KubeCon | CloudNativeCon

North America 2024

Running Quantum-Safe Applications on Kubernetes

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Agenda

1. Understand the Risk

2. Becoming Quantum Safe

3. Protecting Applications

4. Next Steps

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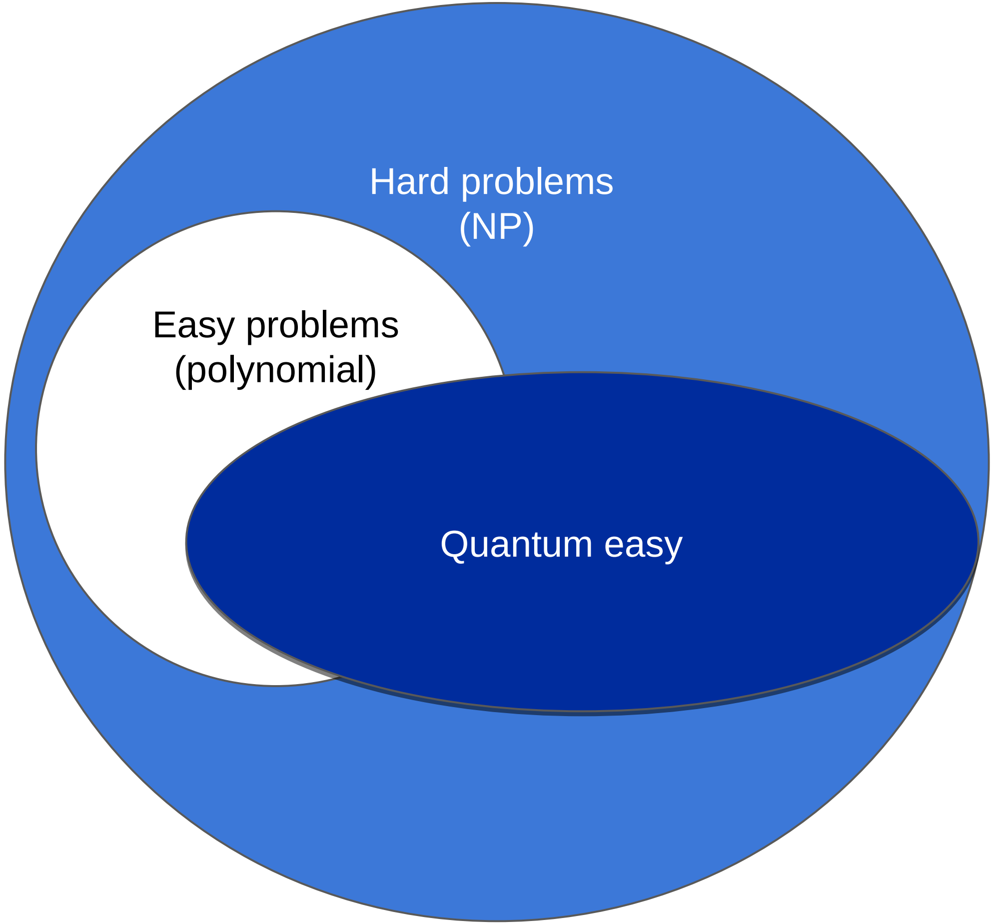
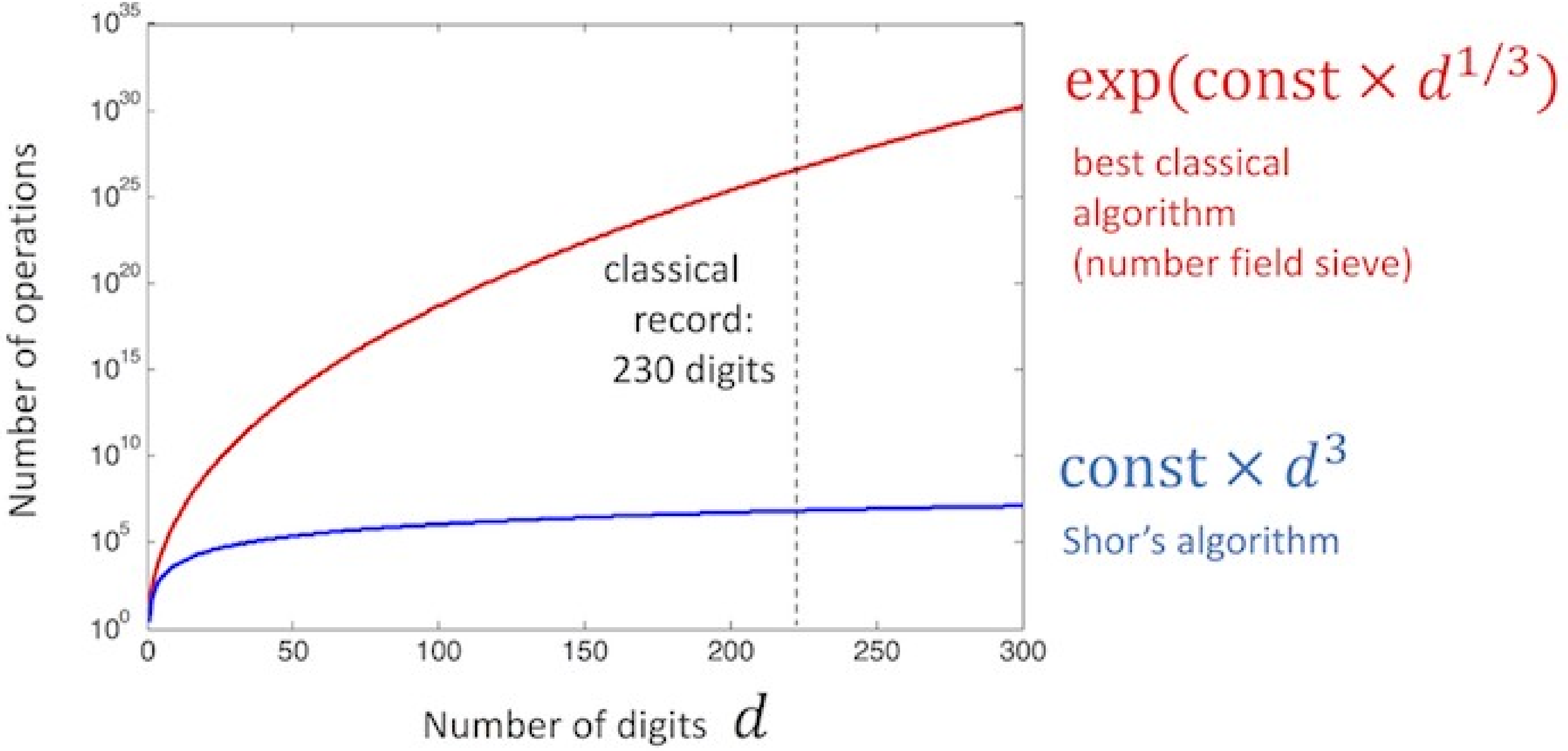
Why quantum?



Ex: Shor's algorithm for factoring



Current cryptography is at risk

Prime factors

$= p \times q$

2048-bit composite integer

```
25195908475657893494027183240048398571429282126204032027777137836043662020707595556264018525880784406918290641249515082189298559149176184502808489120072844992687392807287776735971418347270261896375014971824691165077613379859095700097330459748808428401797429100642458691817195118746121515172654632282216869987549182422433637259085141865462043576798423387184774447920739934236584823824281198163815010674810451660377306056201619676256133844143603833904414952634432190114657544454178424020924616515723350778707749817125772467962926386356373289912154831438167899885040445364023527381951378636564391212010397122822120720357
```

Expected computation time

The most powerful computer **today:**

Millions of years

Shor’s quantum algorithm:

Hours

Per Shor’s algorithm, all public key crypto standards are vulnerable to attacks from large scale quantum computers

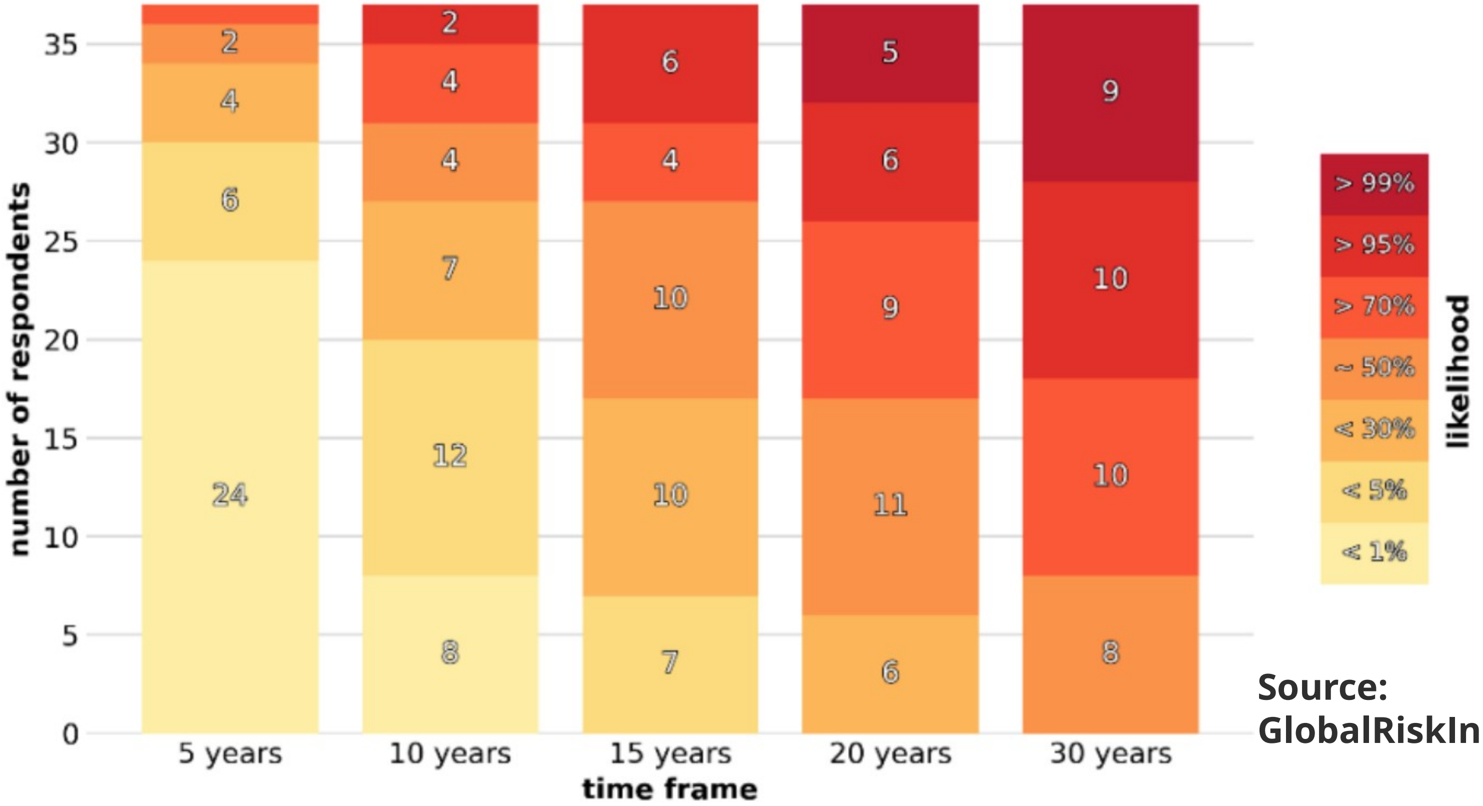
Public Key Encryption	RSA
Digital Signatures	DSA, ECDSA
Key Exchange Algorithms	Diffie-Hellman, ECDH

What will a cybercriminal be able to do?

- Fraudulent authentication
- Forge digital signatures
- Harvest now, decrypt later

2023 EXPERTS' ESTIMATES OF LIKELIHOOD OF A QUANTUM COMPUTER ABLE TO BREAK RSA-2048 IN 24 HOURS

Number of experts who indicated a certain likelihood in each indicated timeframe



Source:
GlobalRiskInsitute.org

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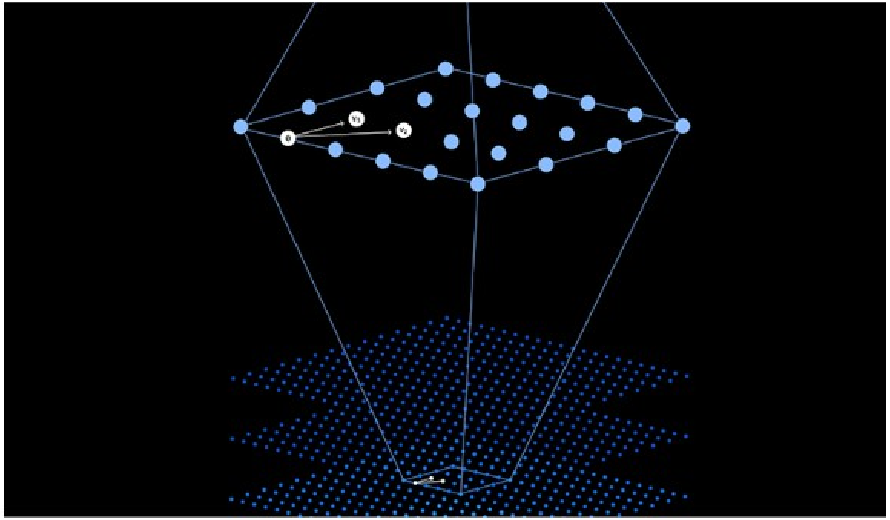
Quantum Safe Cryptography

a.k.a. Post Quantum Cryptography or Quantum Resistant Cryptography

Traditional public-key cryptography relies upon mathematical problems that are difficult to solve on classical computers.

Quantum-safe cryptography includes **a suite of algorithms and systems that are resistant to attacks by both classical and quantum computers.**



Post-Quantum Cryptography PQC

Overview

Short URL: https://www.nist.gov/pqcrypto

FIPS 203, FIPS 204 and FIPS 205, which specify algorithms derived from CRYSTALS-Dilithium, CRYSTALS-KYBER and SPHINCS+, were published August 13, 2024.

4th Round KEMs

Additional Digital Signature Schemes - Round 1 Submissions

PQC License Summary & Excerpts

For a plain-language introduction to post-quantum cryptography, go to: What Is Post-Quantum Cryptography?

Background

NIST initiated a process to solicit, evaluate, and standardize one or more quantum-resistant public-key cryptographic algorithms. **Full details can be found in the Post-Quantum Cryptography Standardization page.**

In recent years, there has been a substantial amount of research on quantum computers – machines that exploit quantum mechanical phenomena to solve mathematical problems that are difficult or intractable for conventional computers. If large-scale quantum computers are ever built, they will be able to break many of the public-key cryptosystems currently in use. This would seriously compromise the confidentiality and integrity of digital communications on the Internet and elsewhere. The goal of *post-*

PROJECT LINKS
Overview
FAQs
News & Updates
Events
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Presentations
ADDITIONAL PAGES
Post-Quantum Cryptography Standardization
Call for Proposals
Example Files
Round 1 Submissions
Round 2 Submissions
Round 3 Submissions
Round 3 Seminars
Round 4 Submissions
Selected Algorithms 2022
Workshops and Timeline
PQC Seminars

Open Source

Post-Quantum Cryptography Alliance

https://pqca.org

To advance the adoption of post-quantum cryptography, by producing high-assurance software implementations of standardized algorithms, and supporting the continued development and standardization of new post-quantum algorithms with software for evaluation and prototyping.

Initial Projects Overview

Open Quantum Safe project

liboqs

Library of many PQ algorithms

- Main profile: standards-track algorithms
- Experimental profile: new algorithms, NIST signatures on-ramp etc.

OQS demos

Prototype integrations of PQ into protocols and applications to support experiments, standardization, interoperability

OQS OpenSSL 3 Provider

Integration of PQ + hybrid algorithms from liboqs into OpenSSL 3 via OpenSSL provider interface

- TLS key exchange, authentication
- X.509
- S/MIME, CMS, CMP

PQ Code Package

“Kyber” code package

High-assurance production source-code implementations of Kyber

- C, x86_64, ARMv8, …
- Rust, Go, …
- audited/certified/formally verified

Plus appropriate wrappers / providers, e.g. Kyber OpenSSL 3 provider

Potential Phase 2 projects

- Dilithium
- XMSS, LMS
- SPHINCS+
- Falcon (-> Phase 3?)

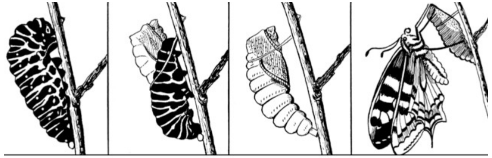
Production track: safe for use in production environments, with external audits or certification

Experimental track: primarily for prototyping and experiments, mindful of potential production use

Becoming Quantum Safe

<u>Discover</u>: Scan source and object code to locate cryptographic assets, dependencies, and vulnerabilities. Build a cryptography bill of materials (CBOM).

<u>Observe</u>: Create a dynamic cryptographic inventory to guide remediation. Analyze cryptographic posture and compliance to prioritize risks.



<u>Transform</u>: Learn and apply quantum-safe remediation patterns in a development environment. Prepare to deploy quantum-safe solutions to your stack.

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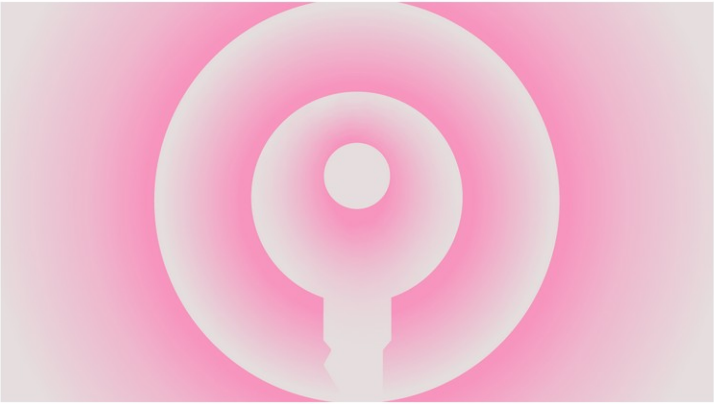
IBM Quantum Technology Qiskit Research Pricing Blog Community Resources Sign in to Platform

Quantum Research
↳ Blog

Bringing quantum-safe security to IBM Quantum Platform, and the world

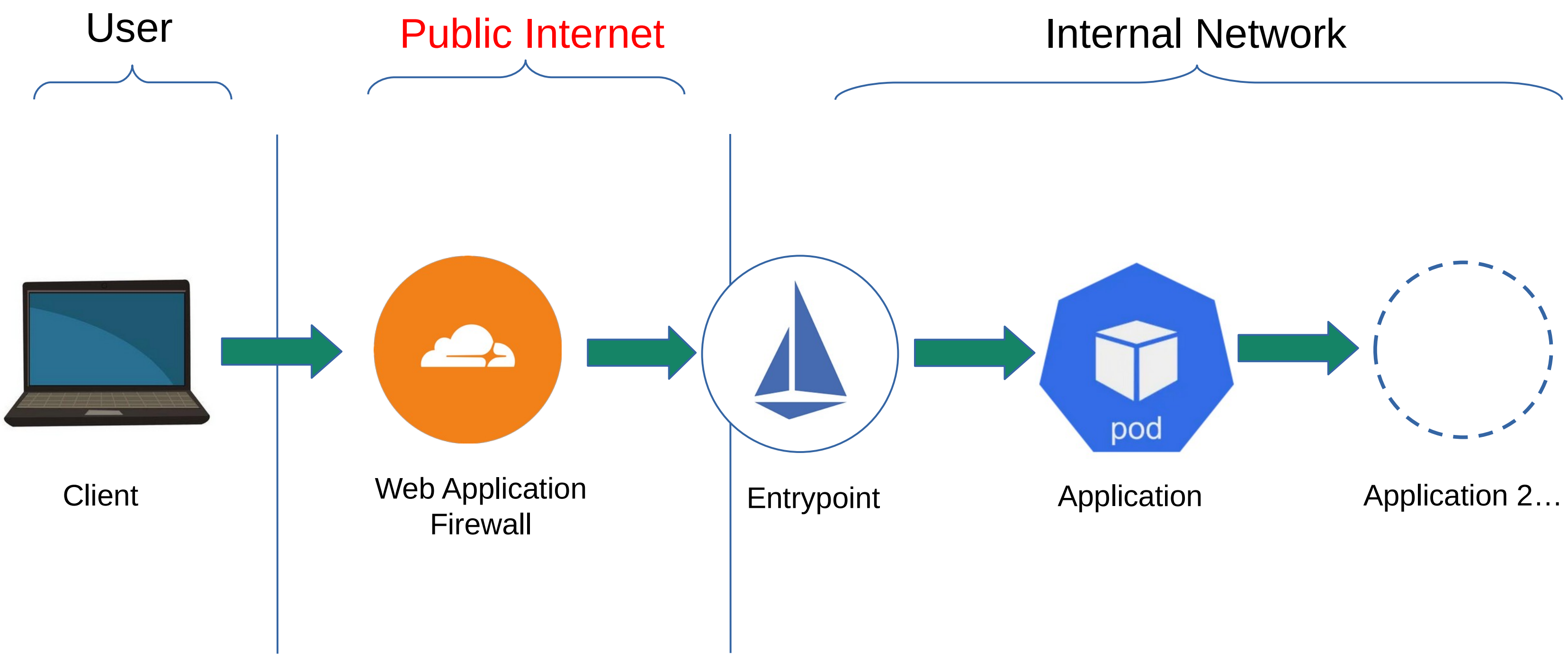
How IBM® is working to make itself, the open source community, and the world quantum safe.



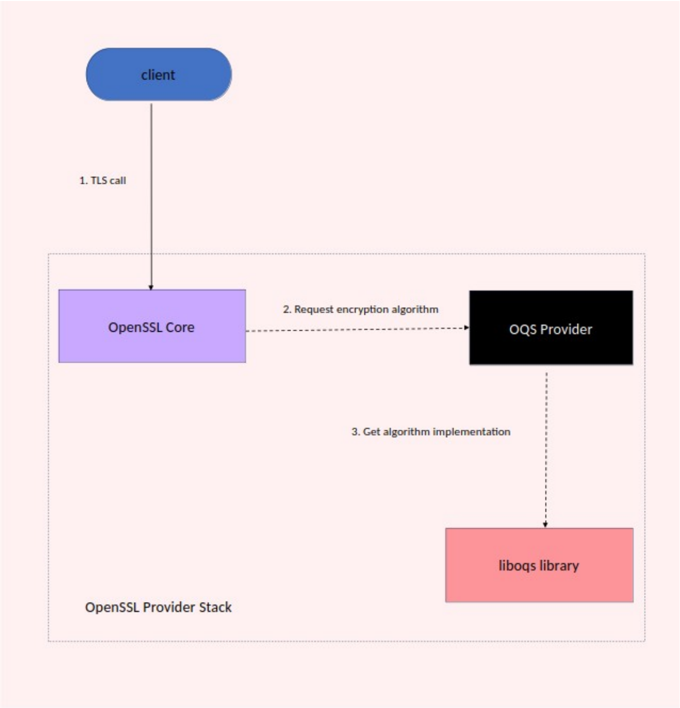
https://www.ibm.com/quantum/blog/iqp-quantum-safe

Quantum Safe Flow

High Level View



Quantum Safe Client: Configuring OpenSSL

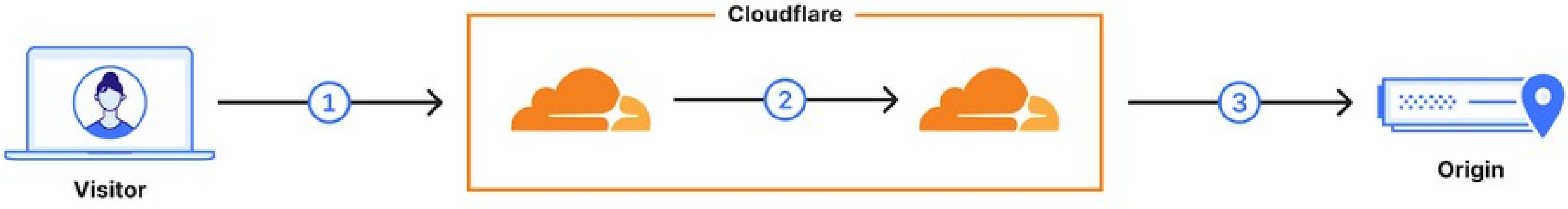


- Install liboqs & oqs-provider
  - https://github.com/open-quantum-safe/liboqs
  - https://github.com/open-quantum-safe/oqs-provider

- Configure OpenSSL to use Kyber algorithm

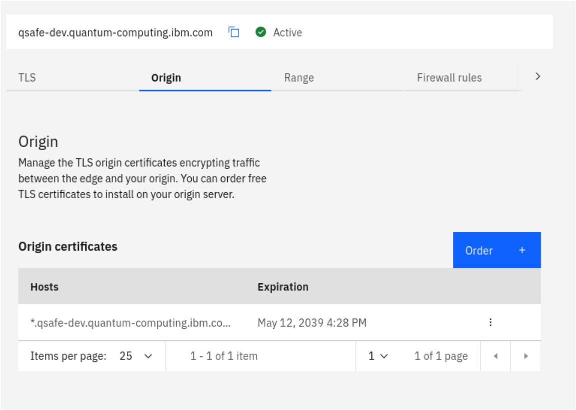
```

[oqsprovider_sect]
activate = 1
module = /opt/conda/lib/ossl-modules/oqsprovider.so

[ ssl_module ]
system_default = tls_system_default

[ tls_system_default ]
TLS.MinProtocol = TLSv1.2
TLS.MaxProtocol = TLSv1.3
DTLS.MinProtocol = DTLSv1.2
DTLS.MaxProtocol = DTLSv1.2
Groups = x25519_kyber768
Ciphersuites = TLS_AES_256_GCM_SHA384:TLS_CHACHA20_POL
CipherString = ECDHE-ECDSA-AES256-GCM-SHA384:ECDHE-RSA

#######################################################
[ ca ]
```

Quantum Safe Firewall:
Enabling PQC in Web Application Firewall

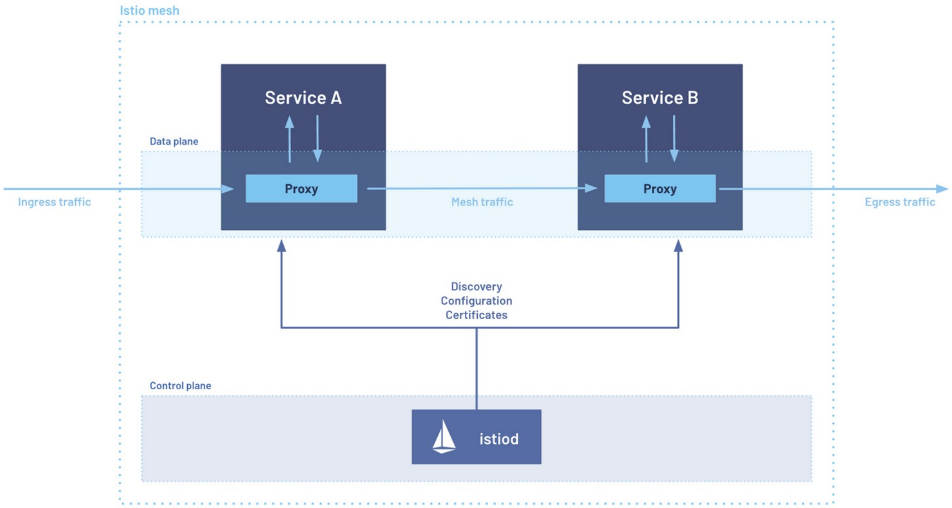


- Enable PQ encryption on IBM Cloud Internet Services
  - https://cloud.ibm.com/apidocs/cis?code=go#update-origin-post-quantum-encryption

- Create new origin cert for Ingress / VirtualService



Quantum Safe Service Mesh: Updating Istio

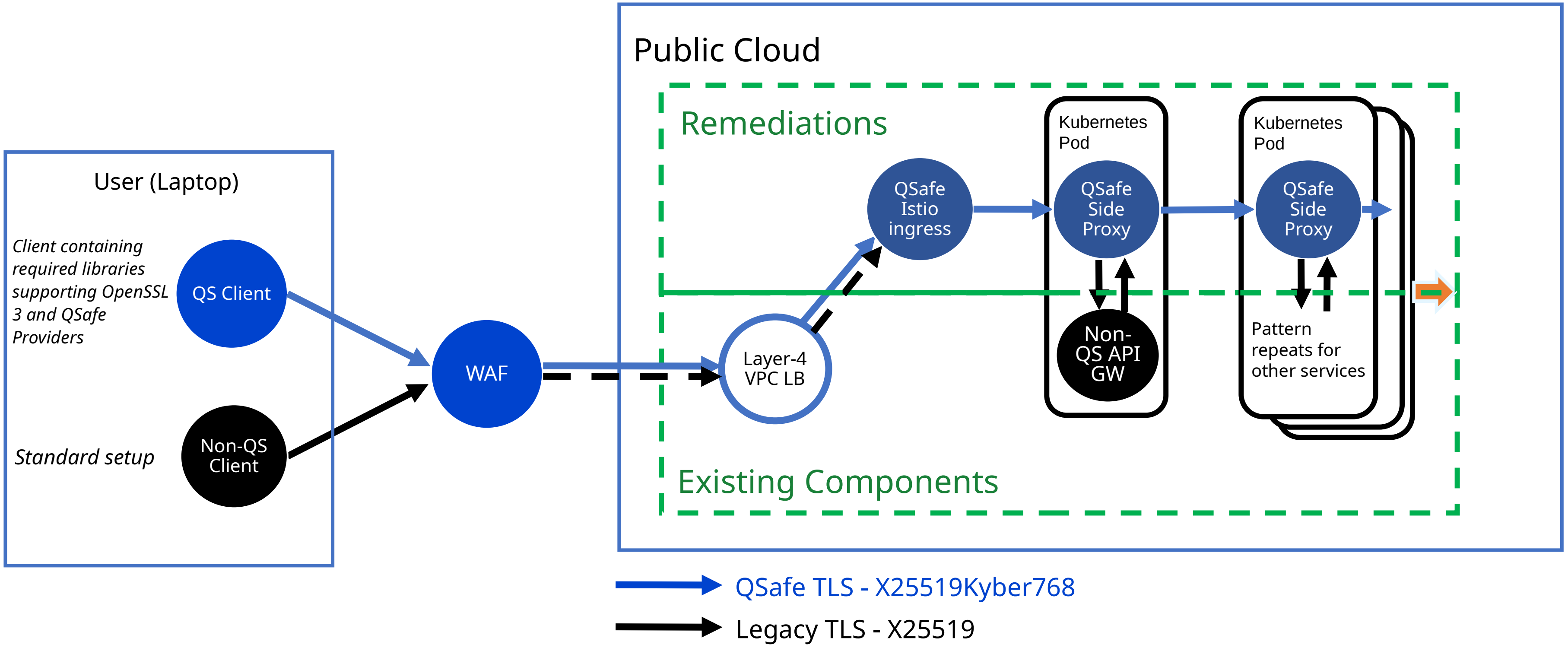


- Envoy
  - QSafe BoringSSL:

    https://github.com/google/boringssl/blob/45cf810dbdbd767f09f8cb0b0fcccd342c39041f/src/ssl/ssl_key_share.cc#L285-L293
- Istio
  - Add QSafe supported group: https://github.com/istio/istio/commit/7635f7ea50514958518eb17b631682f953e723cc
  - Secure mesh traffic: https://github.com/istio/istio/issues/52290

Quantum Safe Flow

Detail View



Demo

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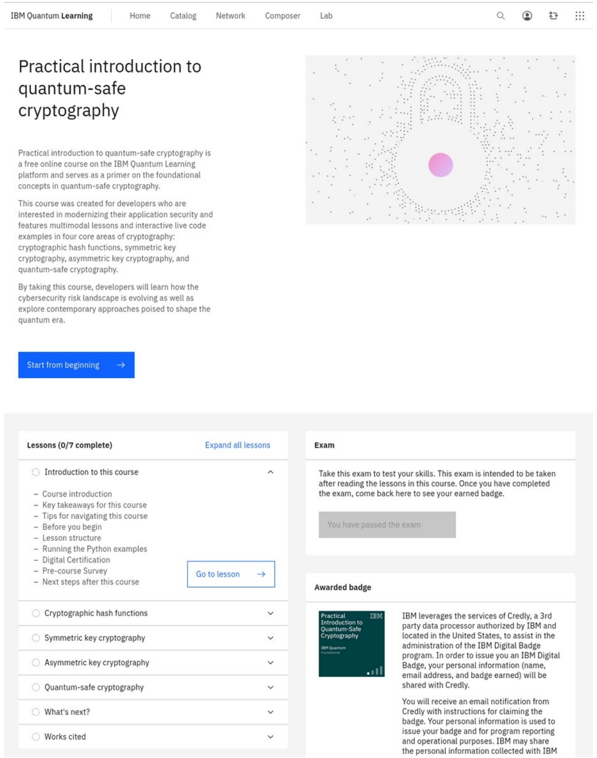
Next Steps

Learn about post-quantum cryptography



Start inventorying your crypto

Next Steps

Learn about post-quantum cryptography

Inventory your crypto

Rate this session

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