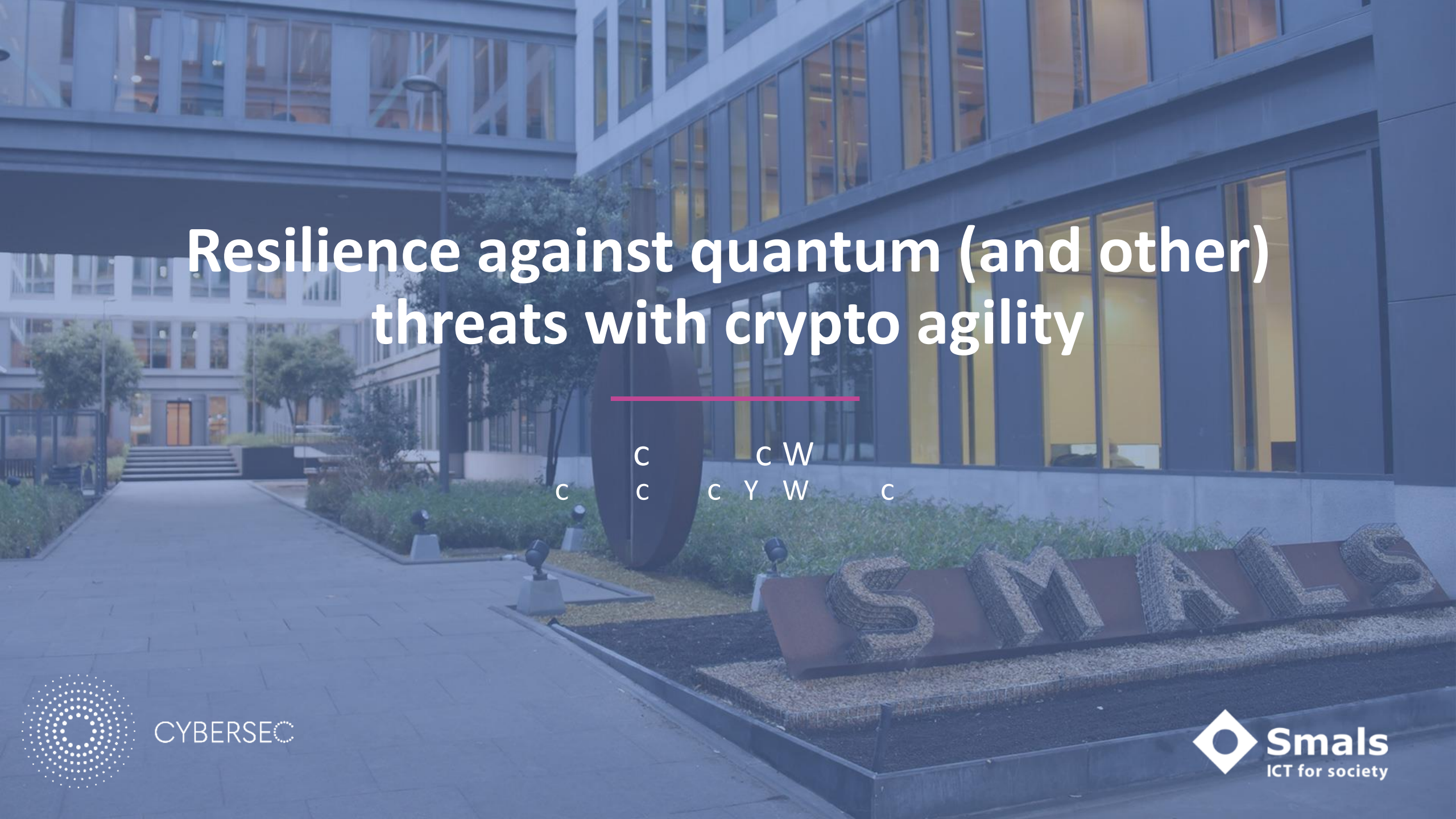
Resilience against quantum (and other) threats with crypto agility

C C W
C C C Y W C



CYBERSEC

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Cryptography is Everywhere

Devices

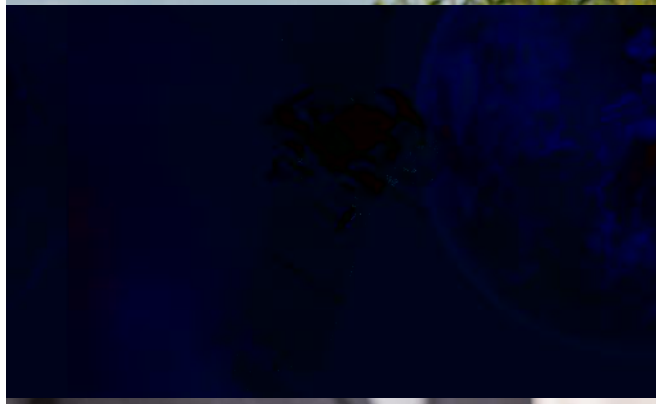
-
- Y c c
- Y c
- c c
-
- c
- W
- WW
-

Interactions

- Wc
- c Y Y
- Y
-
-

Domain

- Y W c
- W c
- c c
- W
-



WITHOUT SECURE CRYPTOGRAPHY, OUR SOCIETY COLLAPSES

Cryptography Under Threat

Cryptographically relevant quantum computers

Would be able to break modern (public-key) cryptography

“To ensure an acceptable level of readiness, we recommend that [the most sensitive use cases] should be protected against ‘store now, decrypt later’ attacks as soon as possible, latest by the end of 2030.”

Y c Y c c c Y Y Y c

Other threats

- c Y c
- c W
- W Y WY

W Y c B Y c c

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IEEE Spectrum FOR THE TECHNOLOGY INSIDER

NEWS | COMPUTING

PC “Quantum-Safe” Crypto Hacked by 10-Year-Old

›Many challenges still lie ahead for postquantum cryptography

BY CHARLES Q. CHOI | 19 AUG 2022 | 7 MIN READ |

Charles Q. Choi is a contributing editor for IEEE Spectrum.

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TAGS

QUANTUM COMPUTING

CRYPTOGRAPHY | NIST

POST-QUANTUM CRYPTOGRA…

FUTURE QUANTUM COMPUTERS may rapidly break modern cryptography. Now researchers find that a promising algorithm designed to protect computers from these advanced attacks could get broken in just 4 minutes. And the catch is that 4-minute time stamp was not achieved by a cutting-edge machine but by a regular 10-year-old desktop computer. This latest, surprising defeat highlights the many hurdles postquantum cryptography will need to clear before adoption, researchers say.

Cryptography Under Threat

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"To ensure an acceptable level of readiness, we recommend that [the most sensitive use cases] should be protected against 'store now, decrypt later' attacks as soon as possible, latest by the end of 2030."

Y c Y c c c Y Y Y c

Other threats

- c Y c
- c W
- W Y WY

W Y c B Y c c

→ MIGRATE ON TIME TO RECOMMENDED CRYPTOGRAPHY

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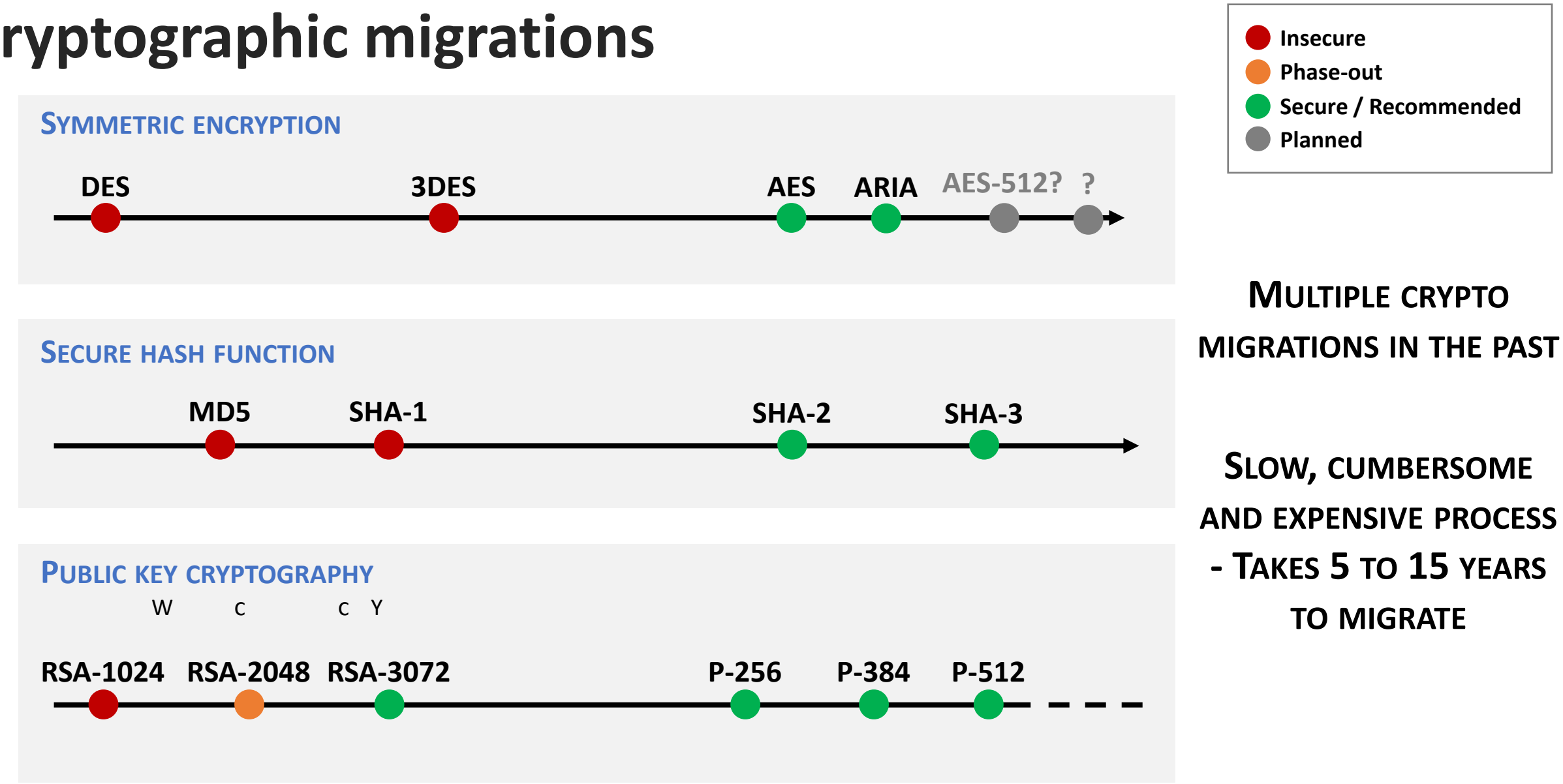
Cryptographic migrations



MULTIPLE CRYPTO MIGRATIONS IN THE PAST

SLOW, CUMBERSOME AND EXPENSIVE PROCESS - TAKES 5 TO 15 YEARS TO MIGRATE

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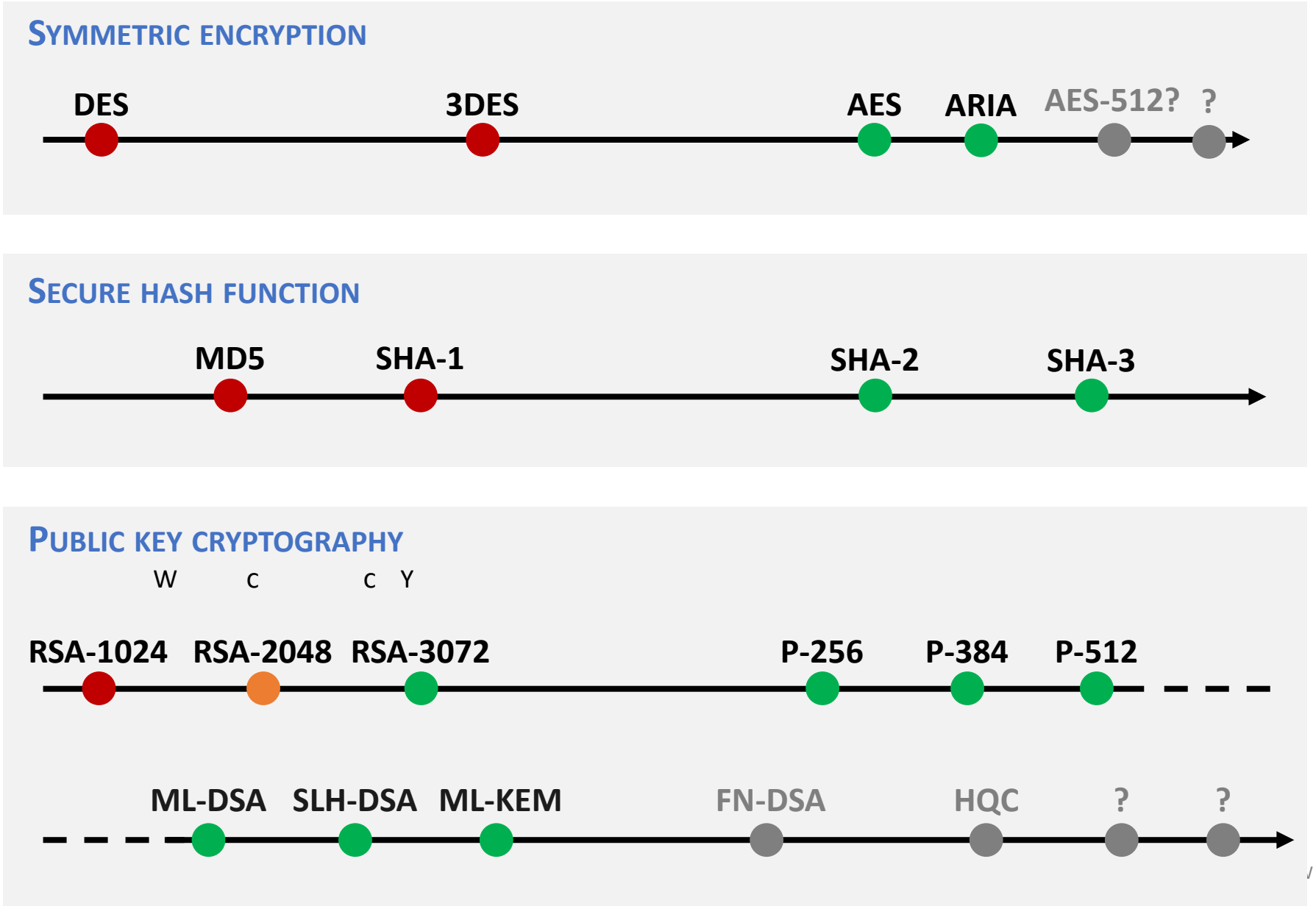
Cryptographic migrations



POTENTIALLY MULTIPLE CRYPTO MIGRATIONS IN THE NOT-SO-DISTANT FUTURE!

BECOMING QUANTUM-READY MAY NOT BE A ONE-TIME SHOT

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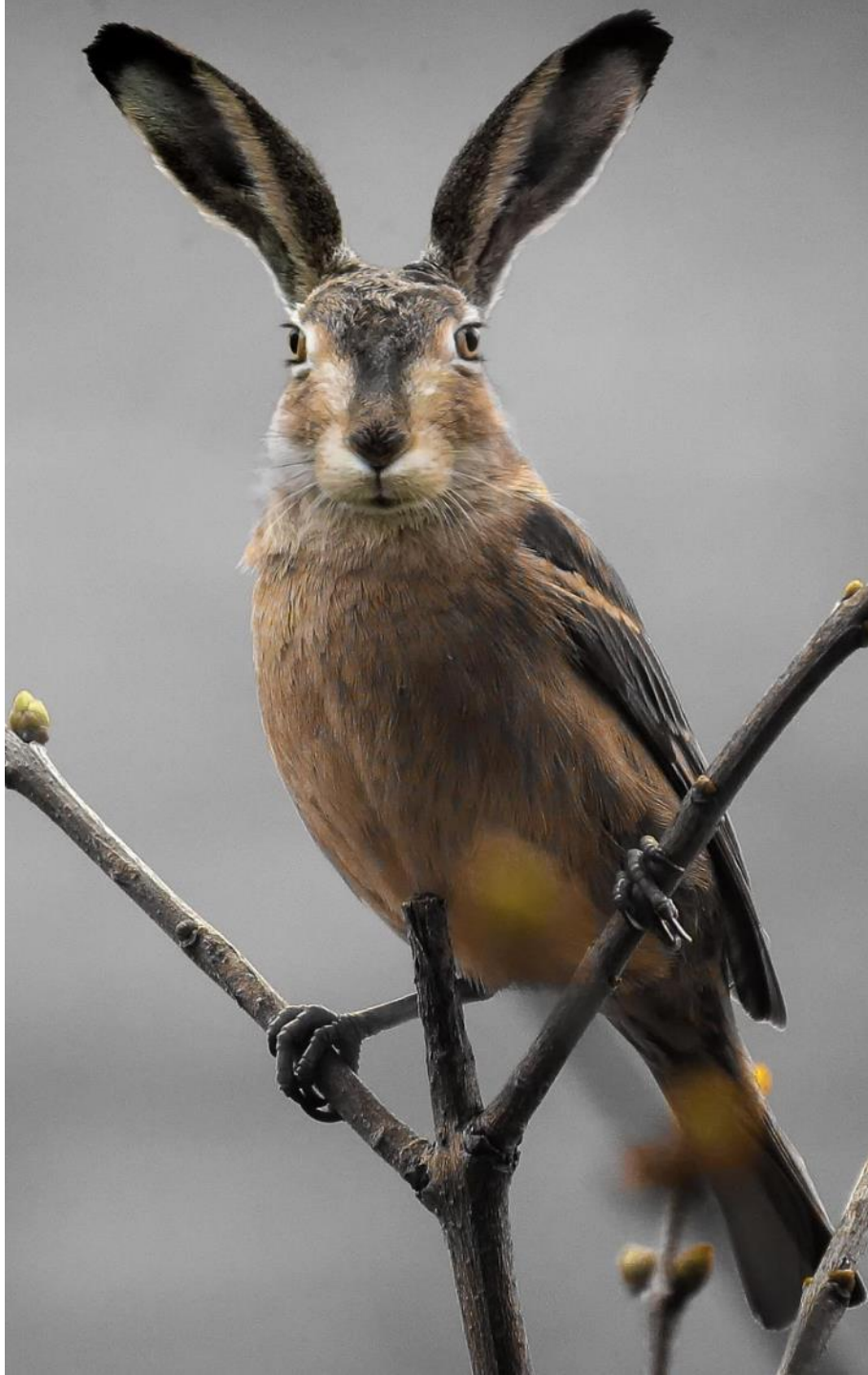
Transitional period in Hybrid Mode

Bundesamt
für Sicherheit in der
Informationstechnik

The quantum-safe algorithms that are currently being standardized are not yet as well researched as the "classical" methods *(for example RSA and ECC). This applies in particular to weaknesses that largely only become apparent in applications, such as typical implementation errors, possible side-channel attacks, etc.* ***BSI therefore recommends that post-quantum cryptography should not be used in isolation if possible, but only in hybrid mode, i.e. in combination with classical algorithms****. […] Hash-based signatures can in principle also be used on its own (i.e., not in hybrid mode).*

→ **EVEN MORE MIGRATIONS!**



Crypto migrations

Challenge

- ❖ W W Y W W c
- ❖ W Y c Y c c Y c

→ **How to facilitate smooth migrations?**

Approach

c c W c Y W W
Y Y c c
c c Y Y c Y

We should accept this and act on it!

Improve cryptographic maturity

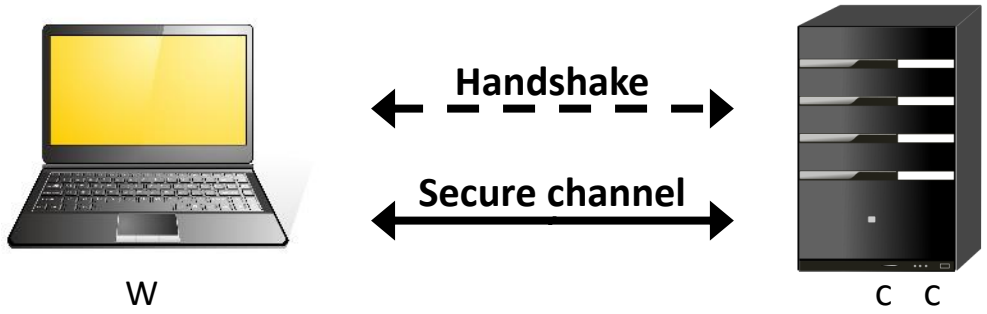
Insight
Crypto inventory
c c c
c

Guidance
Crypto policy
c c
W

Flexibility
Crypto agility
c W c Y
c Y Y

C C C C

Y W c c c W W



Handshake

- C C C
- C C
-
- C C

Supported cipher suites

TLS_AES_128_GCM_SHA256

Supported cipher suites

TLS_AES_128_GCM_SHA256

Y Y

c

c

C c abstract API W c

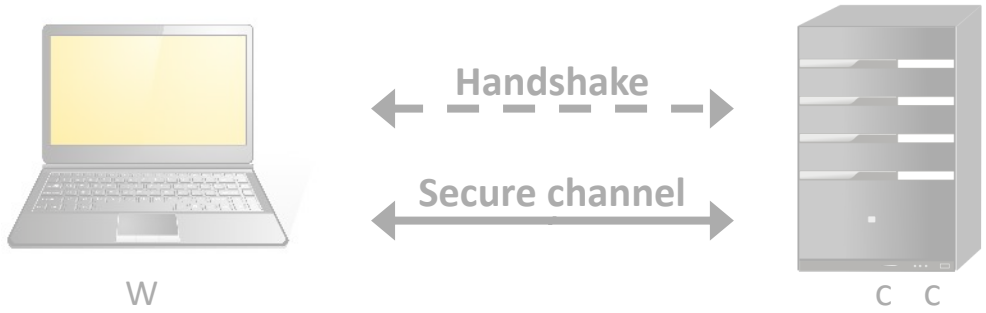
C C selected in real-time

Add remove C C

Cryptographic functions: *Hardware, software, firmware, algorithms, parameters, …*

W Y c c c W c c W c c c Y c

W c c W Y c c



Handshake

Supported cipher suites

TLS_AES_128_GCM_SHA256

Supported cipher suites

TLS_AES_128_GCM_SHA256

Cryptographic Agility

On the level of an IT system

abstract API

selected in real-time

Add remove

At runtime

Cryptographic functions: *Hardware, software, firmware, algorithms, parameters, …*

C C W C

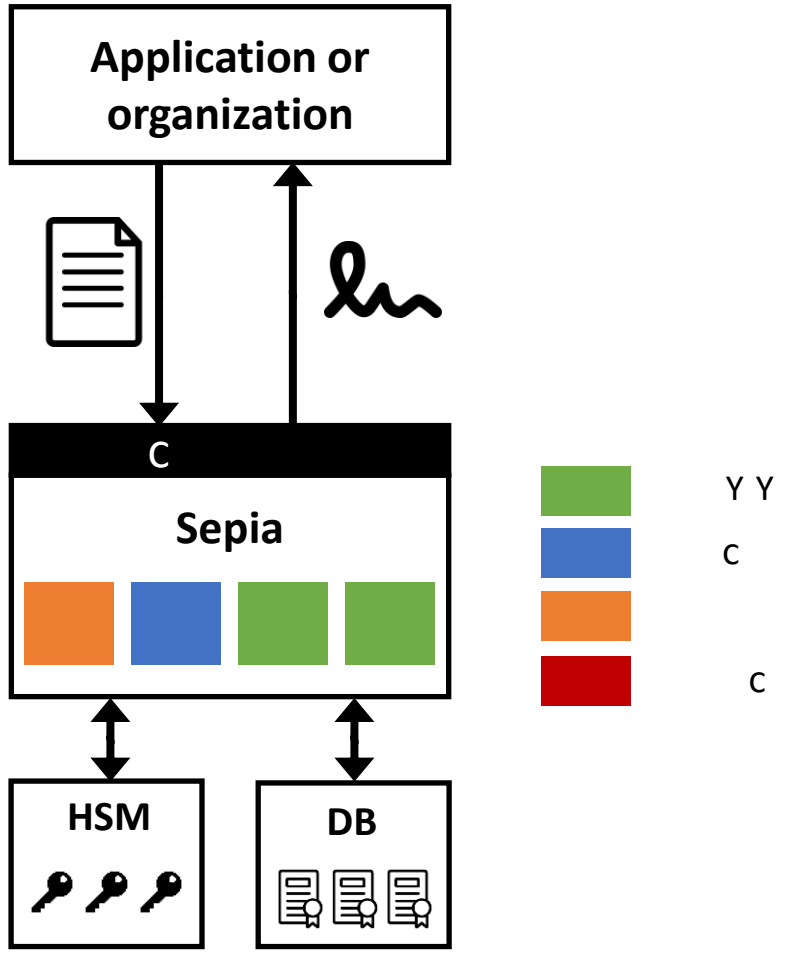
Service developed by Smals

Functionality

- C W C W W C
  C C
- Y C Y C
- C Y C
- C C C C

Motivation

- **Cost reduction by reuse**
  C W
- **Increase security**
- **Crypto agility!**



CRYPTO AGILITY AND COST EFFICIENCY CAN COEXIST

W B Y C C C W |

C W C Y C

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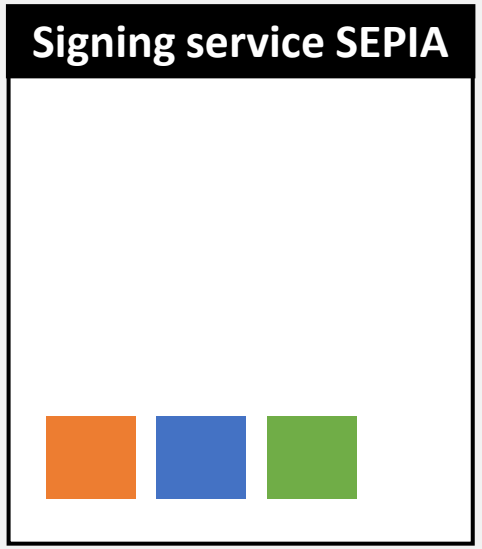
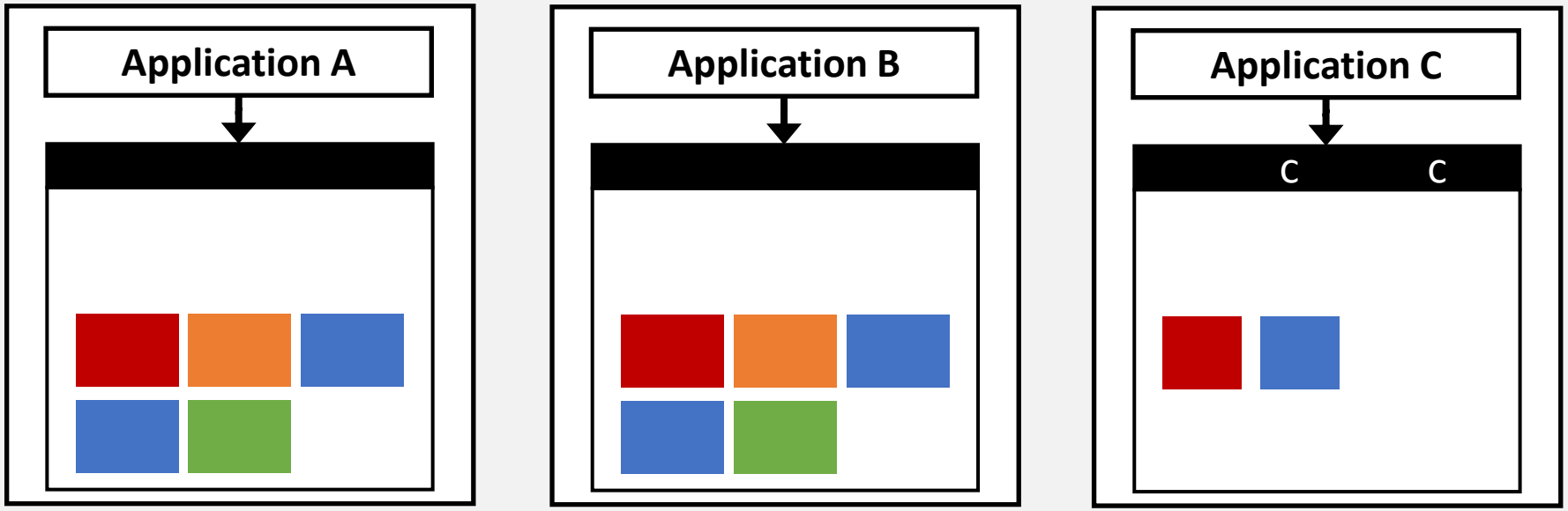
Possible Future Architecture

CENTRAL



LOCAL



Possible Future Architecture

CENTRAL

Implementation service

Cipher suites

Algorithms

Policy service

Policy

W + = W

Deviations

Signing service SEPIA

Certificate mgt.

W

Crypto inventory

LOCAL

Application A

W

Application B

W

Application C

C C

W

"A1 only to decrypt"

Possible Future Architecture

CENTRAL

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W + =

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Certificate mgt.

W

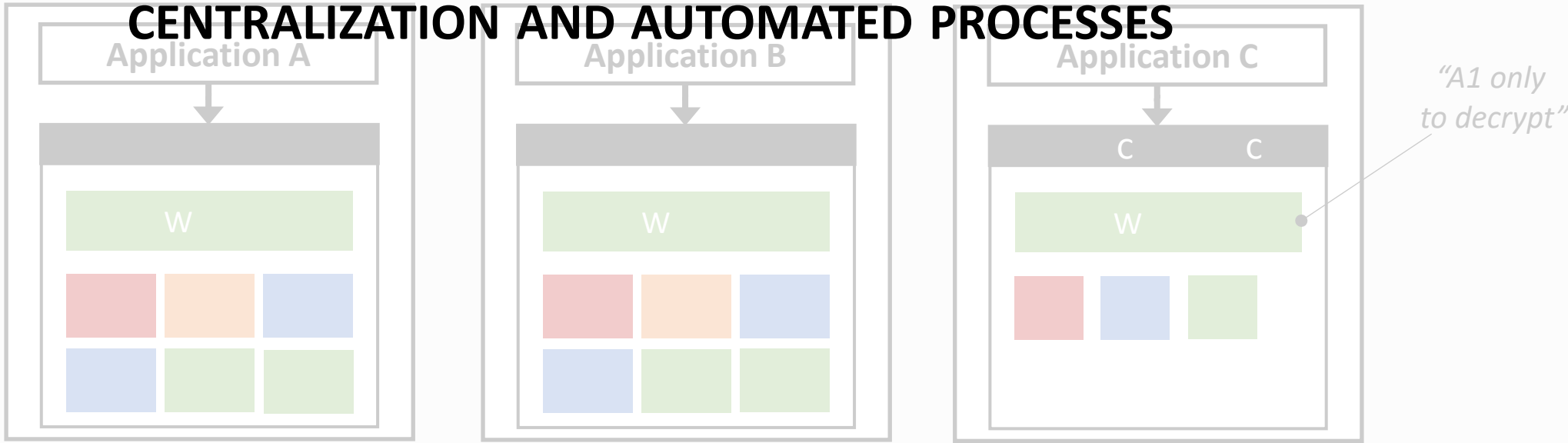
Crypto inventory

CRYPTOGRAPHIC AGILITY

IMPLIES

CENTRALIZATION AND AUTOMATED PROCESSES

LOCAL



Crypto-Agility Maturity Model (CAMM)

Proposal – not yet standardized or adopted – for IT-systems

Initial / Not possible

At least one subsystem or component violates L1 requirements

0

Possible

Systems can be adapted to respond dynamically to future crypto challenges

1

Knowledge
- System knowledge
- Cryptography inventory

Process
- Updateability
- Reversibility

System property
- Extensibility

Prepared

Actual crypto migration still requires some preparatory work

2

Knowledge
- Algorithm IDs

System property
- Cryptographic modularity (API)
- Algorithm intersection
- Algorithm exclusion
- Opportunistic security
- Usability of crypto agility

Practiced

Crypto migration demonstrable, effectively and securely feasible

3

Knowledge
- Performance awareness
- Secure crypto agility

Process
- Policies
- Compliance testing
- Enforceability of CA
- Transition mechanism
- Effectiveness

System property
- Hardware modularity
- Backwards compatibility

Sophisticated

Enables fast crypto migration, applied on broader infrastructure

4

Process
- Automation
- Scalability
- Real-time

System property
- Context independence
- Cross-system interoperability

W B Y C C C W |

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https://camm.h-da.io/

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1

Prepared

Actual crypto migration still requires some preparatory work

Knowledge

- Algorithm IDs
- Algorithm [illegible]
- Cryptographic modularity (API)
- Algorithm intersection
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2

Practiced

Crypto migration demonstrable, effectively and securely feasible

Knowledge

- Performance awareness
- [illegible] crypto agility

Process

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Enables fast crypto migration, applied on broader infrastructure

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- Real-time

System property

- Context independence
- Cross-system interoperability

4

CRYPTOGRAPHIC AGILITY IS A JOURNEY

W B Y C C C W |

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Challenges & open questions

Research on CA

Performance

Middleboxes

Legacy

Standards

Downgrade attacks

QR-codes

IoT

Incompatibilities

Advanced cryptography

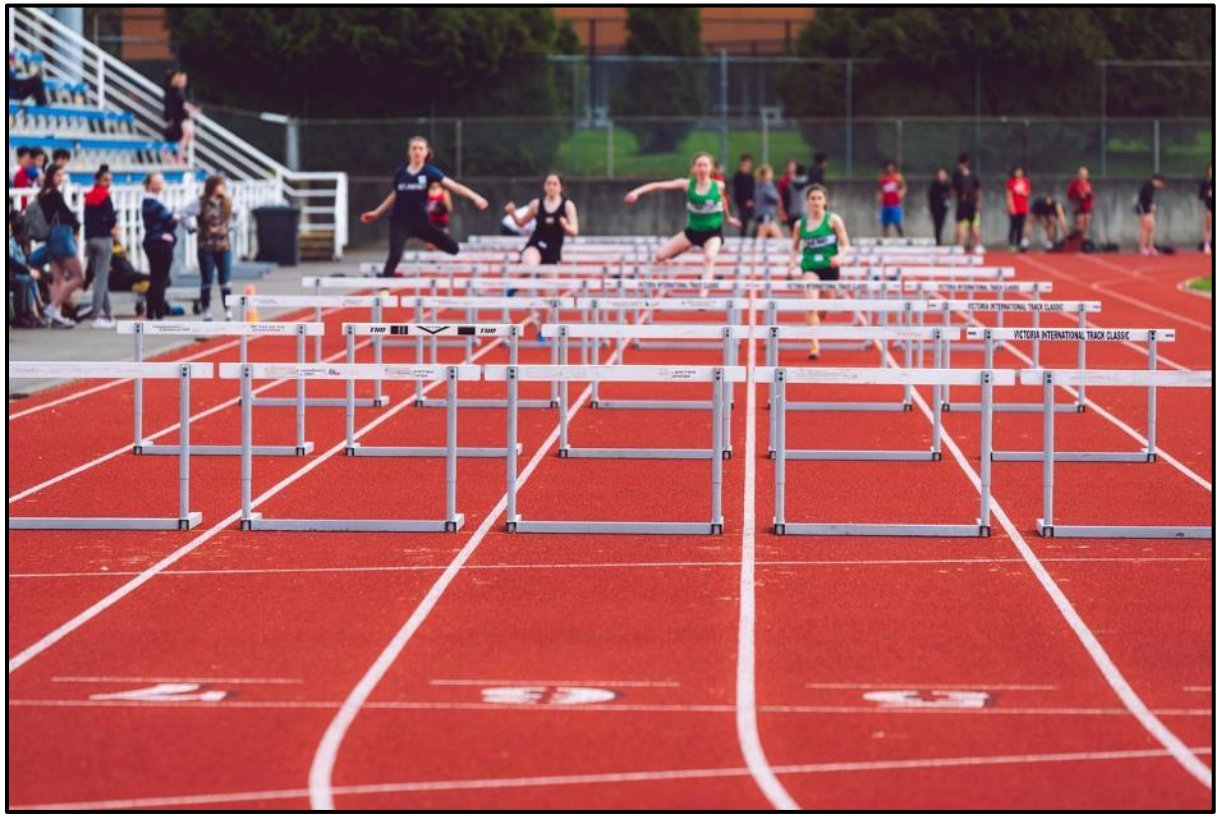
Guidance

X.509 certificates

Smartcards

HSMs

Cryptographic accelerators



BECOMING QUANTUM-READY IS HARD, BECOMING CRYPTO AGILE EVEN HARDER

BUT… IT PAYS OFF IN THE LONG RUN!

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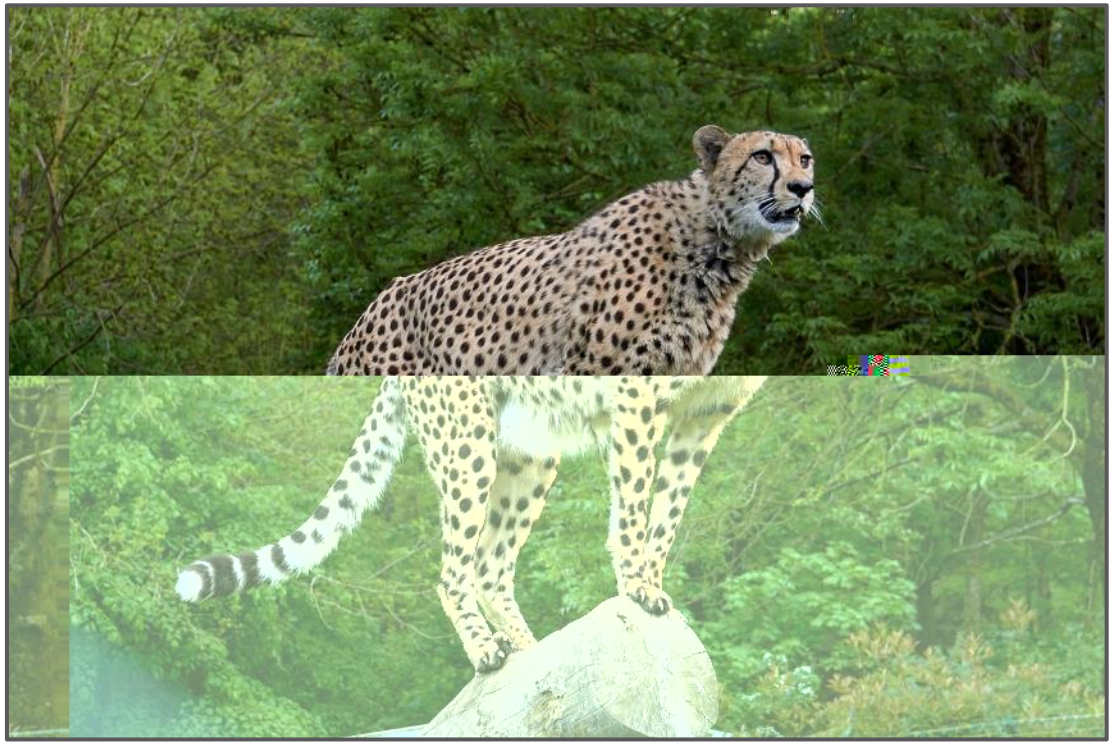
Takeaways



- c Y c Y c
- c Y Y W W
- c Y c W Y c Y
- c W c W W c c
  c W
- **We are early**

BECOME A CHEETAH: EMBRACE CRYPTO AGILITY!

IT WILL BE YOUR CORNERSTONE IN ADAPTING TO YOUR FUTURE CRYPTOGRAPHIC NEEDS

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Thanks for your attention!

B
C

W Y
C

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