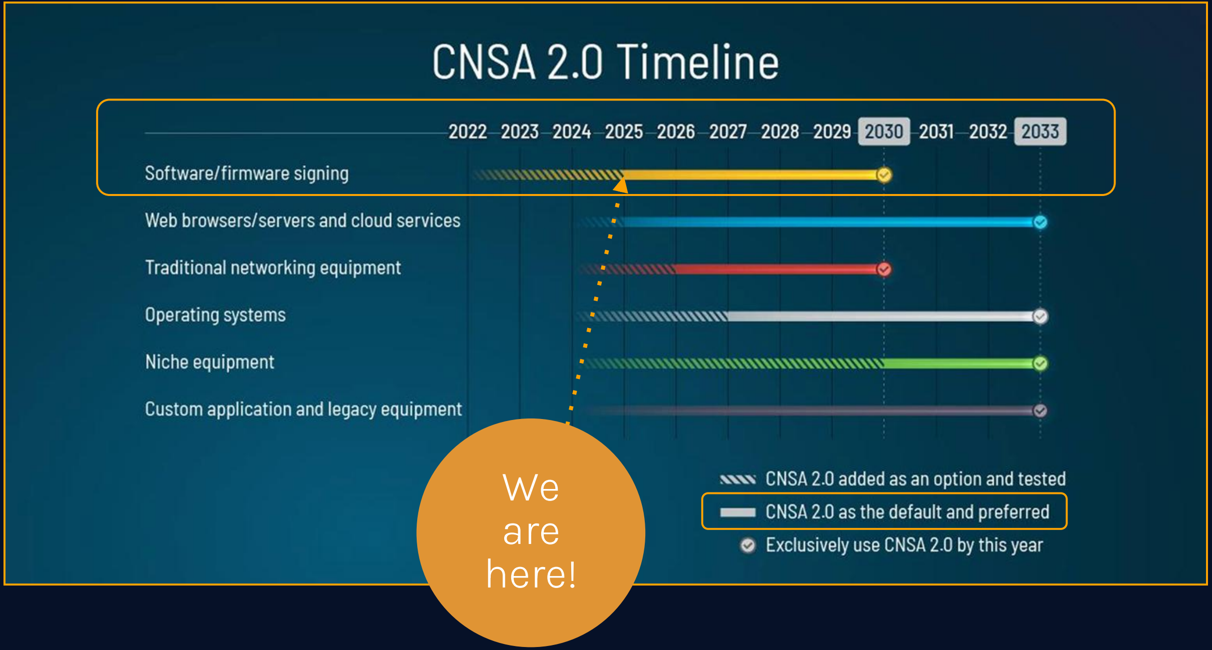
- 2006-2009 U Bochum:
  PhD in Lightweight Cryptography
- 2009-2014 NTU:
  Asst Prof in Cryptographic Engineering
- 2014-2017 NXP Semiconductors:
  Leading internal hardware hacking team
- 2017-2023 xen1thLabs:
  General Manager of the NTVL of the UAE
- 2022 INSEAD:
  Executive MBA
- 2023 PQShield:
  VP of Product

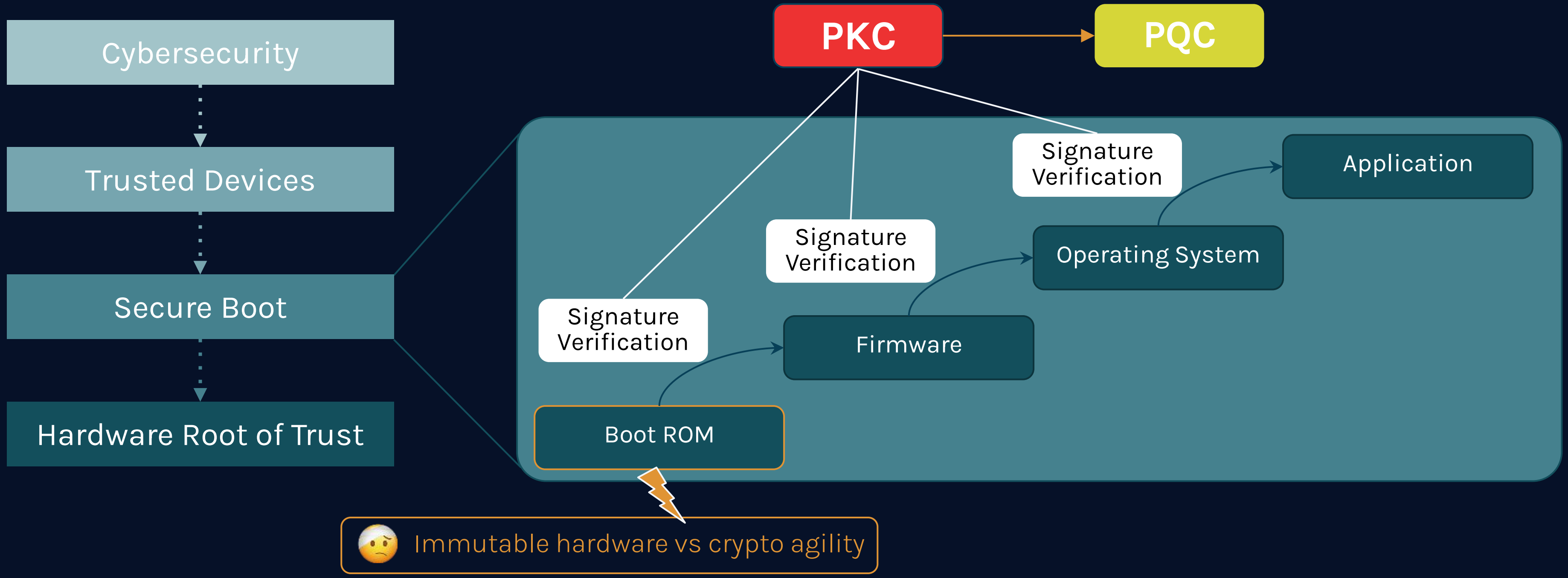
Secure Boot: why act now?



All markets with long product life cycles have to act now:

- Semiconductors
- Automotive
- Defense
- …

Secure Boot: the bedrock of cybersecurity



Secure Boot: full PQC or PQ/T Hybrid?

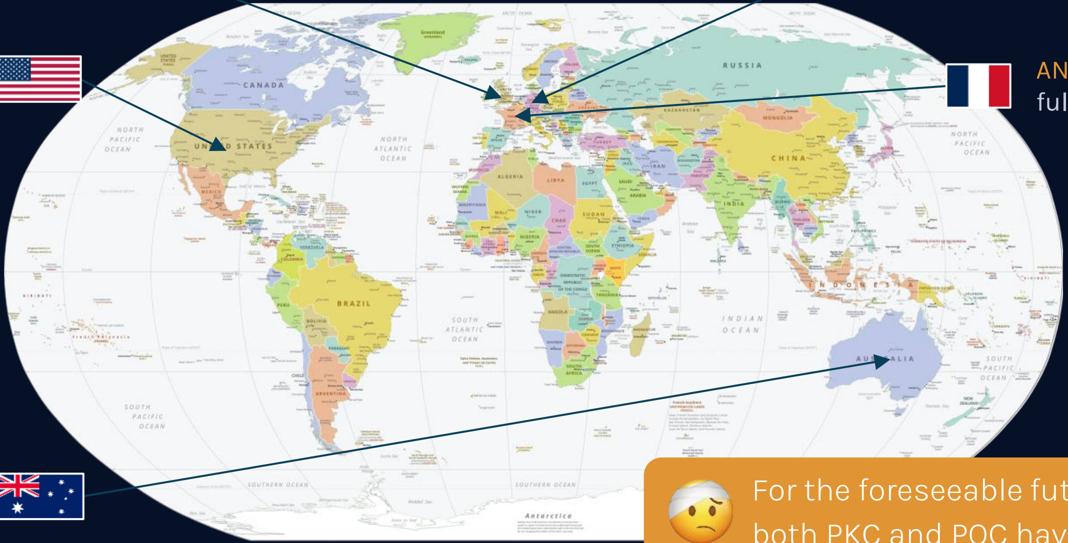
NCSC: Transition to full PQC
PQ/T hybrid should be carefully evaluated

NSA: Transition to full PQC
PQ/T hybrid not recommended (CNSA1.0 for IKEv2 indefinitely)

ASD: Transition to full PQC
PQ/T hybrid not recommended, but not prohibited

BSI: Transition to PQ/T hybrid
optional full PQC at a later stage

ANSSI: Transition to PQ/T hybrid
full PQC after 2030



For the foreseeable future (2030/2035) both PKC and PQC have to be supported

Secure Boot: deprecated and disallowed algorithms

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
USA	Fully PQC										
UK	Fully PQC										
AUS	Fully PQC										
FR	PQ/ T Hybrid					Fully PQC					
DE	PQ/ T Hybrid					Fully PQC Optional					

Conflicting regulatory requirements regarding use of RSA and ECDSA

Not to mention additional regional algorithms…

Painpoints: PQ/T Hybrid = 2x complexity

PQ/T Hybrid doubles number of algorithms to support

Increases cost due to increased
- Memory
- Area

Greater computational overhead
- Latency
- Energy consumption

Greater bandwidth overhead
- Latency
- Throughput

Increased complexity results in more difficult:

- Maintenance
- Analysis
- Secure implementation

Protectability: Side-Channel

Algorithm	Grade (5= best)	Argument
ML-DSA	3	Operations computing directly on the long term secrets are easy to protect, while ephemeral secrets involve more complicated operations.
FN-DSA	1	Contains floating point operations vulnerable to SCA.
SLH-DSA	5	Due to the structure of HBS, very few SCA attack paths exist.
LMS	5	Similar to SLH-DSA, but with a limited number of traces available.
XMSS	5	Similar to SLH-DSA, but with a limited number of traces available.

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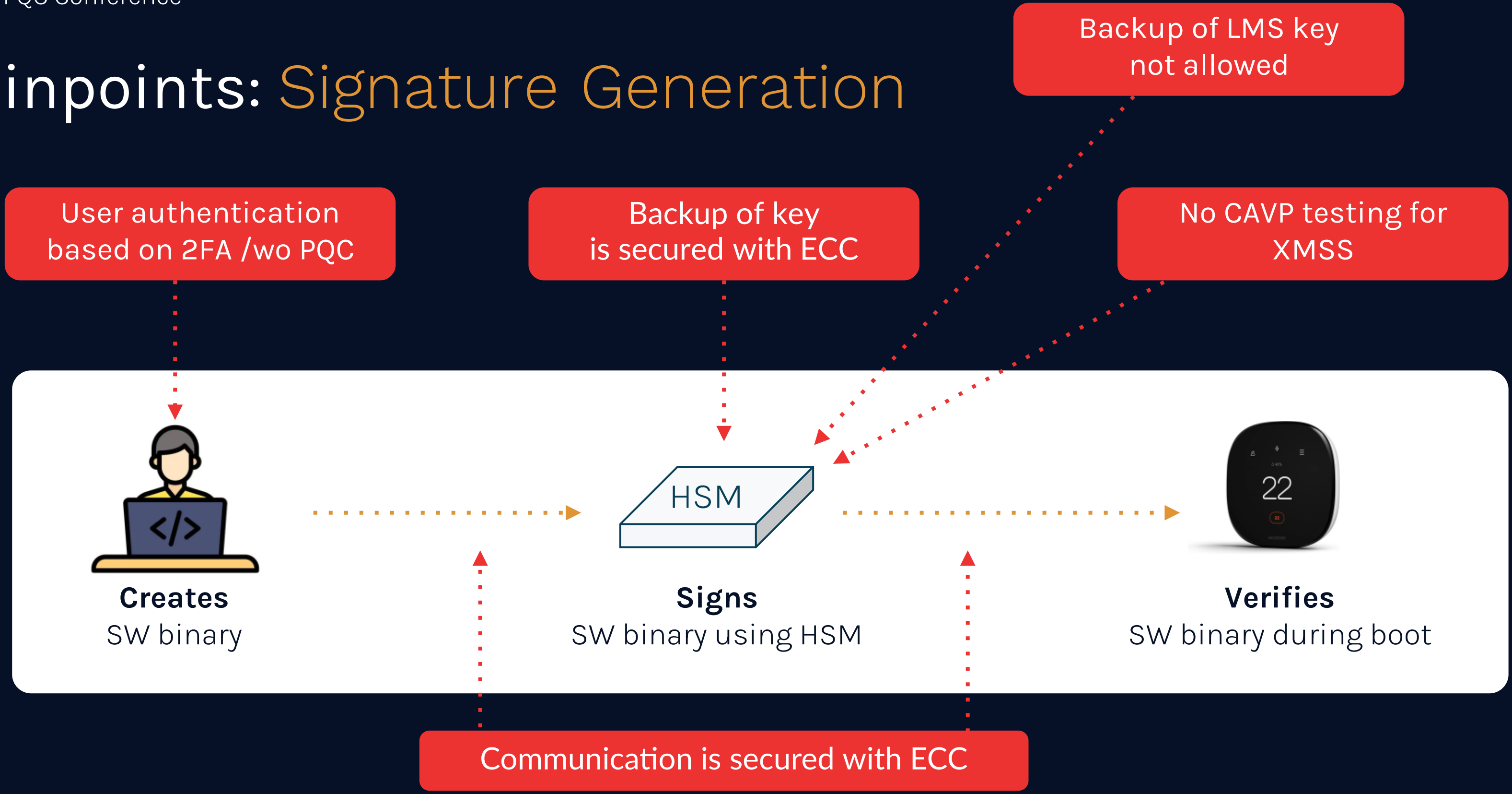
Protectability: Fault Attack

Algorithm	Grade (5= best)	Argument
ML-DSA	3	Protection against loop-abort attacks required. Full signature recomputation has relatively low performance cost due to rejection sampling.
FN-DSA	2	Recomputation countermeasure against FA using faulty valid signatures, is more costly than for ML-DSA.
SLH-DSA	1	FA forcing multiple uses of one time signature (WOTS) scheme.
LMS	1	Similar to SLH-DSA but with a limited number of faults.
XMSS	1	Similar to SLH-DSA but with a limited number of faults.

Painpoints: Signature Generation



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Secure Boot Challenges: no silver bullet in sight

Cybersecurity

Trusted Devices

Secure Boot

Hardware Root of Trust

Painpoint Crypto Agility:
- ROM code cannot be changed once manufactu
- Favours more mature algorithms like LMS

Painpoint Government Compliance:
- SLH-DSA and FN-DSA not all ment use
- XMSS not FIPS certifia

Painpoint PQ/T Hybri
- France ers mandate PQ/T hybrid
- Do e for ML-DSA and FN-DSA

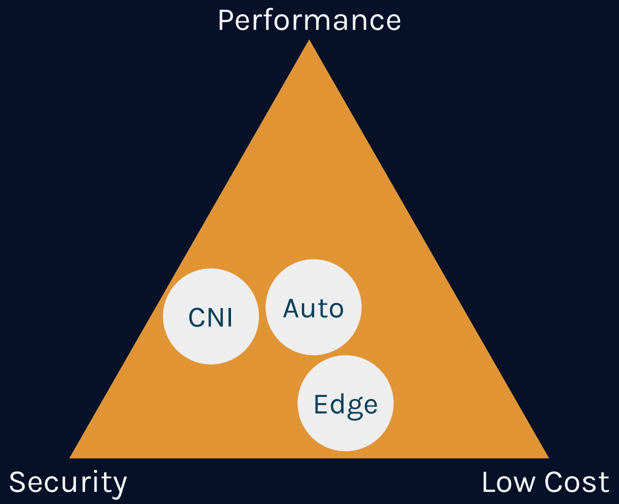
ure Generation:
- ware signature generation requires using an HSM
- No practical HSM for LMS and XMSS available

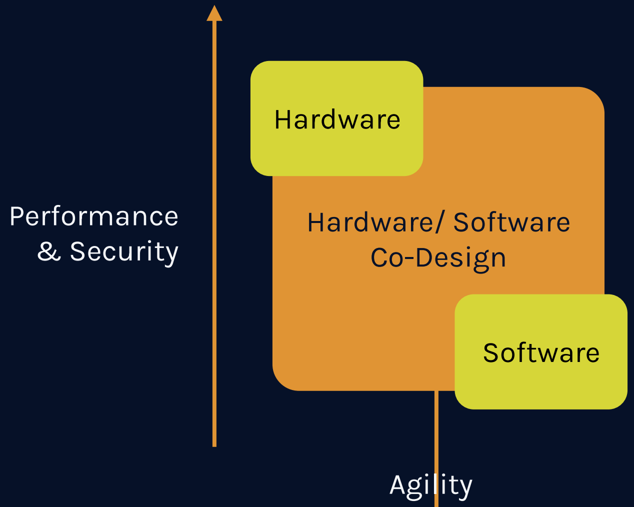
There is no one-size-fits-all solution

Algorithmic choice: no silver bullet in sight

Algorithm	CNSA2.0	PQ/T Hybrid	SCA	Fault	CAVP/ACVP	Key Backup
ML-DSA	V	V	3	3	V	V
FN-DSA	X	V	1	2	X	V
SLH-DSA	X	X	5	1	V	V
LMS	V	X	5	1	V	X
XMSS	V	X	5	1	X	X

Secure Boot: trade-offs, hardware, and software





Use-case specific optimization goals

- Performance
- Security
- Cost

Optimized integrated solution

- Hardware for performance and security
- Software for agility

Take away: optimized, flexible HW/SW solutions required

- CNSA2.0 already mandates quantum-safe secure boot today
- Secure boot is the bedrock of cybersecurity
- Different regulatory timelines -transition and deprecation- require configurability
- For the foreseeable future a zoo of algorithms -PKC and PQC- need to be supported
- No silver bullet available

Flexible HW/SW co-design solutions optimized for specific use cases required

PQShield

think openly, build securely