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Secure Boot and Key Management for Embedded Devices in the Post-Quantum Transition

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Dr. Xin Qiu brings over 25 years of expertise in Public Key Infrastructure (PKI), device and software security, with a portfolio of 90+ patents.

She leads cross-functional teams delivering trusted, scalable security services to device manufacturers and network operators worldwide.

Agenda

- Introduction - background
- Key Challenges to Post-Quantum Cryptography (PQC) Adoption
- 3-Stage Transition Framework for Gradual PQC Adoption
- Secure Boot & Device Credential Provisioning & Key Mgmt.
- Conclusions

Post Quantum Cryptography (PQC) in Simple Terms

RSA / ECC under quantum threat

- Quantum computers could break today's public-key algorithms

PQC, quantum safe

- New cryptographic algorithms resistant to quantum attacks
- Based on lattice, code-based, or hash-based math instead of integer factoring (RSA) & elliptic curve discrete logarithm (ECC)

NIST standardization progress

- NIST has completed standardization of the first post-quantum algorithms, signaling the industry's move from research to implementation readiness

Why PQC Transition Is Critical Now?

Past transition were slow

- MD5→SHA, DES→AES took years.

PQC is broader in scope

- replacing all public-key algorithms across systems and protocols.

Requires balance

- agility without disrupting core services

Delaying action increases risks

- adversaries may already be harvesting encrypted data for future quantum decryption

Key Considerations – Device Lifecycle & Cost

Long Device Lifespans

- Many hardware systems—consumer and non-consumer alike—are designed to last 10–15+ years.

High Replacement Costs

- Replacing deployed devices is complex and expensive.

In-Field Update

- Limited infrastructure and device capability for secure in-field updates, including secure software and PQC credential provisioning.

Hardware Constraints

Limited Availability of PQC-Ready Hardware

- PQC-capable security chips are not yet available
- Many existing devices cannot be easily upgraded for PQC

PQC Chip and Hardware Design Takes Time

- Developing dedicated PQC accelerators is complex, costly, and affects performance
- Integration requires significant redesign and validation

Leveraging Symmetric Encryption for PQC Transition

Symmetric encryption such as AES remains secure

- Even against quantum attacks, AES-256 retains 128-bit security

How Symmetric Encryption Helps:

- Protects PQC keys: Secures keys at rest and in transit
- Leverages Existing Hardware – Many devices already support AES hardware acceleration
- Bridges the Transition - Provides an efficient alternative before PQC-ready chips become available

We can use existing hardware security features as a foundation to bootstrap PQC migration

Where Security is Enforced

Two dominant approaches in industry to security -

Reactive: Detection-based security reacts to attacks

Network security and malware detection focus on identifying and responding to threats after systems are already running.

Regulatory and ecosystem requires building trust upfront – "Security by Design"

Focus of Today's Presentation

Proactive: Device and Software Security

Device Credentials:

Keys and certificates enable secure access to infrastructure, services, and resources.

Software Trust:

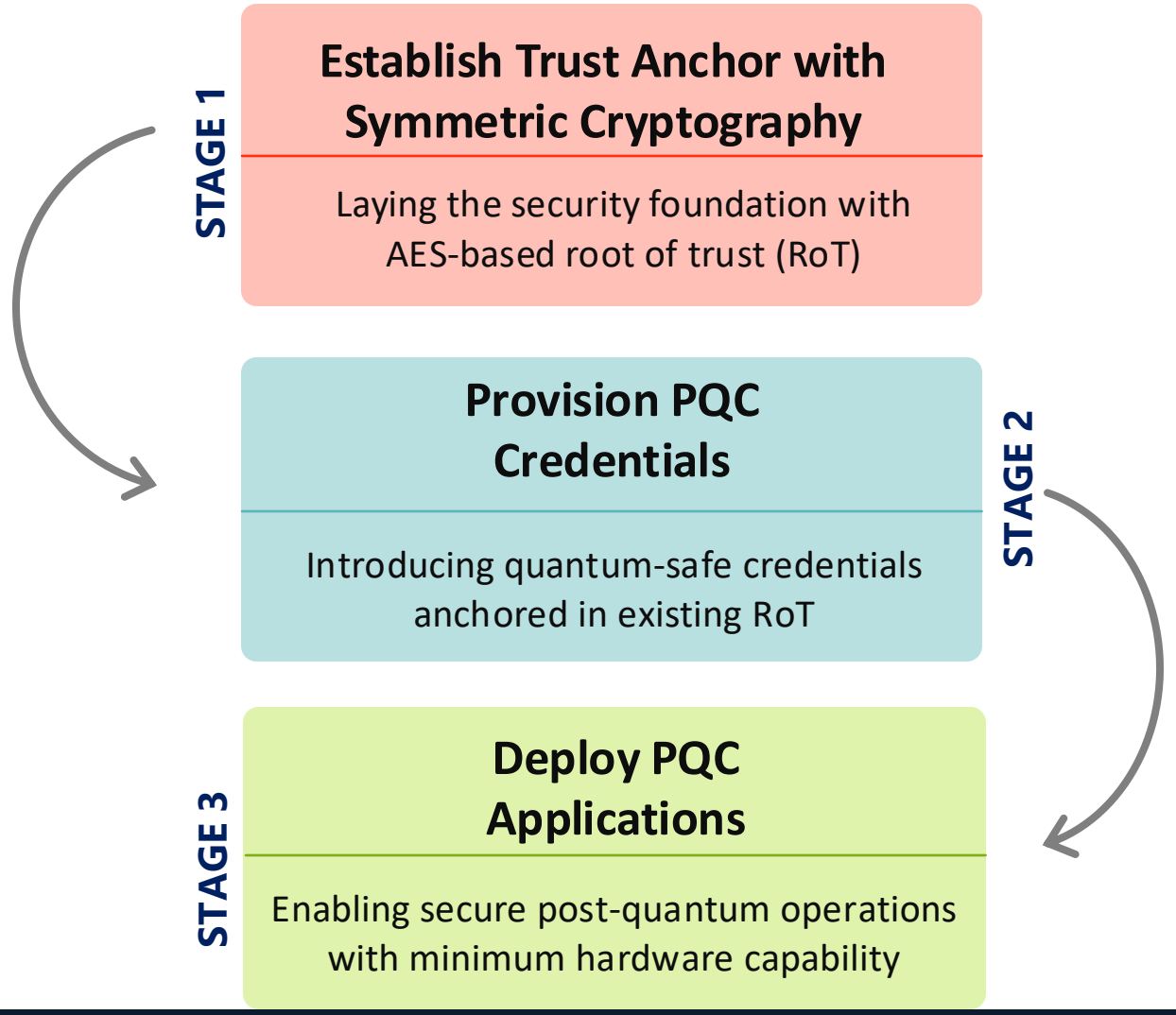
Authenticity, composition visibility, and vulnerability awareness before deployment.

3-Stage Transition Plan

- Leverage device's built-in hardware AES engine to perform authenticated secure boot.
- Store a unique pre-shared AES key in the chip's protected memory.
- Manage keys and access control from the infrastructure side to enforce policy and trust.

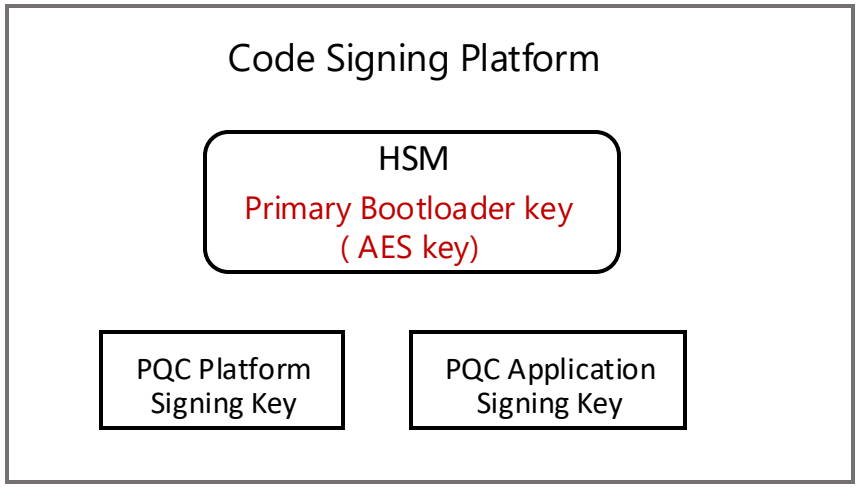
- Securely download the provisioning software to the device, using the secure boot in Stage 1.
- Generate PQC credentials on the device to avoid key exposure.
- Protect PQC private keys using the AES key (already securely stored on chip).

- Securely distribute and install PQC-enabled applications, again leveraging the trusted boot chain from Stage 1.
- Use the PQC credentials provisioned in Stage 2 to enable secure communication and data protection.

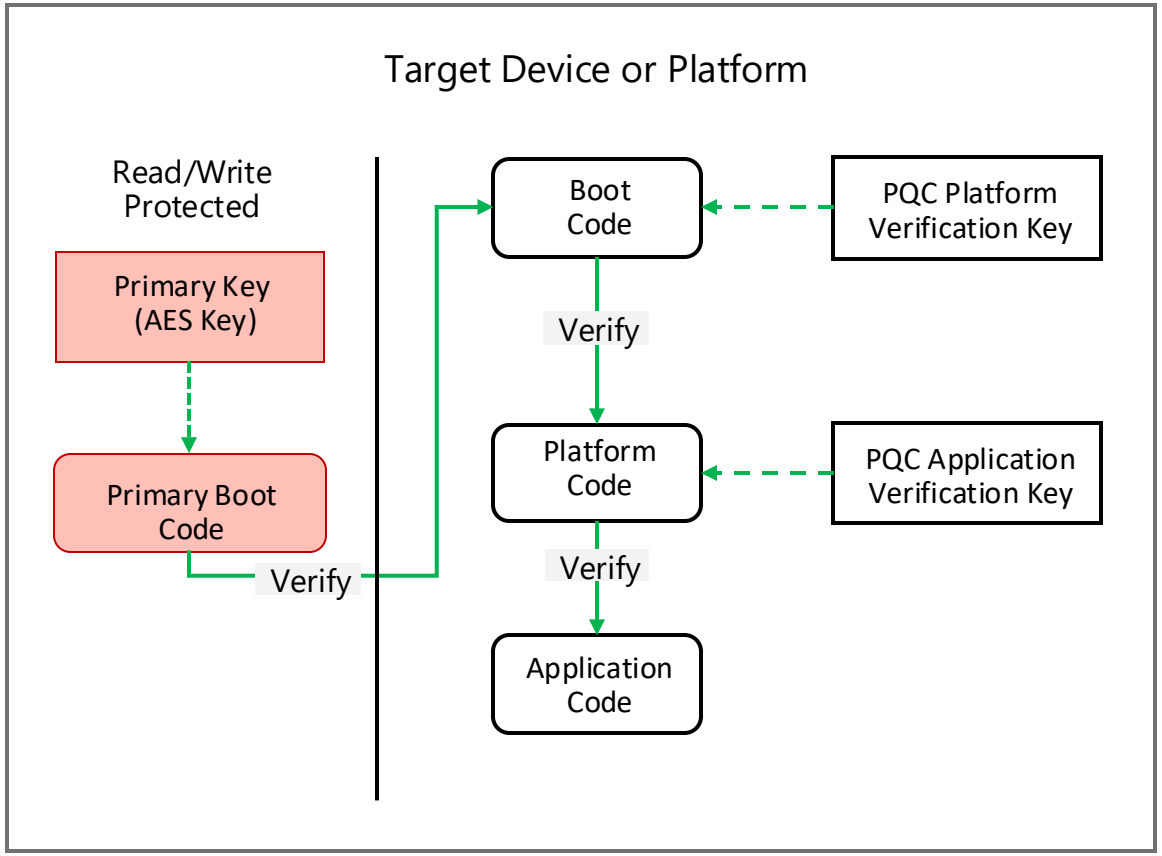


AES RoT for PQC-Based Software Protection

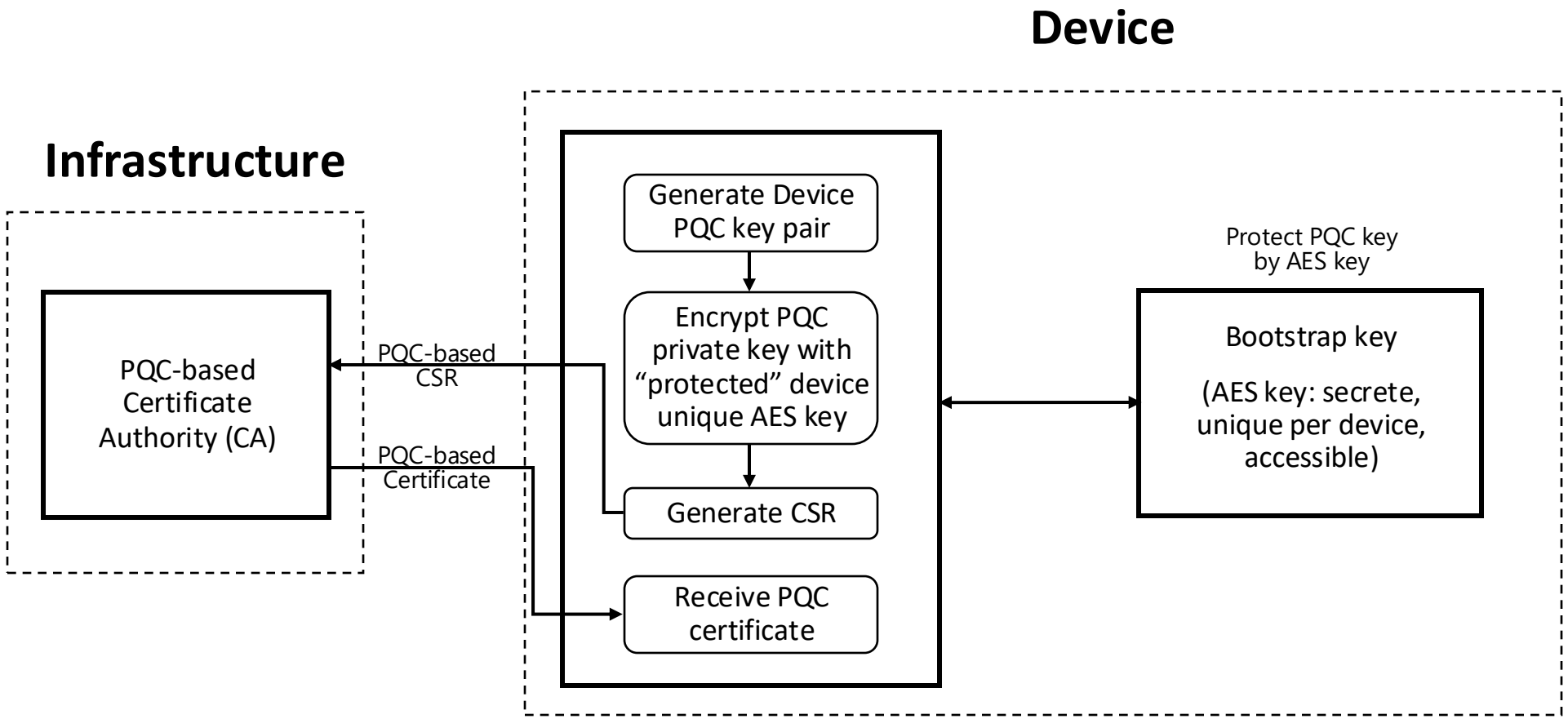
Infrastructure: Signing



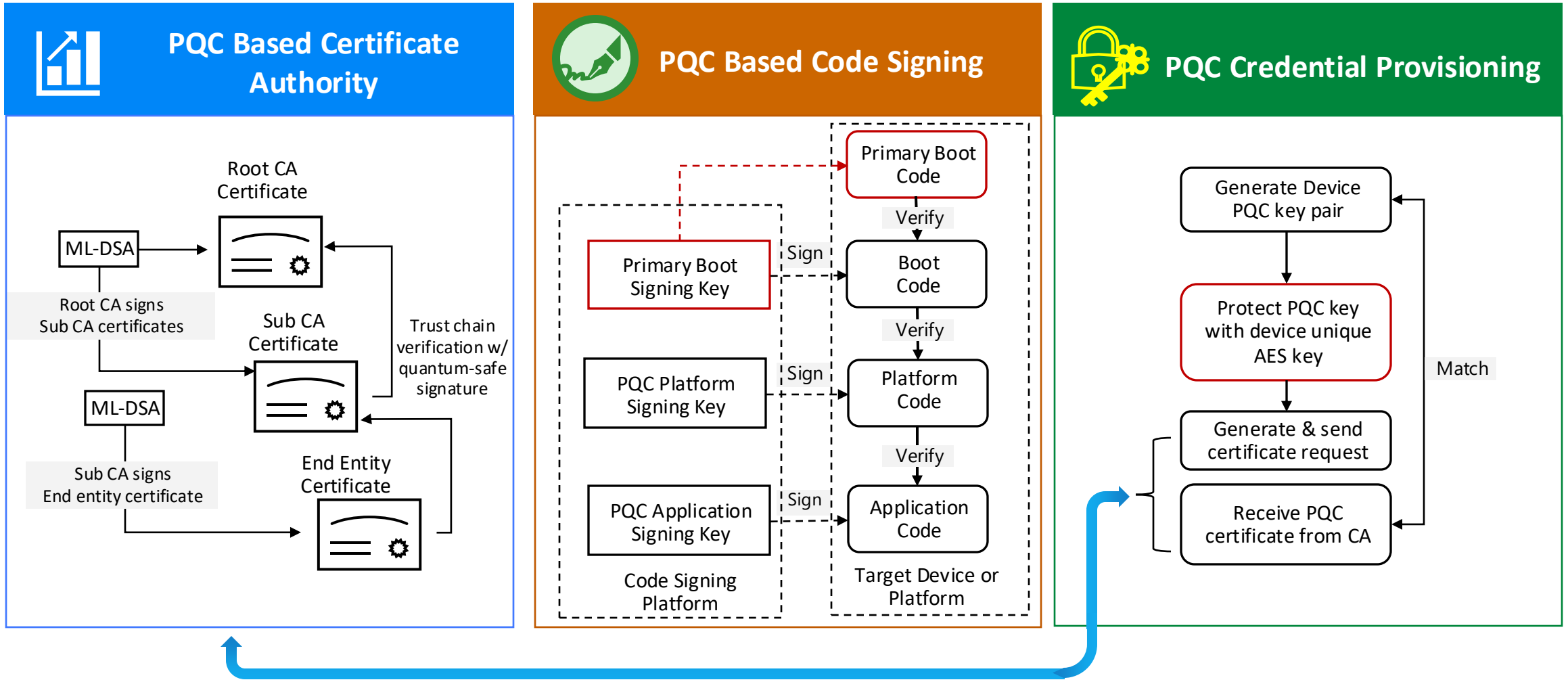
Device: Verifying



AES Protected PQC Credentials Provisioning



Quantum-Safe Advancement Focus



Practical Path to Post-Quantum Readiness

Key decisions

- When and where to introduce PQC
- How to manage mixed device capabilities at scale
- How to evolve cryptography without service disruption

How to engage

- Assess device populations and lifecycle constraints
- Align PQC strategy with operational and business realities
- Pilot safely, then scale across vendors

Key Takeaways

A full hardware swap is unrealistic - an incremental transition through software implementation could be considered.

Balancing security & practicality is needed to ensure both security and feasibility

This framework is about making post-quantum migration actually deployable on real devices to minimize the immediate risk

THANK YOU!

Q&A

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