Post-Quantum

Cryptography Conference

A Framework for Cryptographic Agility

Navaneeth Rameshan
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PKI Consortium

A Framework For Cryptographic Agility

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The Typical Crypto Call

```python
from cryptography.hazmat.primitives.asymmetric import ec
from cryptography.hazmat.primitives import hashes

# Generate ECDSA private key
private_key = ec.generate_private_key(ec.SECP256R1())

# Sign some data
data = b"data"
signature = private_key.sign(data, ec.ECDSA(hashes.SHA256()))

# Verify signature
public_key = private_key.public_key()
public_key.verify(signature, data, ec.ECDSA(hashes.SHA256()))
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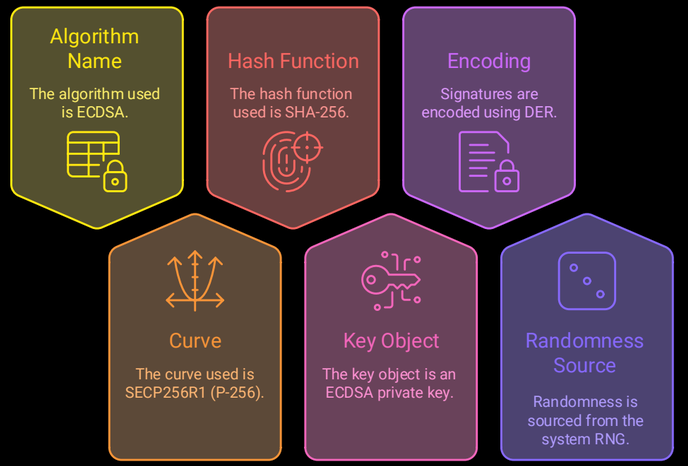

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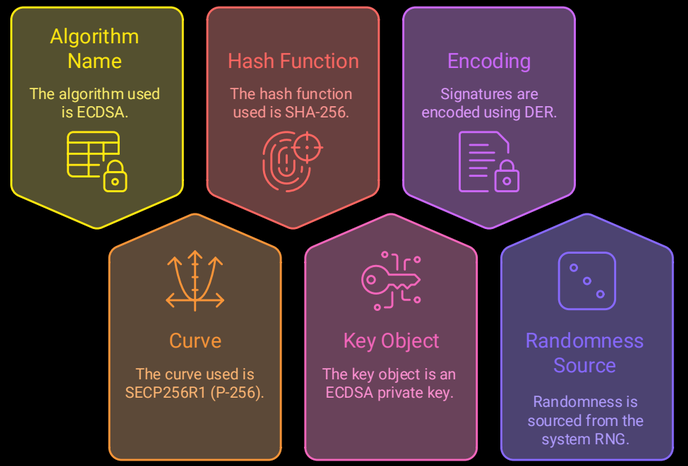
Input Abstraction



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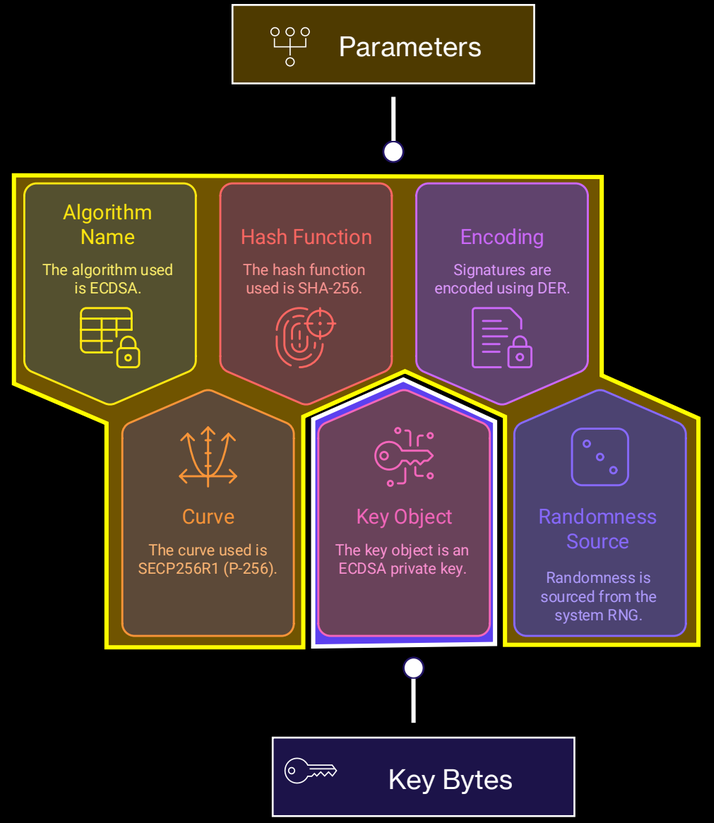

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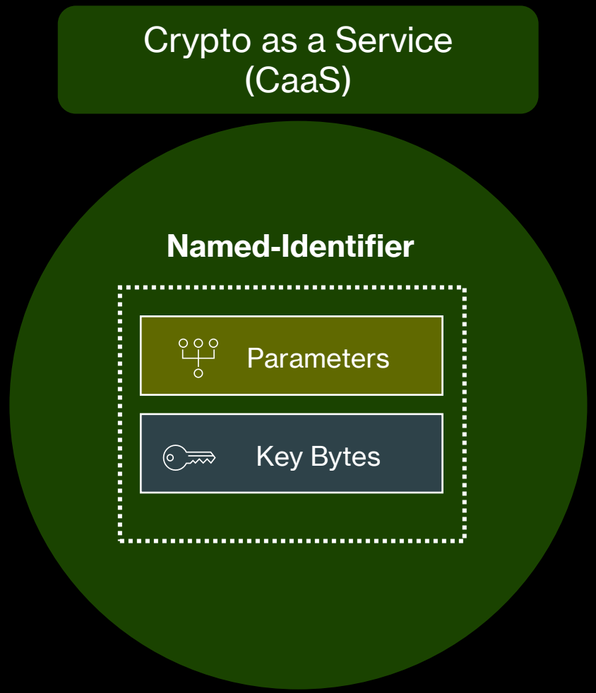
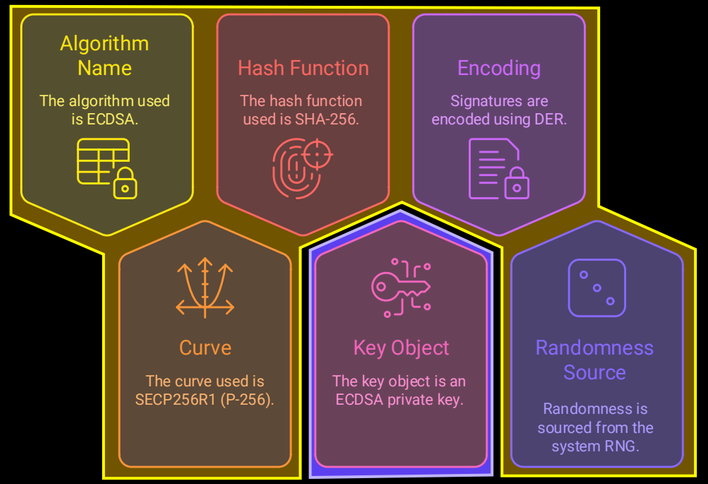
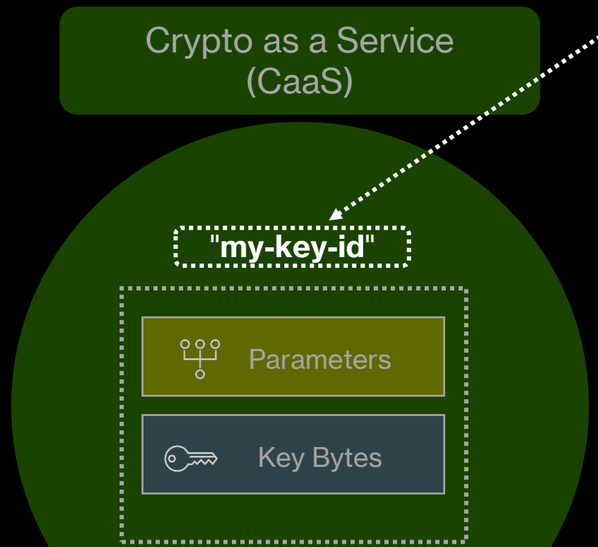




Hide key and parameters under a "*named-identifier*"

What If Signing Looked Like This?

```
# Old API: many knobs & dials
# New API: just “operation” + “named key identifier”
ciphertext = crypto_service.sign("my-key-id", b"data")
```



Under the hood

my-key-id → resolves to a key with certain set of parameters

Decouples app from Crypto Specifics

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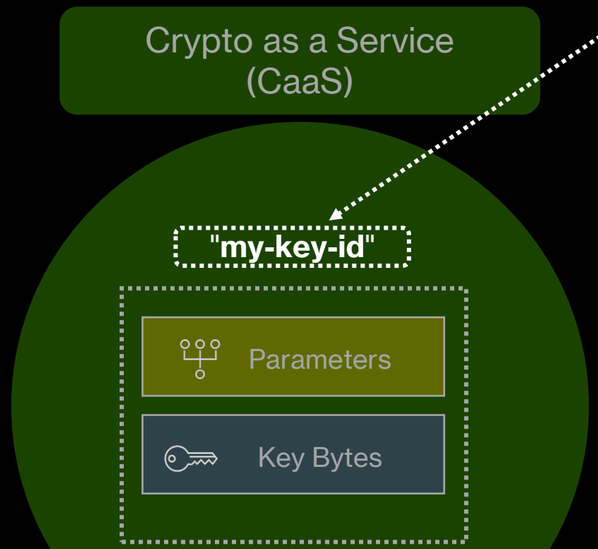

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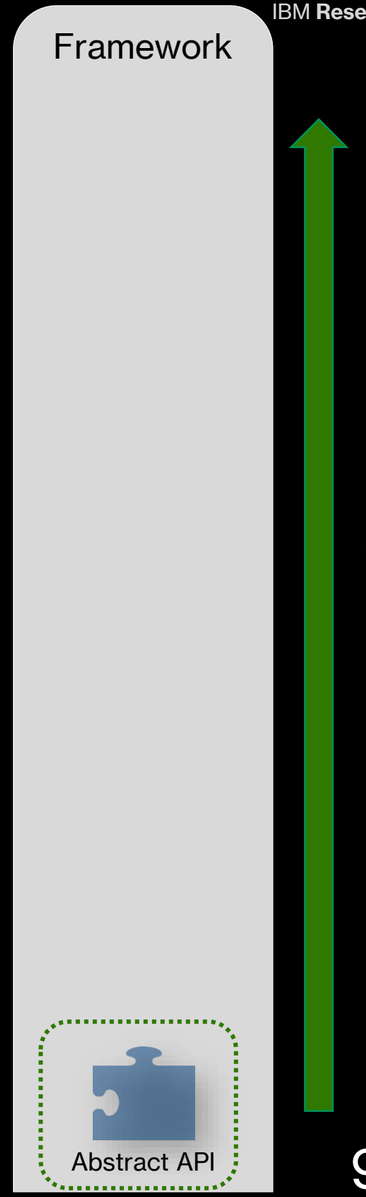
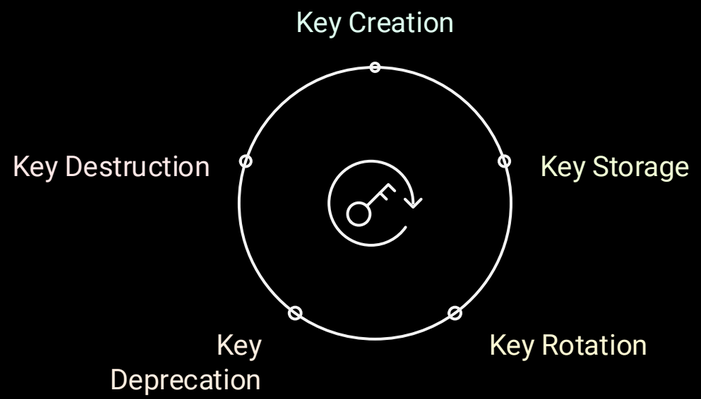
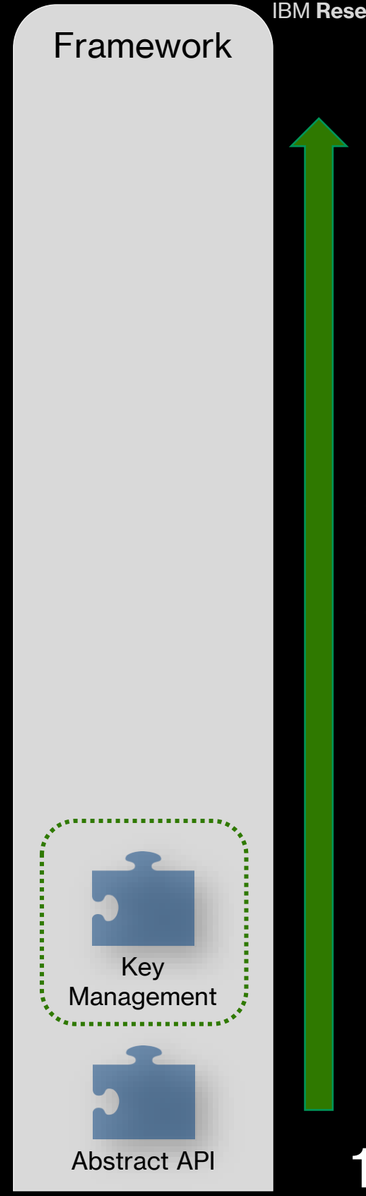
`Decouples app from Crypto Specifics`



Key Lifecycle Management

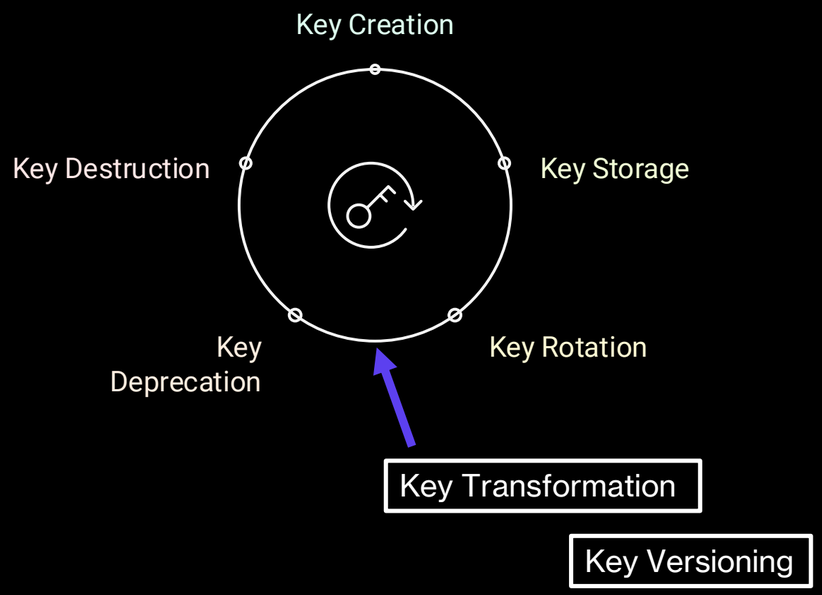


If keys are abstract, their lifecycle must be managed



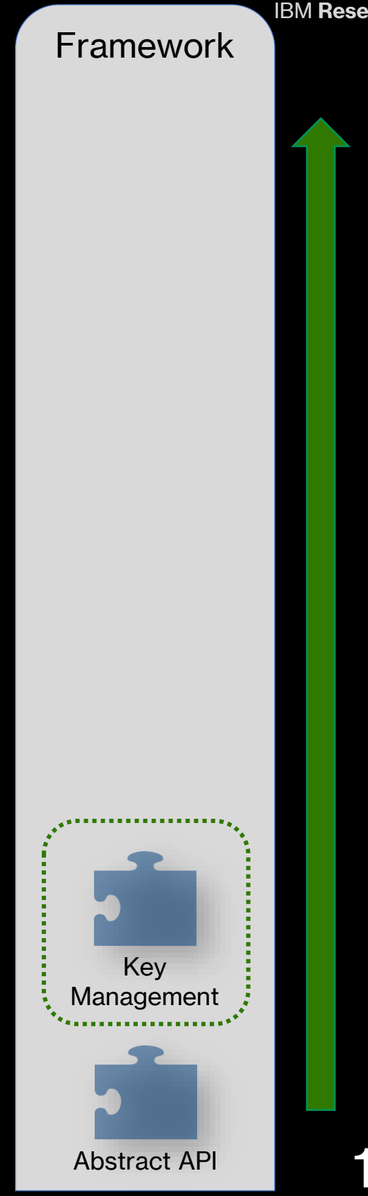
Key Lifecycle Management

Lifecycle Management ("my-key-id")

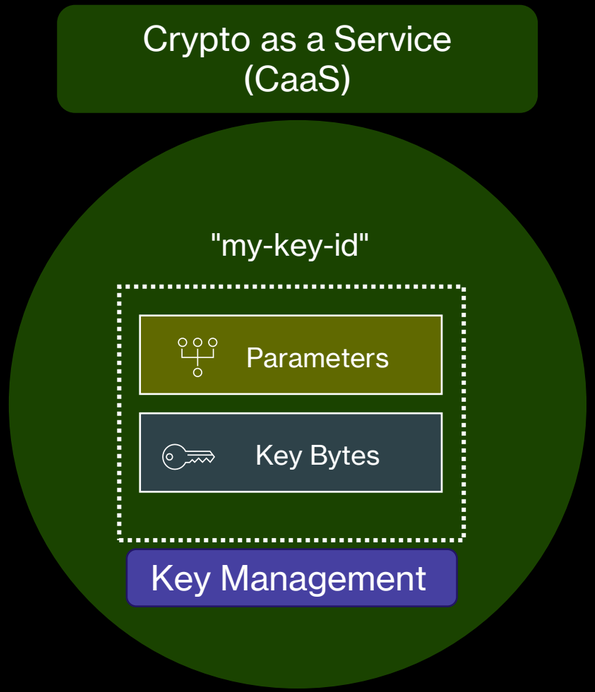


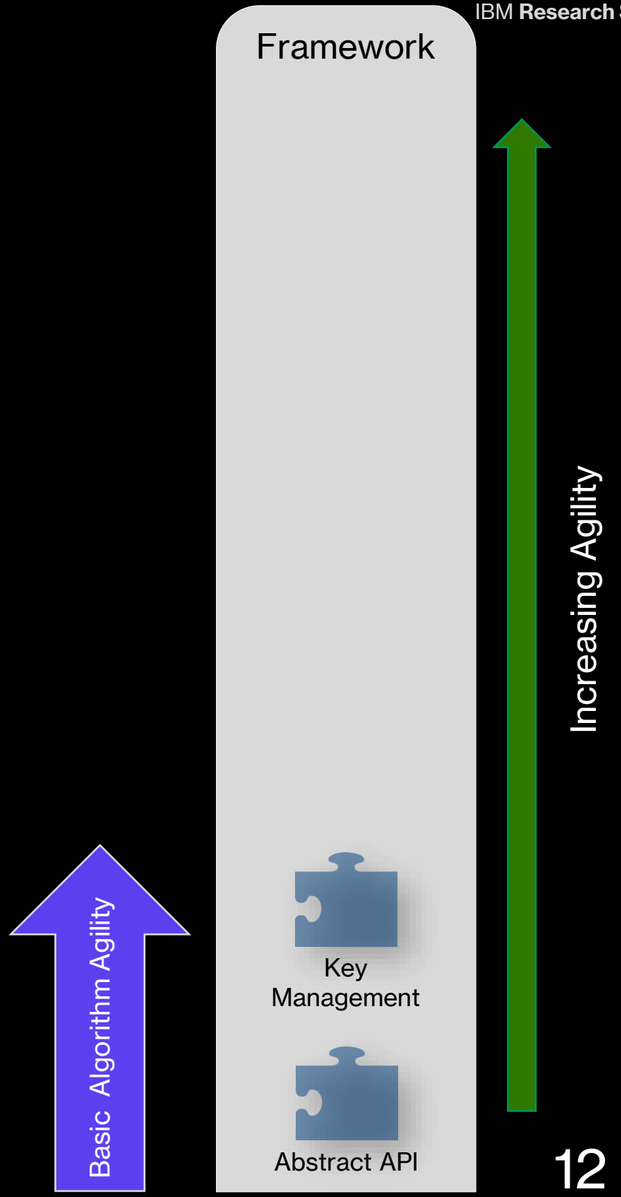
If keys are abstract, their lifecycle must be managed

Action	Key Bytes	Parameters
Rotation	Changes	Retained
Transformation	Can-Change	Can-Change



What Have We Achieved So Far?





How To Create The Key?

ECDSA Signature

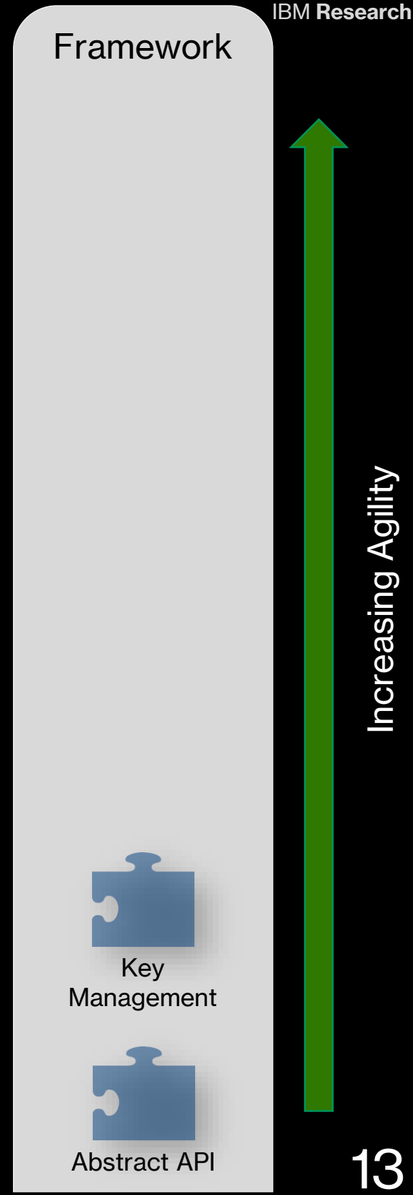
```
# Old API: many knobs & dials

# Create key with a template that captures relevant parameters
crypto_service.create_key("my-key-id", "ECDSA_P256_SHA256")

# New API: just “operation” + “named key identifier”
ciphertext = crypto_service.sign("my-key-id", b"data")
```

Use a key template that captures all the relevant parameters

We still need to know the key type!!



Replace "Template" with "Scope"

ECDSA Signature

```
# Old API: many knobs & dials

# Create key with a template that captures relevant parameters
crypto_service.create_key("my-key-id", "ECDSA_P256_SHA256")

# New API: just “operation” + “named key identifier”
ciphertext = crypto_service.sign("my-key-id", b"data")
```

ECDSA Signature

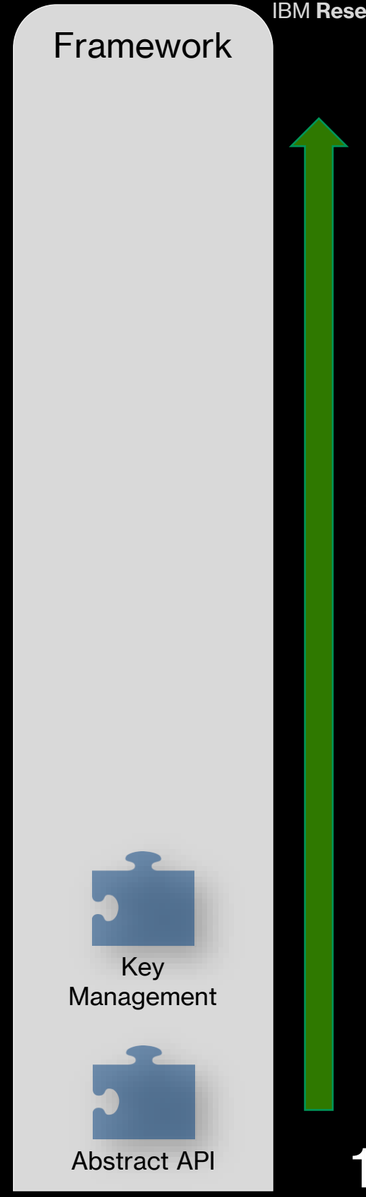
```
# Old API: many knobs & dials

# Create key with a scope for intended use
crypto_service.create_key("my-key-id", "signature")

# New API: just “operation” + “named key identifier”
ciphertext = crypto_service.sign("my-key-id", b"data")
```

Scope: Intended purpose of use

- Authenticated data encryption
- Block Cipher
- Signature
- MAC/HMAC ...



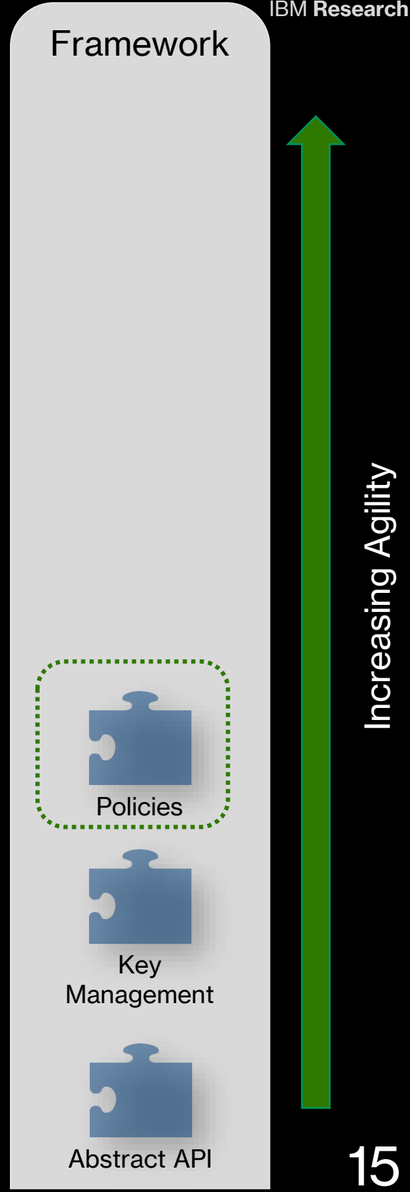
Policy Auto-Selects Algorithm

Scope	Preferred Algorithm	Fallback Algorithm
Authenticated Data Encryption	AES-GCM-96	ChaCha20-Poly1305
Signature	ECDSA-P256-SHA256	Ed25519

Under the hood

Policies determine which *algorithms* are allowed for each *scope*

Changing policies swaps algorithms without touching app code



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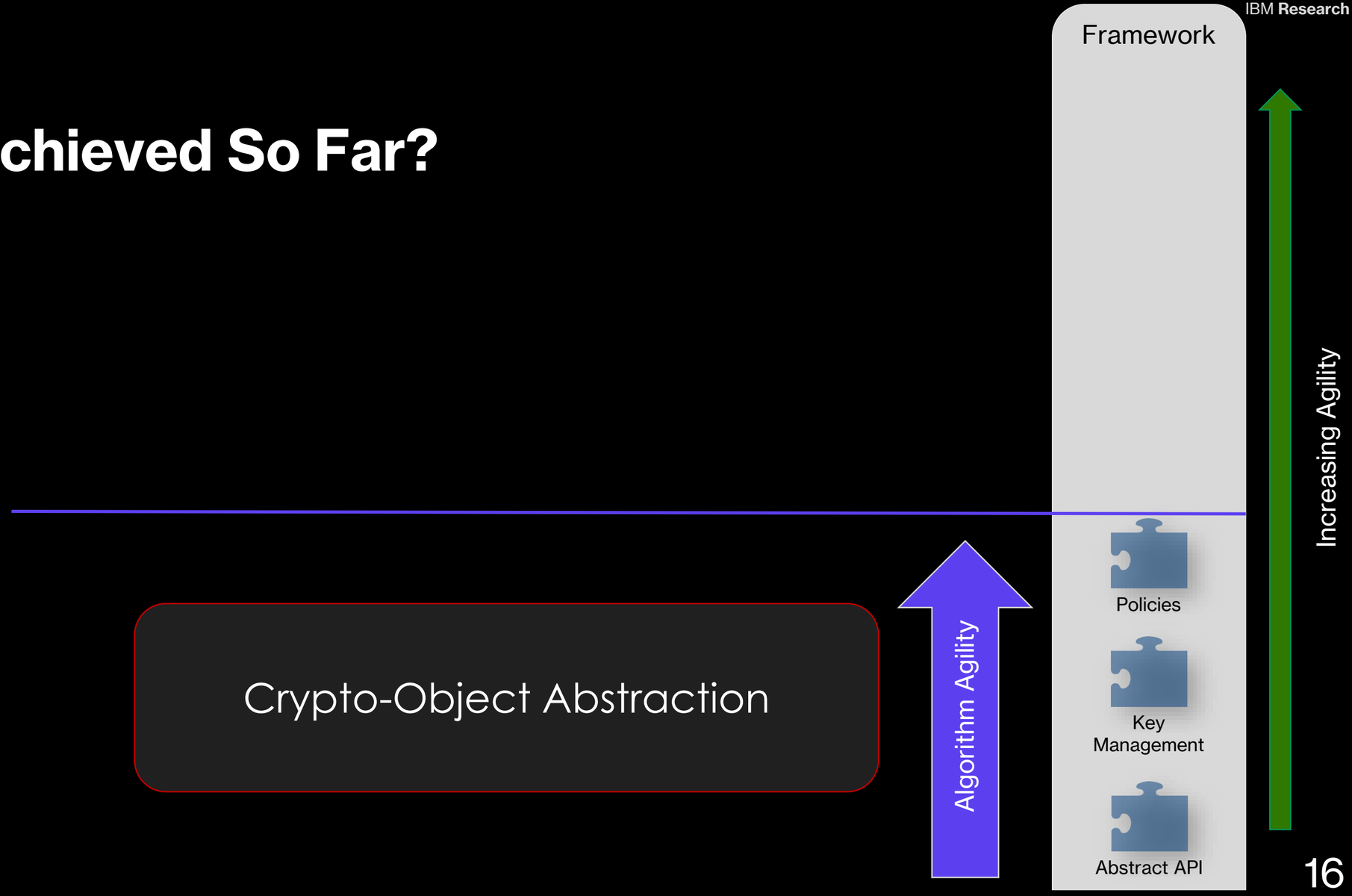
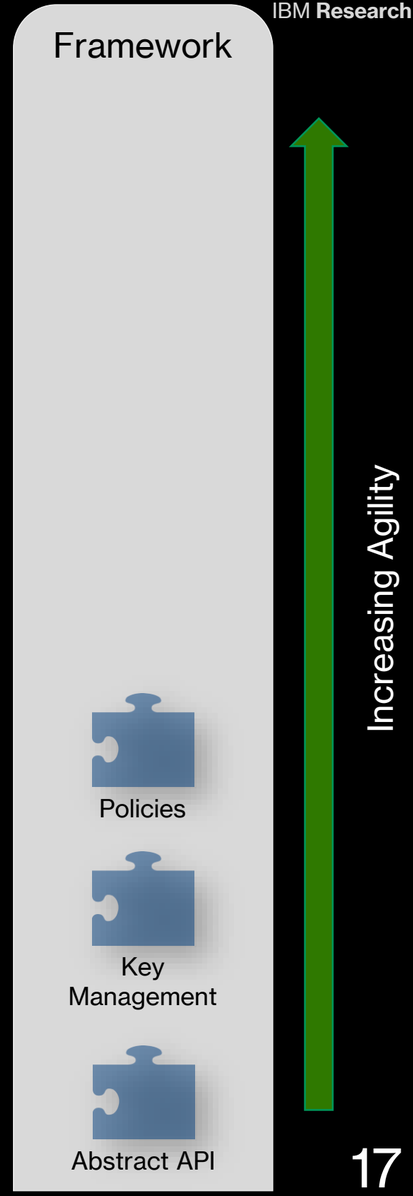


Who Sets the Policies and Rules?

Application developers should not be able to set policies



Who Sets the Policies and Rules?

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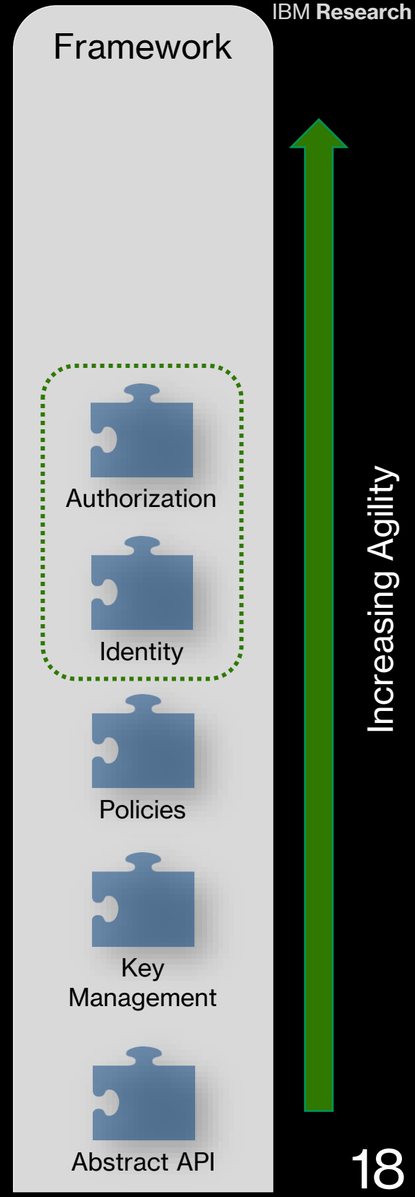
Identity and Access Management for separation of responsibilities

- CISO/Crypto Admin → Sets Policies
- App Developer → Uses crypto via key IDs



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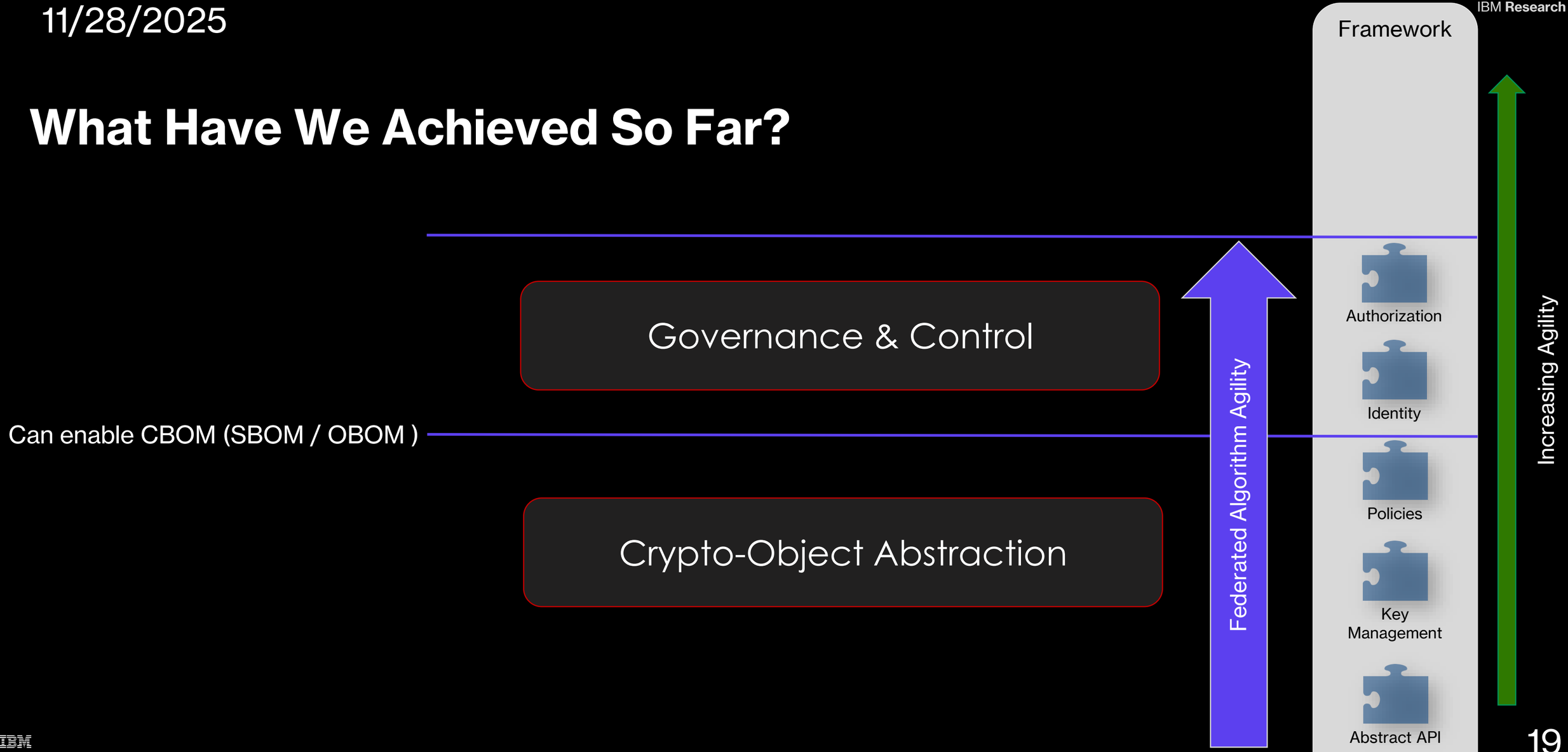


What Have We Achieved So Far?

Processing Agility

Governance & Control

Can enable CBOM (SBOM / OBOM)

Crypto-Object Abstraction

Crypto-Workflow Agility

Framework

Authorization

Identity

Policies

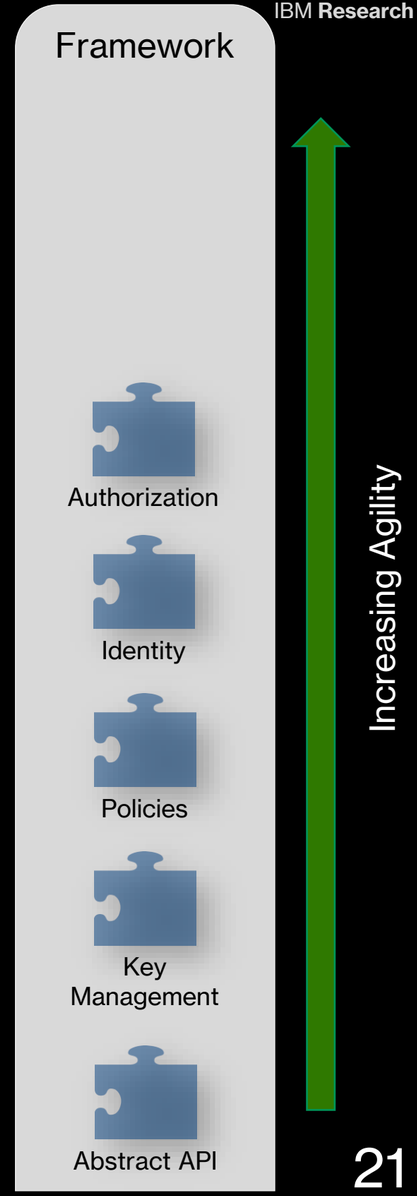
Key Management

Abstract API

Increasing Agility

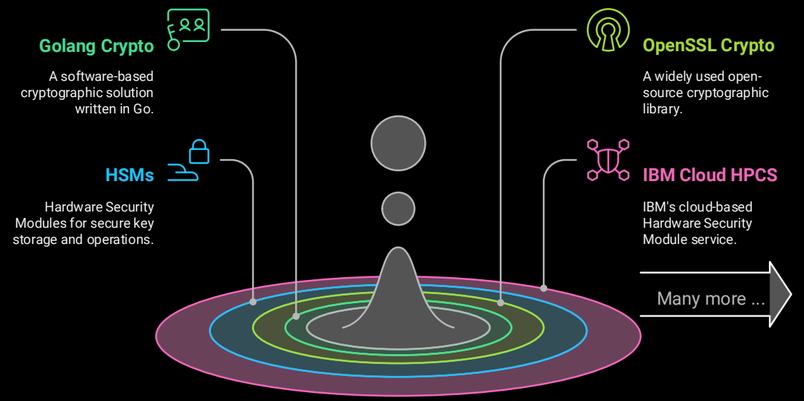
Crypto-Processing Agility

Where is Cryptography executed?



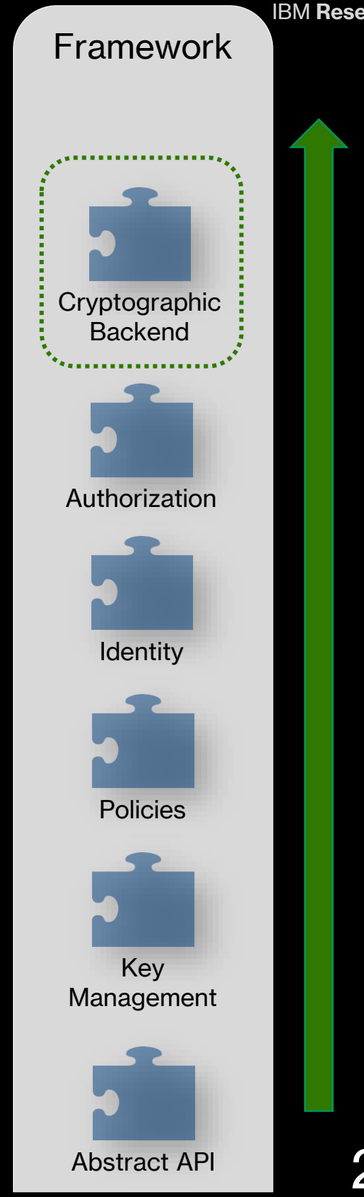
Crypto-Processing Agility

Where is Cryptography executed?

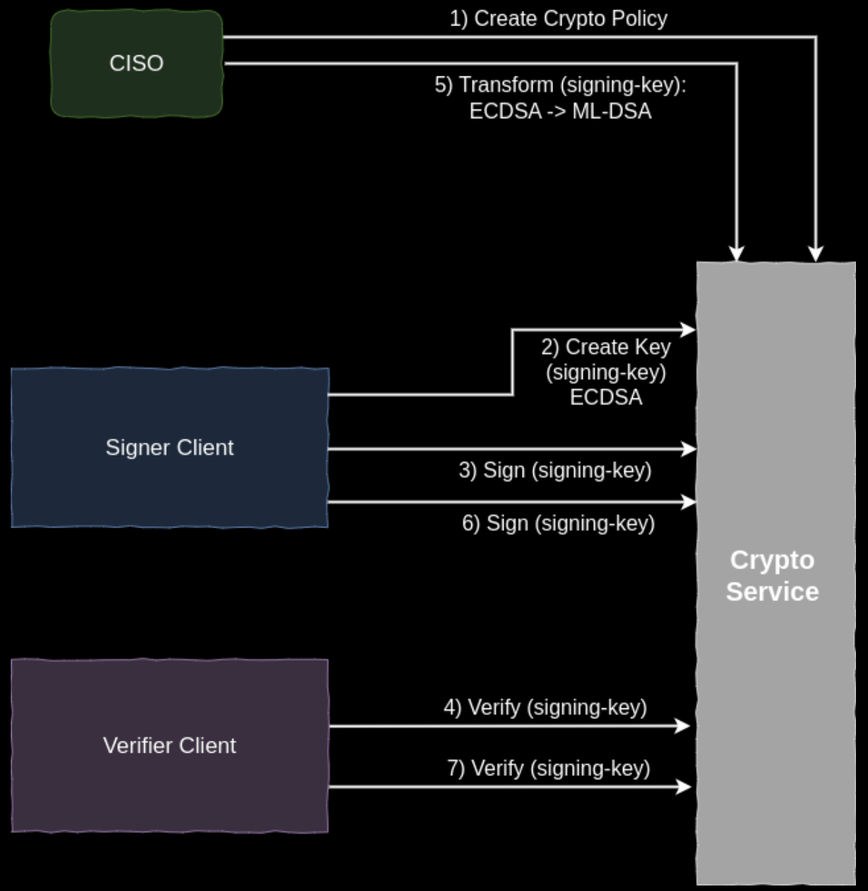


Backend = Crypto Libraries, HSM, Cloud KMS …

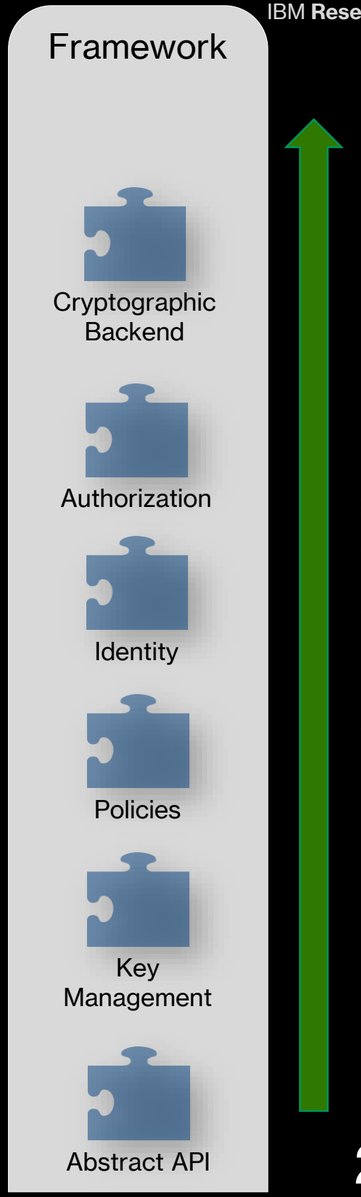
Abstract API and policy lets us switch cryptographic implementations at will



Sample Agile Workflow

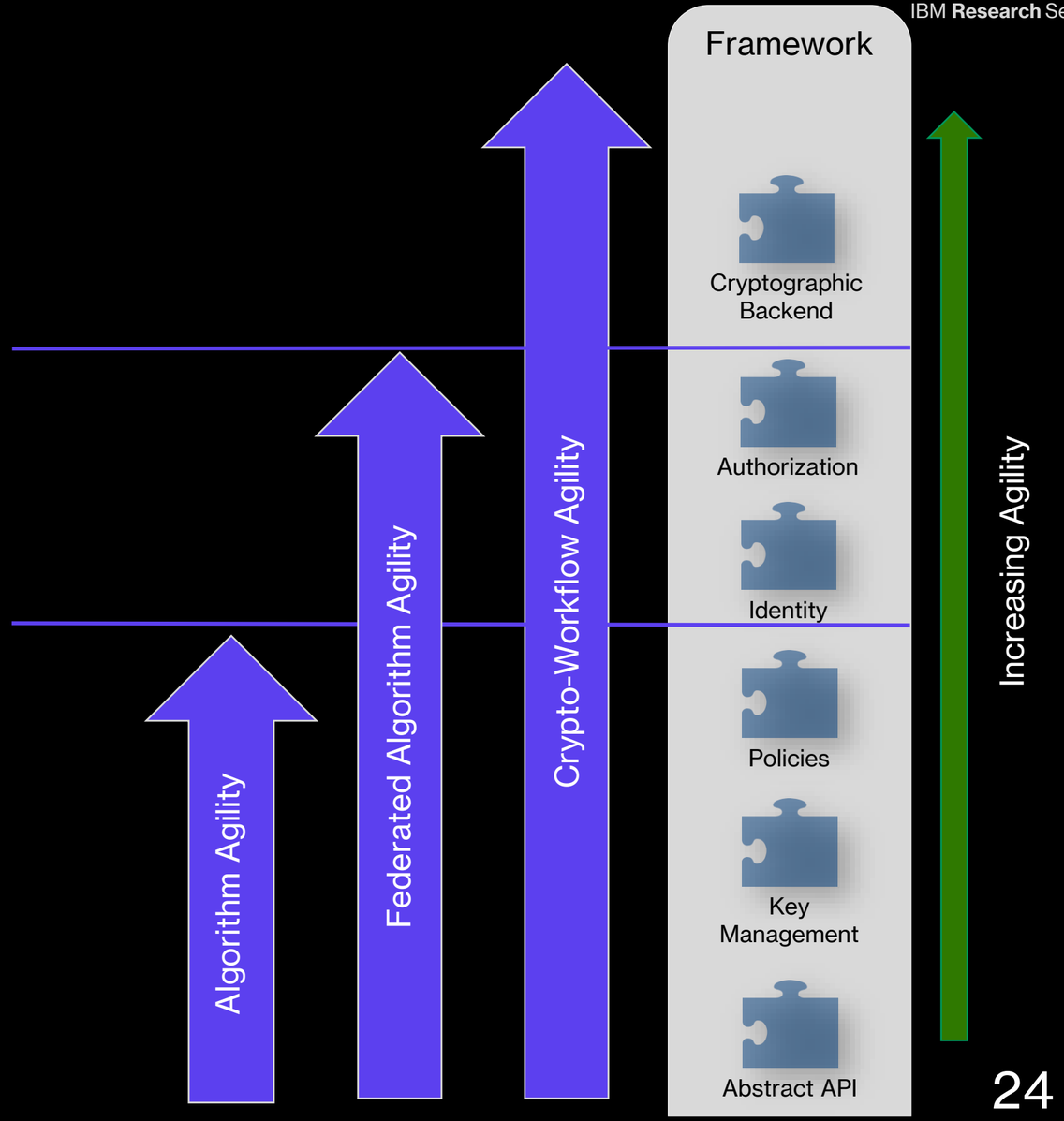


1. CISO officer creates a crypto policy which allows both ECDSA and ML-DSA algorithms and keys
2. Signer client creates an ECDSA Key called (“signing-key")
3. Signer client signs with key “signing-key”, and gets back a signature
4. Verifier client verifies the signature with key “signing-key”
5. The CISO officer now transforms the key signing-key to ML-DSA or updates policy to use ML-DSA
6. The signer client signs a new transaction with key “signing-key”. Under the hood, without any application-level code changes, this automatically is signed with ML-DSA
7. The verifier client verifies the new signature with key “signing-key” and gets a successful validation, again without any code changes



Adoption Path For Organizations

1. Replace direct crypto calls with abstract API
2. Centralize key lifecycle management
3. Introduce scope-based policies
4. Add strict identity & access control
5. Enable crypto-backend flexibility
6. ...



Putting It All Together

Thank You

Questions?