POST-QUANTUM CRYPTOGRAPHY: A NEW CYBERSECURITY ERA

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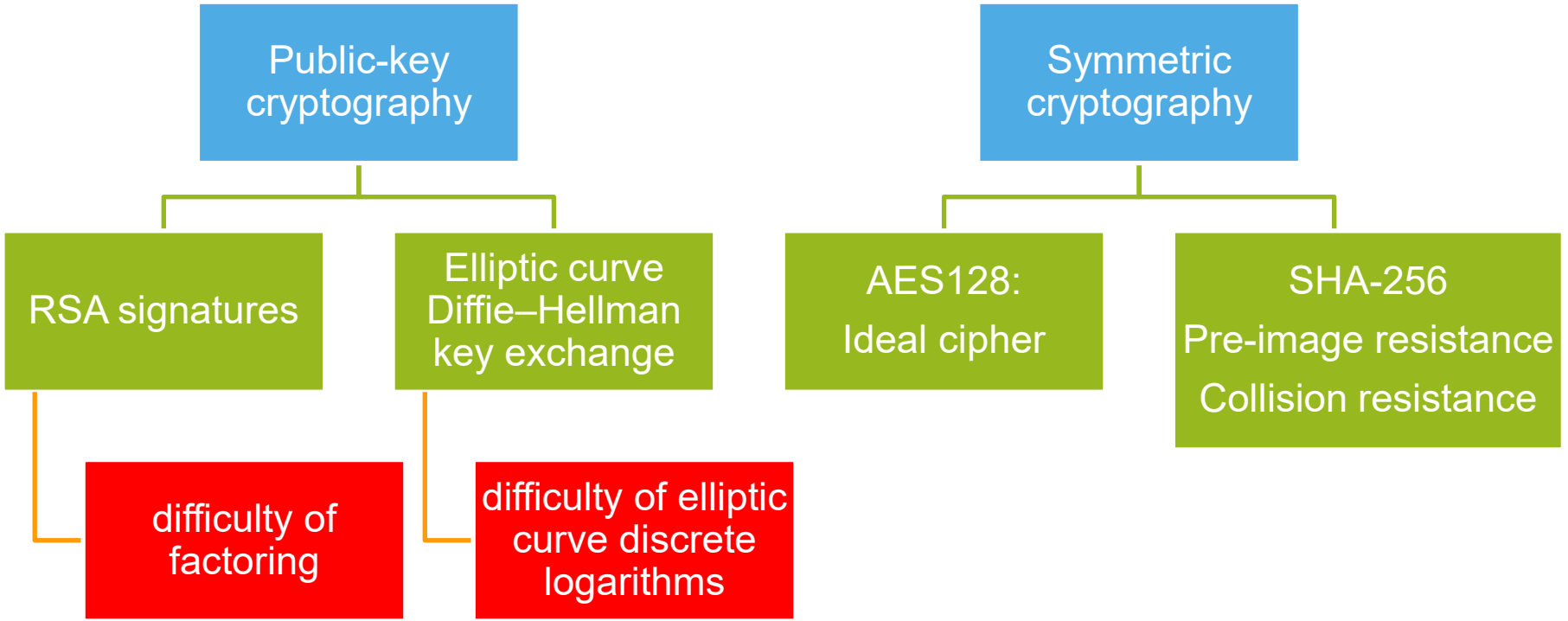
SECURE CONNECTIONS FOR A SMARTER WORLD

AGENDA

- Quantum computing
  - Opportunities
  - Threats
- Post-quantum cryptography standards
  - Winners
  - Timeline
- Use case study: S32G impact assessment
  - Impact in practice
  - Re-using hardware
  - Secure boot

CONTEMPORARY CRYPTOGRAPHY
TLS-ECDHE-RSA-AES128-GCM-SHA256



Microsoft is collaborating with some of the world's top mathemati
build a scalable, fault-tolerant, universal quantum computer. Resea
breakthroughs to develop both the quantum hardware and the sof

Microsoft is making these investments because the team knows a
computing.

Overview Publications Videos Groups Projects Events C

The roots of Microsoft's quantum computing effort go back nearly
investigate the complex mathematical theory behind topological q

Over time, the team has brought together mathematicians and cor
"Station Q" lab was established in 2005 on the campus of the Univ
physicists and start experimentally investigating the topological eff

The Santa Barbara lab became the center of Microsoft's research in
fractional Quantum Hall effect.

Google AI Blog

The latest news from Google AI

Quantum Supremacy Using a Programmable Superconducting Processor

Wednesday, October 23, 2019

Posted by John Martinis, Chief Scientist Quantum Hardware and Sergio Boixo, Chief Scientist Quantum Computing Theory, Google AI Quantum

technologyreview.com/s/603163/intel-bets-it-can-turn-everyday-silicon-into-quantum-computings-wonder-material

Machines

Bets It Can Turn Everyday n into Quantum Computing's ler Material

largest chip company sees a novel path toward of immense power.

nite December 21, 2016

his to test quantum computing devices at

WIRED BACKCHANNEL BUSINESS CULTURE GEAR IDEAS SCIENCE SECURITY

TOM SIMONITE BUSINESS 12.03.2020 02:00 PM

China Stakes Its Claim to Quantum Supremacy

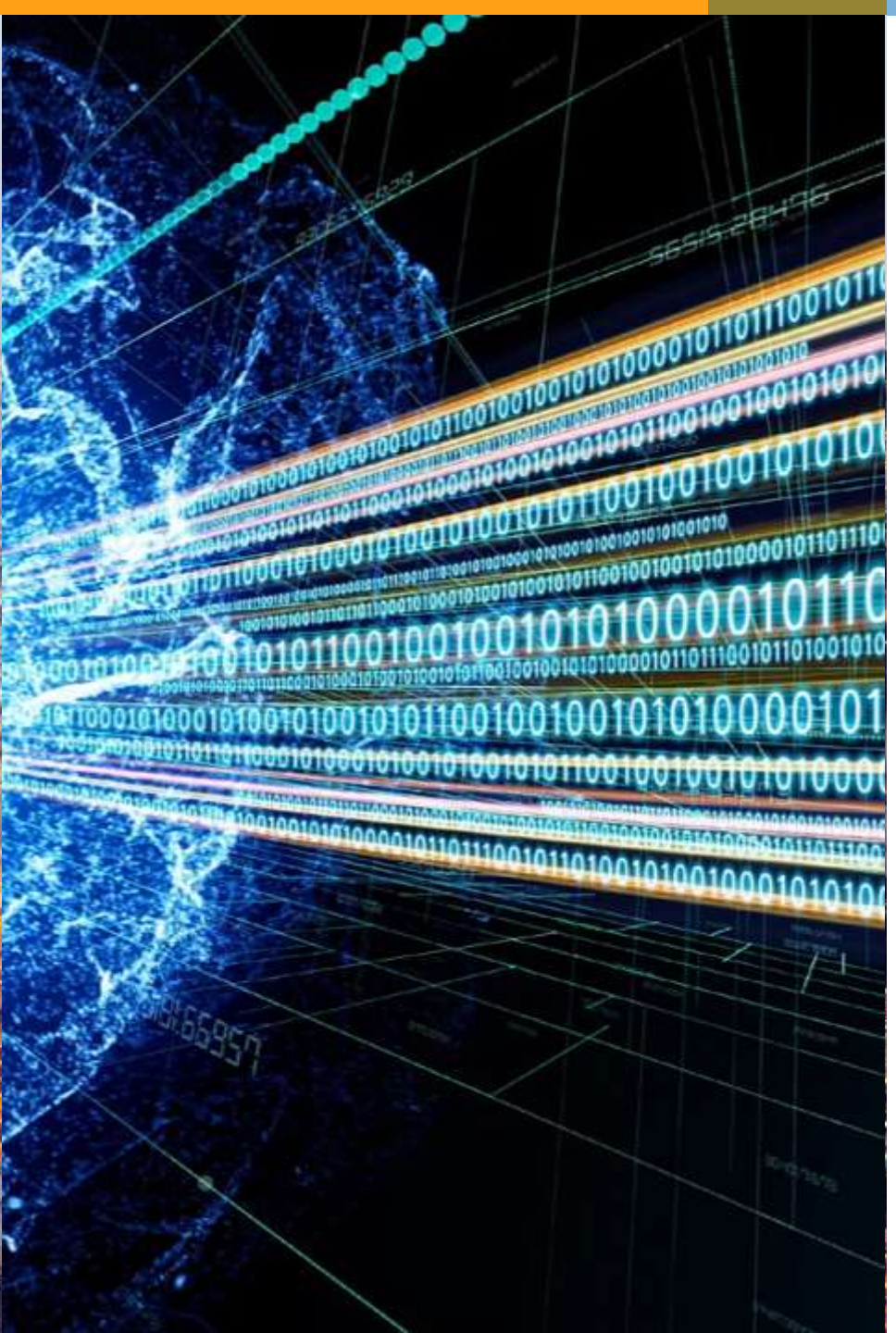
Google trumpeted its quantum computer that outperformed a conventional supercomputer. A Chinese group says it's done the same, with different technology.

g you in the face all along.
in the race to build
l offer immense processing
ı mechanics.

for simulating molecules on a quantum computer.

The breakthrough, outlined in a research paper to be published in the scientific journal

e all developing quantum components that are different from the ones crunching data in today's



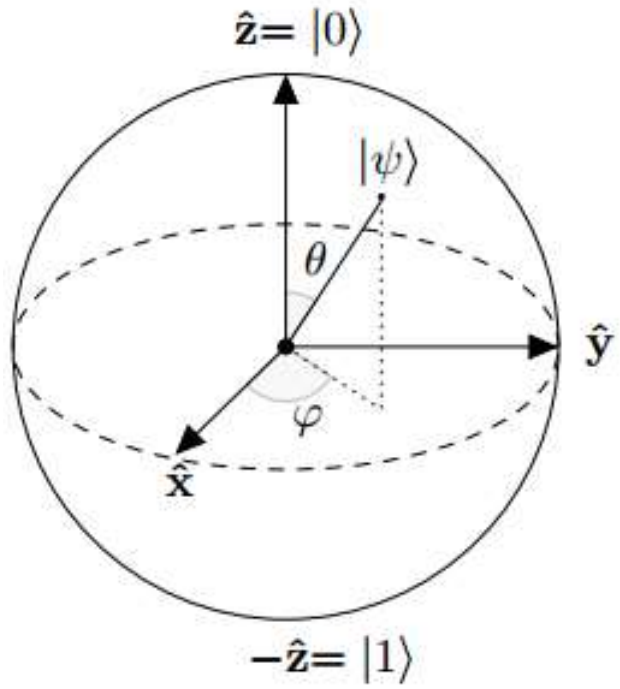
ADVANCES IN QUANTUM COMPUTING

Quantum computers hold the promise of being able to take on certain problems exponentially faster compared to a normal computer

- Healthcare and pharmaceuticals
- Materials
- Sustainability solutions
- Financial trading
- Big data and many other complex problems and simulations

QUANTUM COMPUTING

Computer systems and algorithms based on principles of quantum mechanics
- Superposition
- Interference
- Entanglement



- A classical bit can only be in the state corresponding to 0 or the state corresponding to 1
- A qubit may be in a superposition of both states
  → when measured it is always 0 or 1

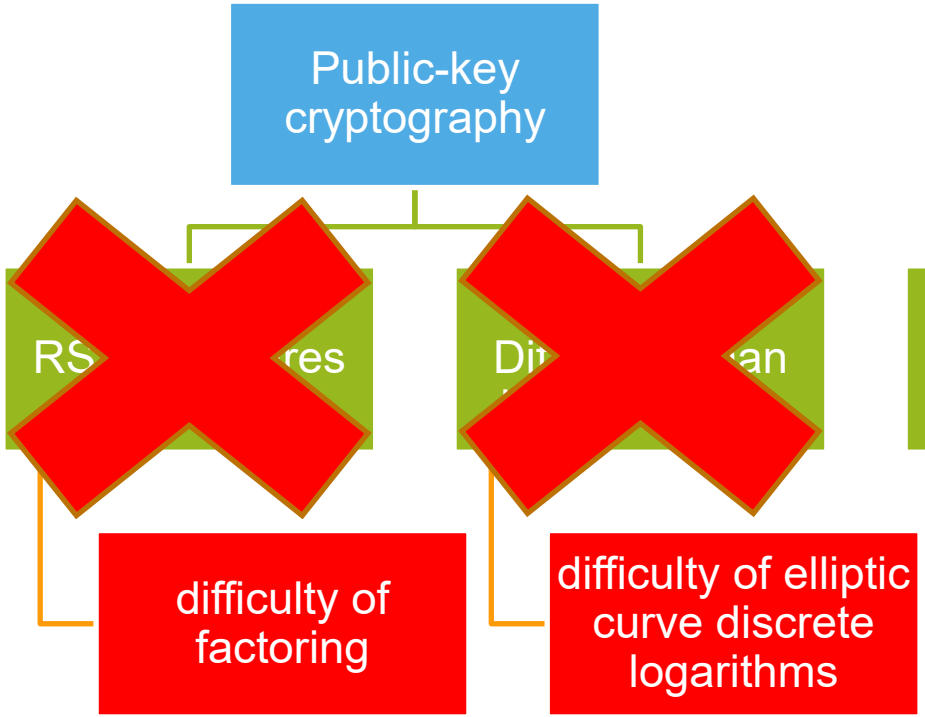
Shor's quantum algorithm (1994).
Polynomial time algorithm to factor integers.
Impact. If we assume the availability of a large quantum computer, then one can break RSA instantly.

State-of-the-art.
IBM's 127-Qubit Quantum Processor
Break RSA-3072:
~10,000 qubits are needed

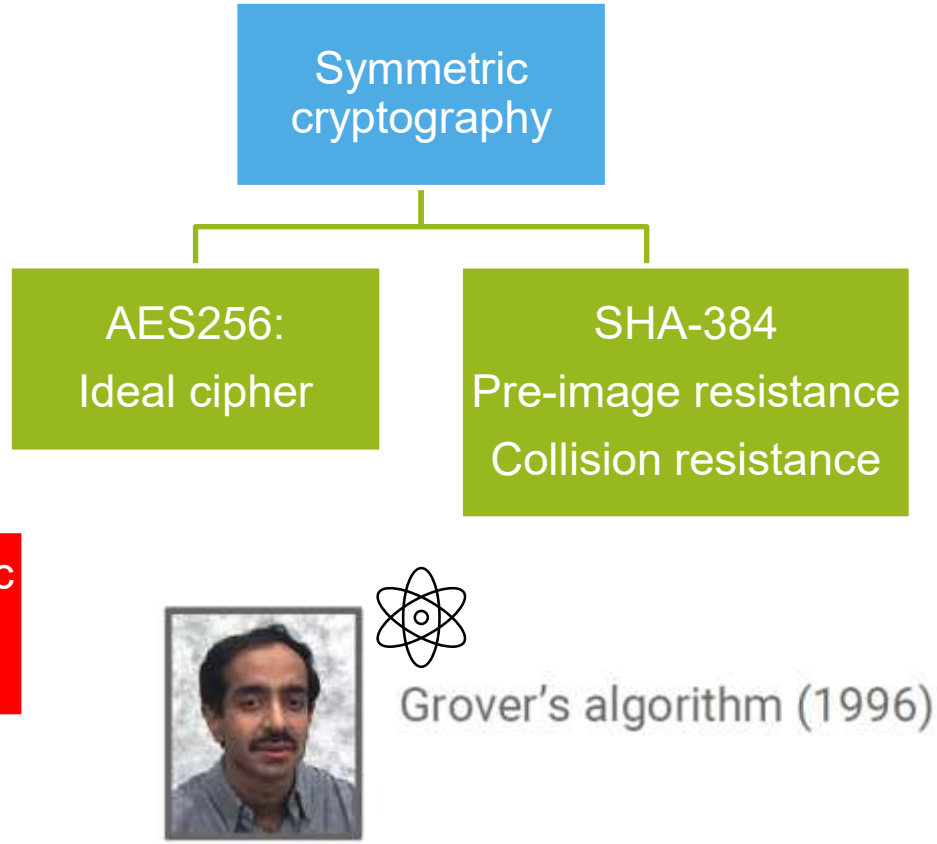
CONTEMPORARY CRYPTOGRAPHY

TLS-~~ECDHE-RSA~~-AES256-GCM-SHA384

"Double" the key sizes



Shor's algorithm (1994)



Grover's algorithm (1996)

Quantum Potential To destroy Security As We know it

Confidential email messages, private documents, and financial transactions
Secure today but may be compromised in the future, even if recorded & encrypted

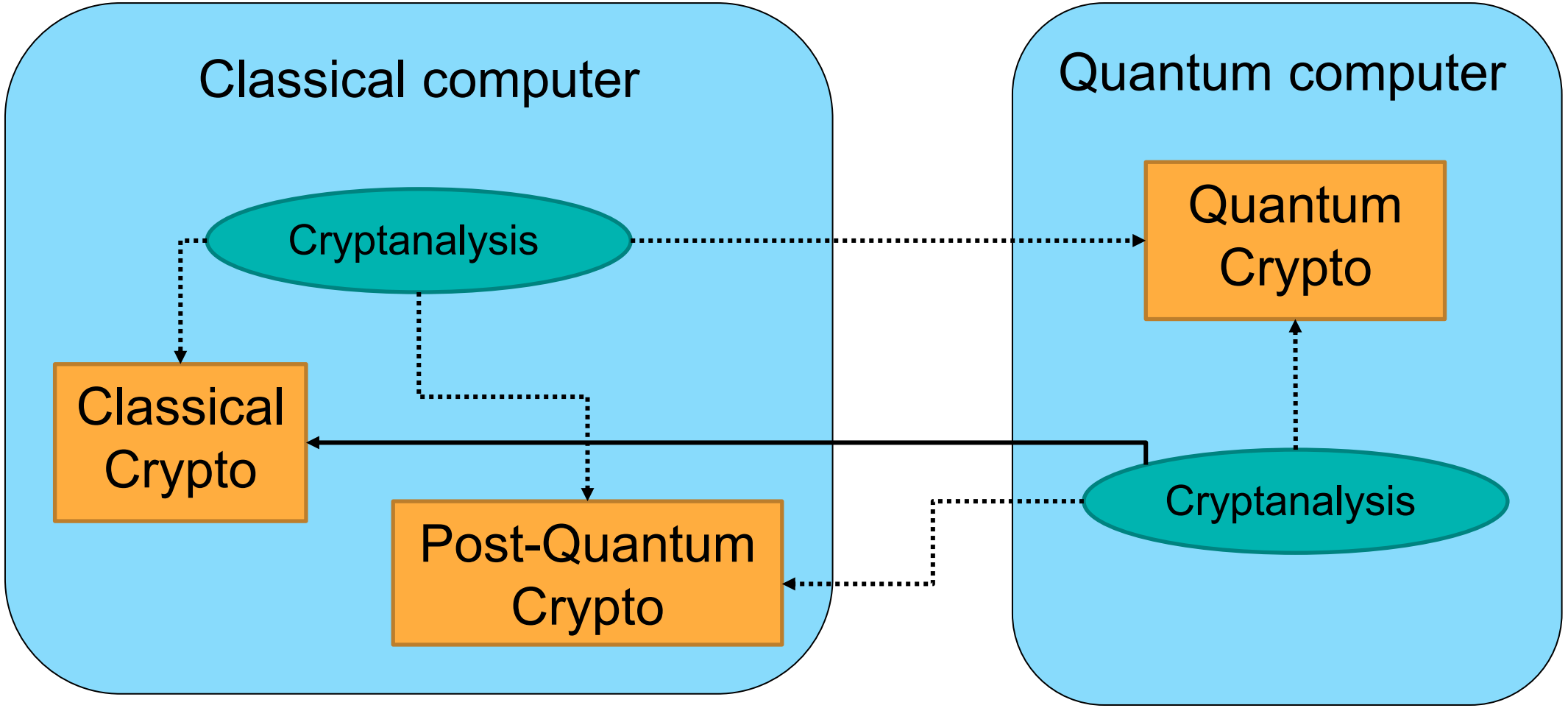
Firmware update mechanisms in vehicles
May be circumvented and allow dangerous modifications

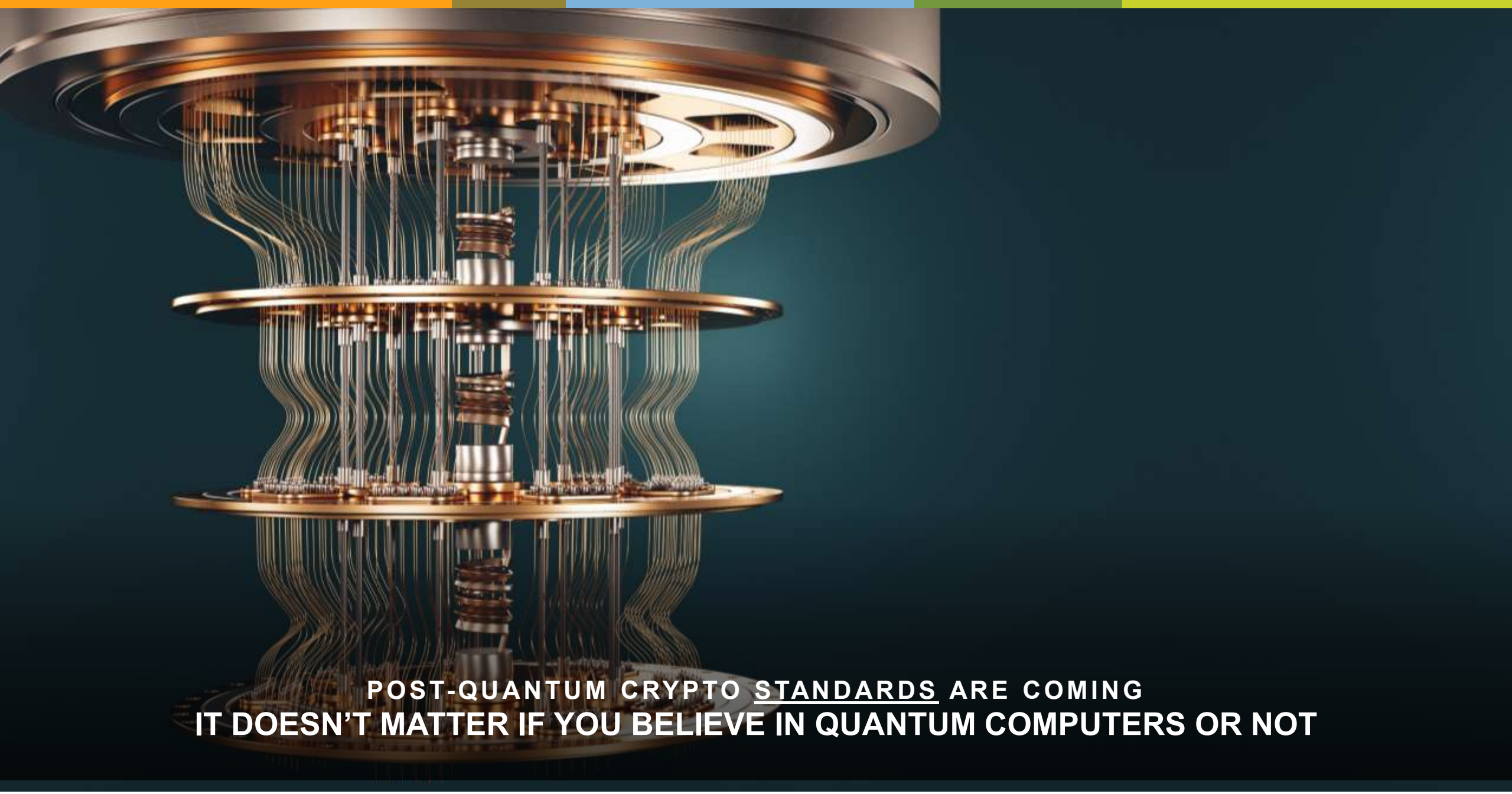
Critical industrial and public service infrastructure (for healthcare, utilities, and transportation using internet and virtual private networks)
Could become exposed – potentially destabilize cities

Audit trails and digitally signed documents associated with safety (auto certification and pharmaceutical authorizations)
Could be retrospectively modified

The integrity of blockchains
Could be retrospectively compromised - could include fraudulent manipulation of ledger and cryptocurrency transactions

POST-QUANTUM VERSUS QUANTUM CRYPTO





POST-QUANTUM CRYPTO STANDARDS ARE COMING

IT DOESN'T MATTER IF YOU BELIEVE IN QUANTUM COMPUTERS OR NOT

POST-QUANTUM CRYPTO STANDARDIZATION

2016
- Formal call for proposals

2017
- Deadline for submissions
- 69 candidates received

2019
- Second Round Candidates announced: 26 remaining candidates

2020
- Third Round Candidates announced: 7 Finalists and 8 Alternates

2022
- Announcement of Winners to be Standardized

2024 - 2030
- Standards Available
- Migration to PQC

AUTOMOTIVE | EGOVERNMENT | BANK CARDS | SMART MOBILITY (MIFARE) CARDS | TAGS & AUTHENTICATION | READERS | MOBILE

STANDARDS – NIST

Winners	Secondary Winners	Round 4 Candidates	Digital Signature Competition
CRYSTALS-Kyber	Falcon	HQC	*Proposals due '23*
CRYSTALS-Dilithium	SPHINCS+	BIKE	
		Classic McEliece	
		SIKE	

2024 — 2025? — 2028? — 2030?

NIST PQC Standard (Key Exchange + Digital Signatures)

PQC Standard #2 (Digital Signatures)

POST-QUANTUM CRYPTO IS ON THE HORIZON

AUTOMOTIVE

70%

70% connected cars by 2025

INDUSTRIAL & IOT

12B

IoT Edge & end nodes from 6B units in ‘21 to 12B units in ‘25

MOBILE

60B

Tagging 60B products per year by 2025

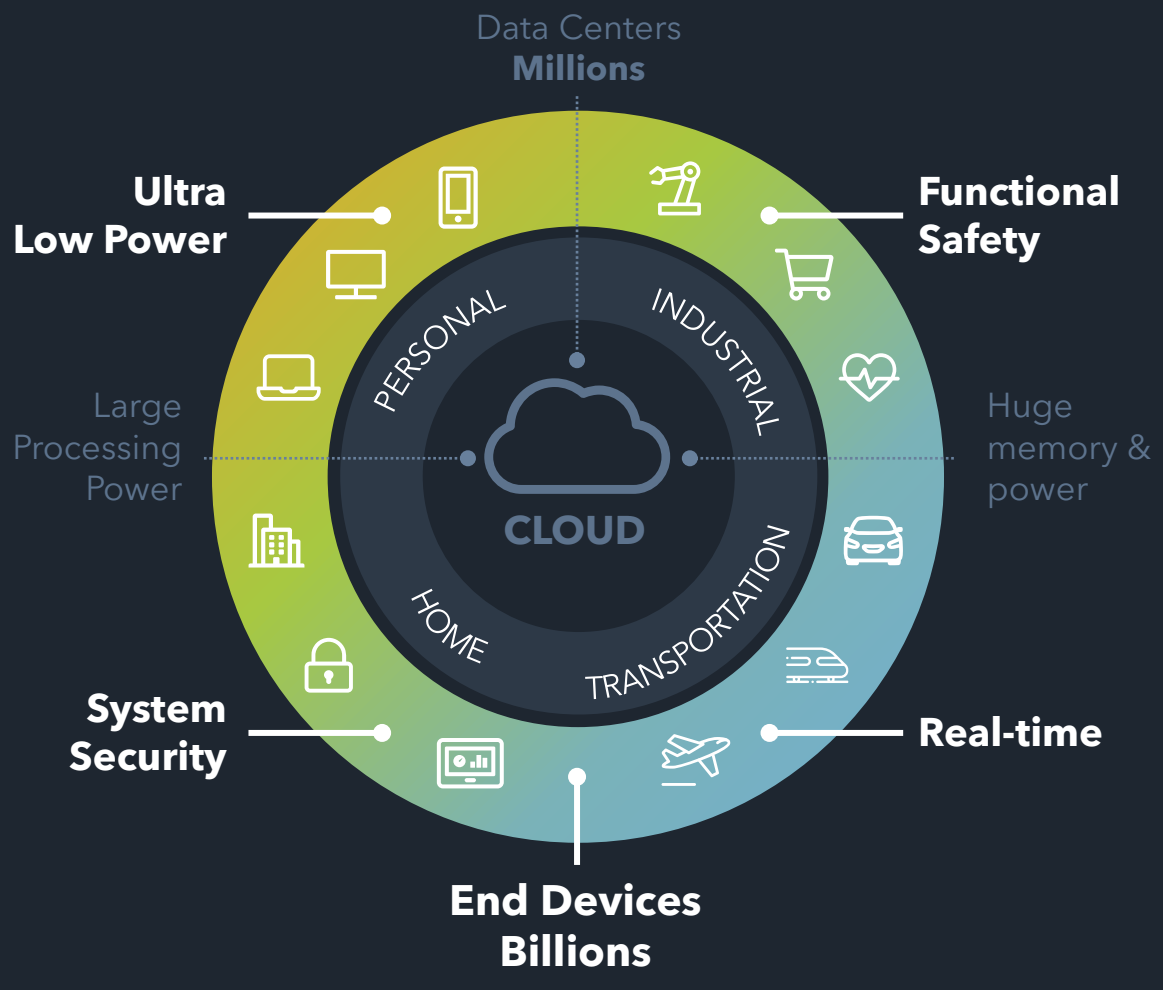
COMMUNICATION INFRASTRUCTURE

40B

Secure anchors & services for 40B processors

1. Source: NXP, Strategy Analytics, Evercore, Ericsson, IDTechex,

IMPACT PQC ON OUR ECO-SYSTEM



Data collection, processing and decisions at the edge
Devices securely connected to the cloud

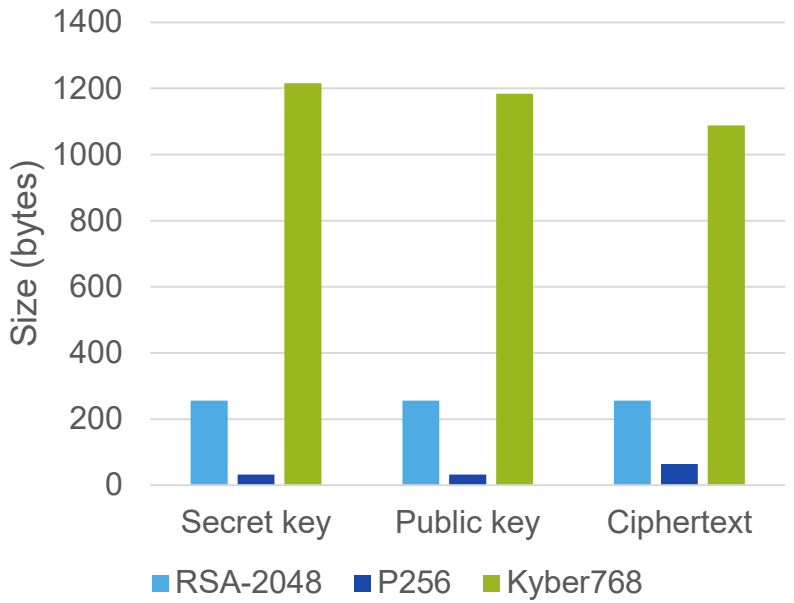
No Silver Bullet
If a crypto scheme was better, we would have standardized this already

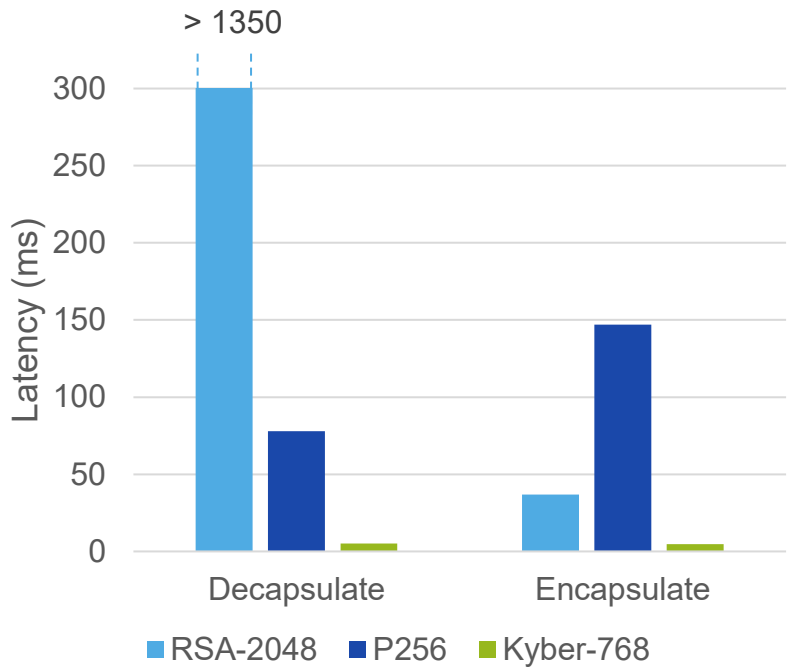
Cryptographic Keys
Orders of magnitude larger.
In the final: up to 1.3MB
Winners: up to 4.8KB
(ECC: 32 bytes, RSA: 384 bytes)

Performance
Varies: some faster some significantly slower.
SHA-3 is a dominating component (~80%)

Memory
Orders of magnitude more:
up 100KB memory of RAM when executing
NXP had dedicated implementations reaching
~16 KB of RAM

Bandwidth & Power
Larger signatures (up to 4.6KB) → more bandwidth required → increase in power usage



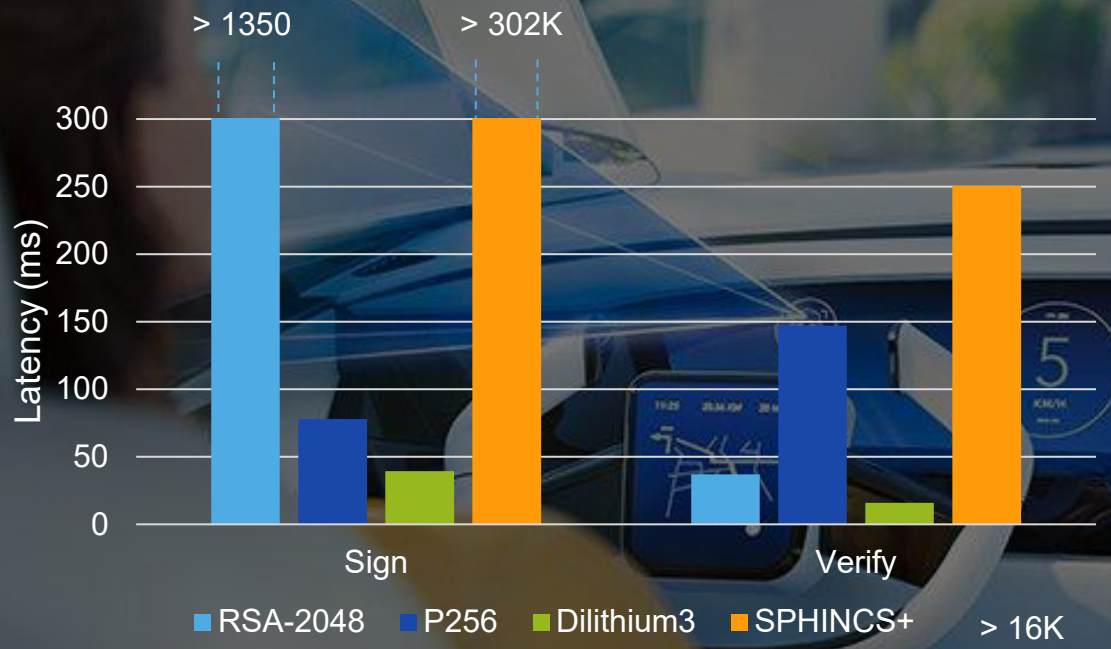


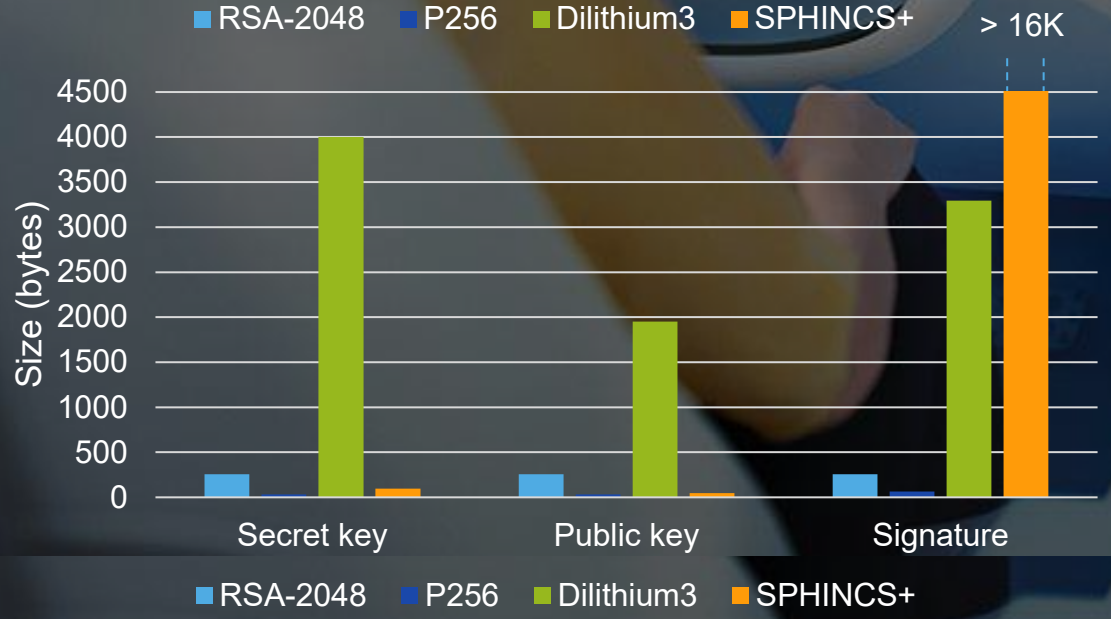
KEY-EXCHANGE IMPACT

Kyber **co-designed by NXP** with IBM, ARM and academic partners

- Measurements on Cortex-M4 @ 168MHz from pqm4 framework
- Functional implementation only (not hardened)
- **70 ~ 80 percent** of run-time in SHA-3

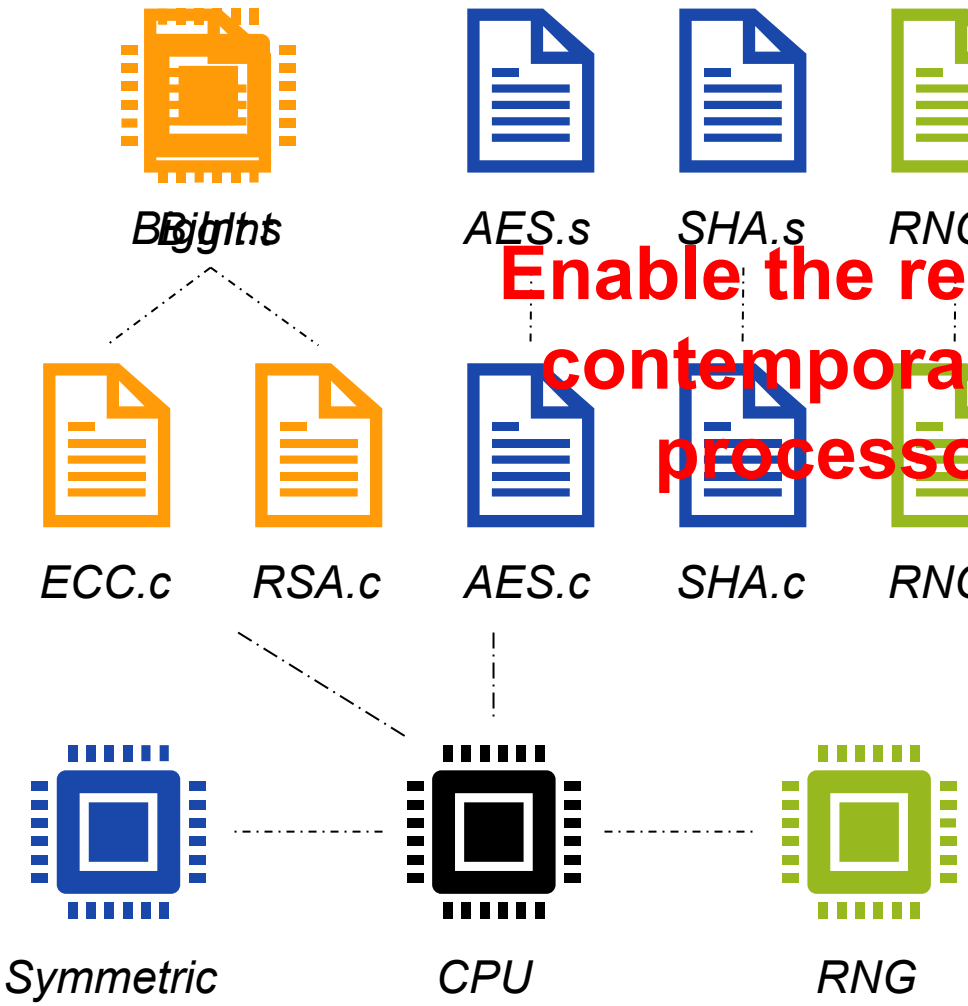
DIGITAL SIGNATURE IMPACT





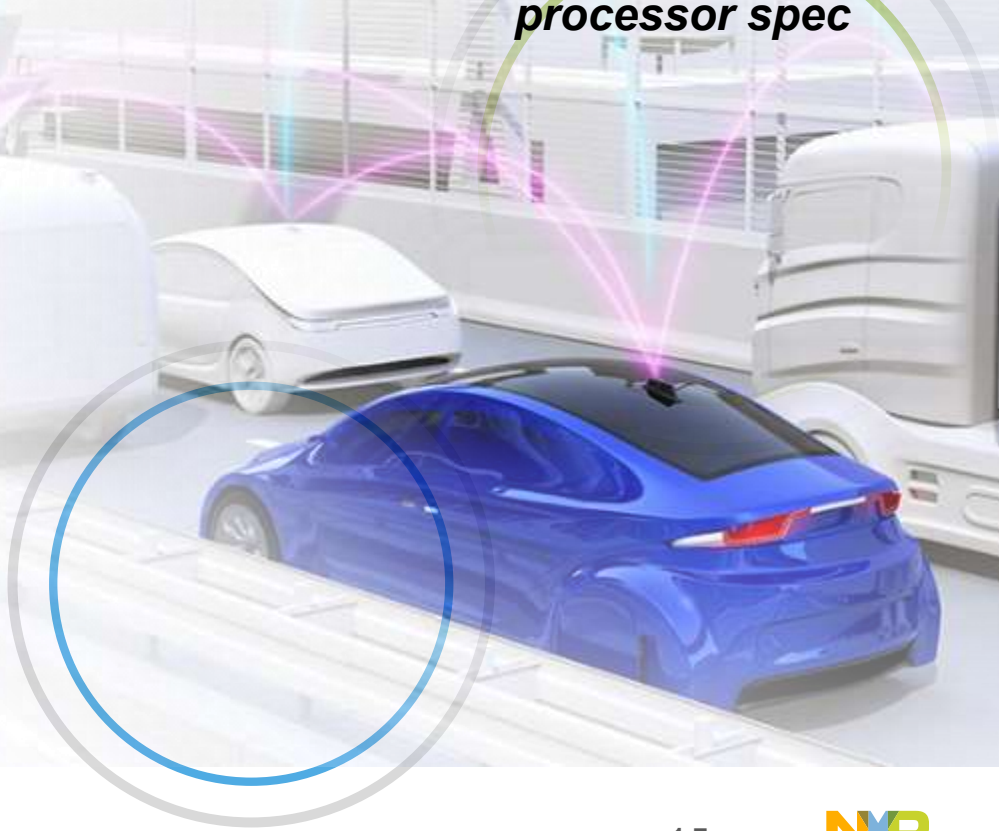
USE CASE STUDY
IMPACT ASSESSMENT: S32G

IMPLEMENTING CLASSICAL CRYPTOGRAPHY



Enable the re-use of contemporary co-processors

S32G2 automotive processor spec



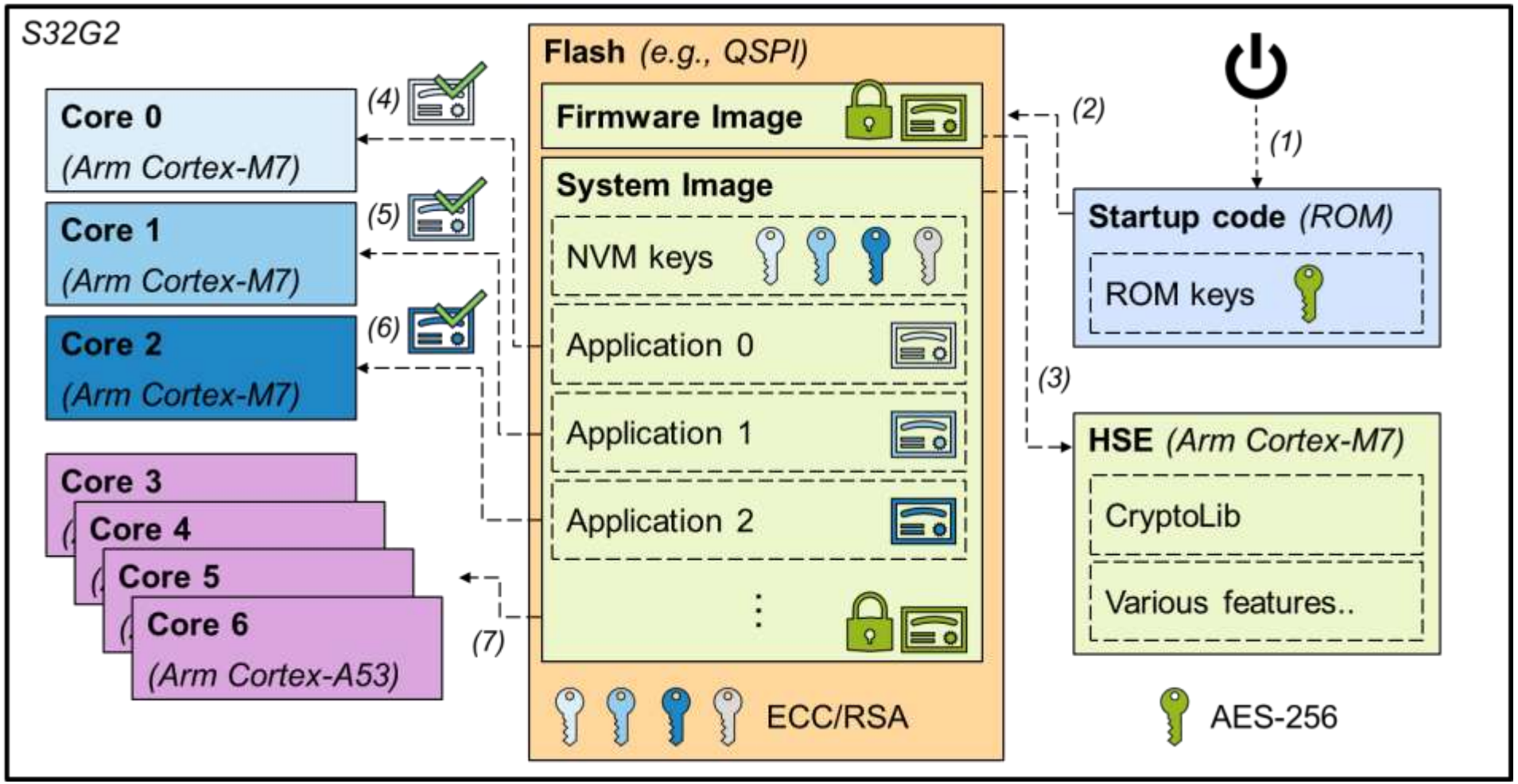
ARITHMETIC CO-PROCESSORS

RE-USING EXISTING HARDWARE		
	ARITHMETIC CO-PROCESSORS	Dedicated secure hardware widely available to accelerate ECC and RSA
	POST-QUANTUM CRYPTOGRAPHY	PQC work on completely different objects. Not straight-forward to re-use this hardware
	KRONECKER+	Our new approach to run PQC on existing and deployed hardware. See: Bos, Renes, van Vredendaal; Post-Quantum Cryptography with Contemporary Co-Processors: Beyond Kronecker, Schönhage-Strassen & Nussbaumer; USENIX 2022

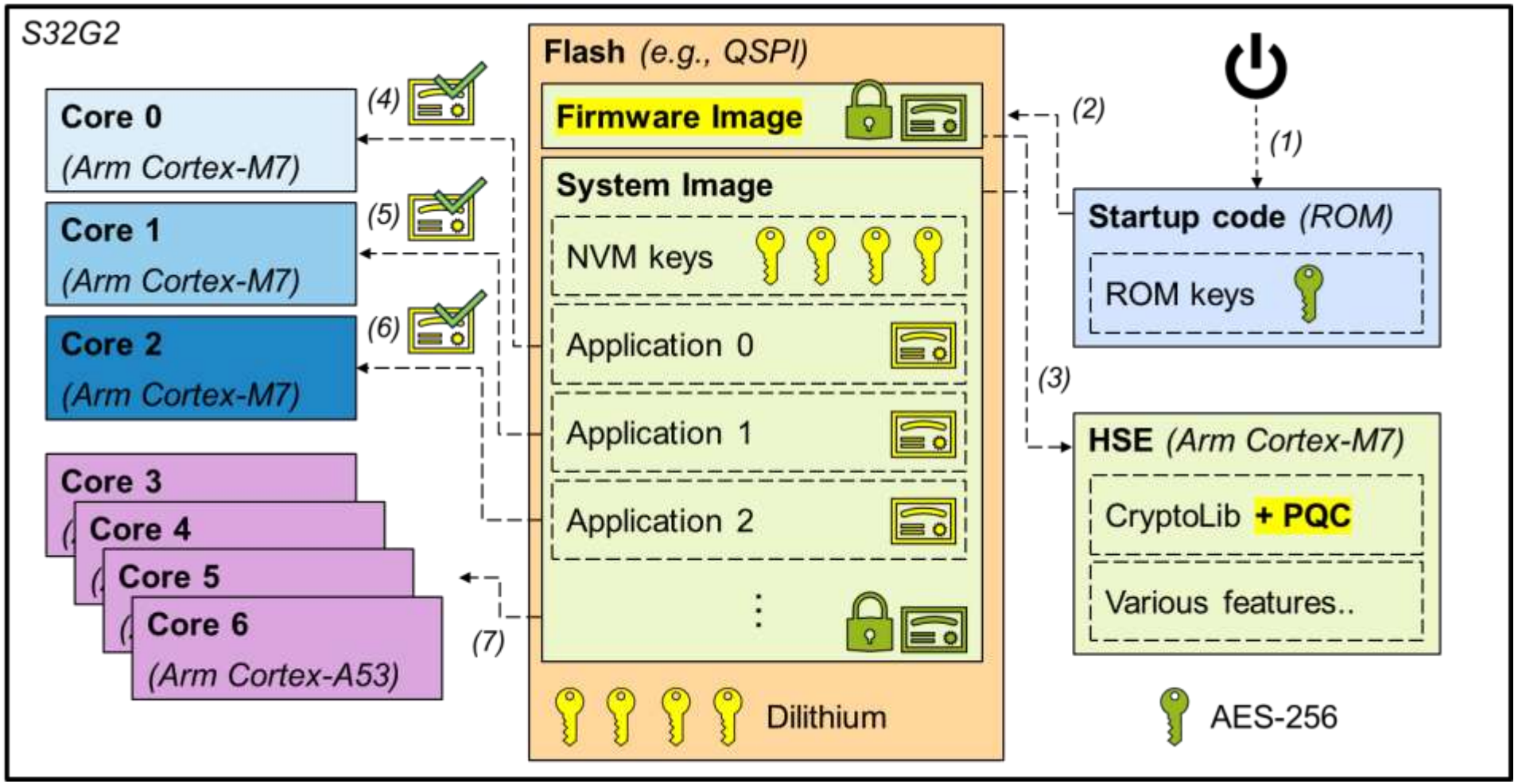
multiplications required

Multiplier width	512	256	128
Schoolbook	256	1024	4096
Kronecker+	16	32	64

PQC DEMO: HSE SECURE BOOT OVERVIEW



PQC DEMO: HSE SECURE BOOT OVERVIEW



INTRODUCING THE S32G

Vehicle Network Processor optimized for gateway, domain controller and safety controller applications

S32G introduces network acceleration to automotive with functional safety and security

Enables new service-oriented gateways to rapidly deploy new services and support over-the-air (OTA) upgradeable vehicles

High level of compute with legacy automotive and Ethernet network interfaces ideal for domain controllers

High-level of ASIL D processing for AD/ADAS safety controllers

S32G2 VEHICLE NETWORK PROCESSOR – A NEW TYPE OF AUTOMOTIVE PROCESSOR

OUR TARGET PLATFORM: S32G274A

3 Lockstep Arm® Cortex®-M7 Microcontrollers

4 Cluster Lockstep Cortex-A53 Microprocessors

8 MB of system RAM

POST-QUANTUM CRYPTO

Can we enable PQC secure boot?

Integrate PQC secure signature verification

SAFE ASSURE™ by NXP

www.nxp.com/S32G2

EDGELOCK™ ASSURANCE by NXP

BENCHMARKS FOR AUTHENTICATION OF FW SIGNATURE ON THE S32G2

Alg.	Size		Performance (ms)			
			1 KB		128 KB	
	PK	Sig.	Inst.	Boot	Inst.	Boot
RSA 4K	512	512	2.6	0.0	2.7	0.2
ECDSA-p256	64	64	6.2	0.0	6.4	0.2
Dilithium-3	**1952**	**3293**	**16.7**	**0.0**	**16.9**	**0.2**

- Demonstrator only, further optimizations are possible (such as hardware accelerated SHA-3)
- Signature verification only required once for installation!
- During boot the signature verification can be replaced with a check of the Reference Proof of Authenticity

To appear:
J. W. Bos, B. Carlson, J. Renes, M. Rotaru, D. Sprenkels, G. P. Waters: Post-Quantum Secure Boot on Vehicle Network Processors. Embedded Security in Cars (escar) 2022

CUSTOMER-FIRST APPROACH FOR POST-QUANTUM CRYPTOGRAPHY

- Customer support for migration
- Continued innovation for high-assurance implementations (resistance against side-channel and fault attacks) and dedicated PQC hardware
- Crypto agility with seamless upgradability of our existing devices

For more details check out [nxp.com/pqc](nxp.com/pqc)

SECURE CONNECTIONS
FOR A SMARTER WORLD