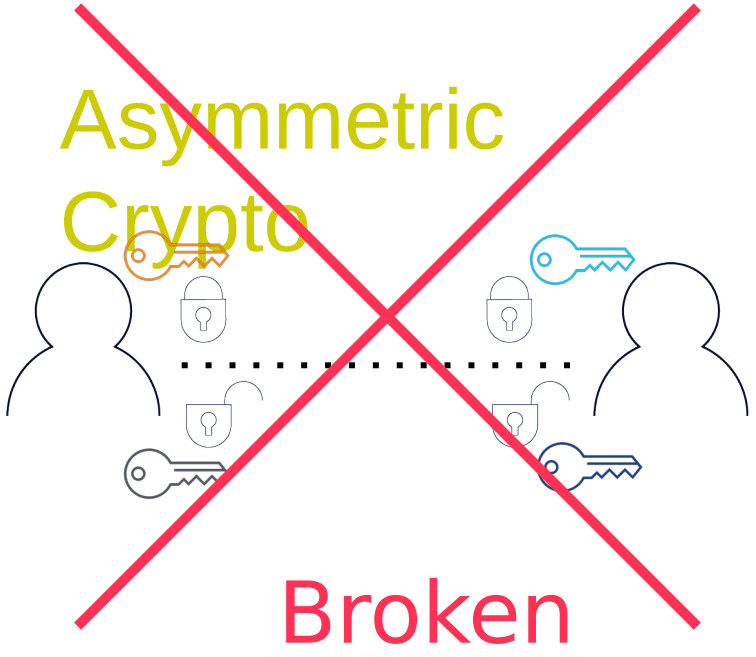
PQ KEMs for COSE AND JOSE

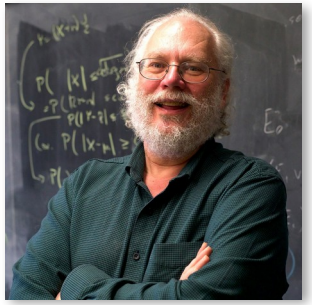
draft-reddy-cose-jose-pqc-kem

Tirumaleswar Reddy, Hannes Tschofenig, Aritra Banerjee

IETF 119, Brisbane

Impact of Quantum Computers in Cryptography

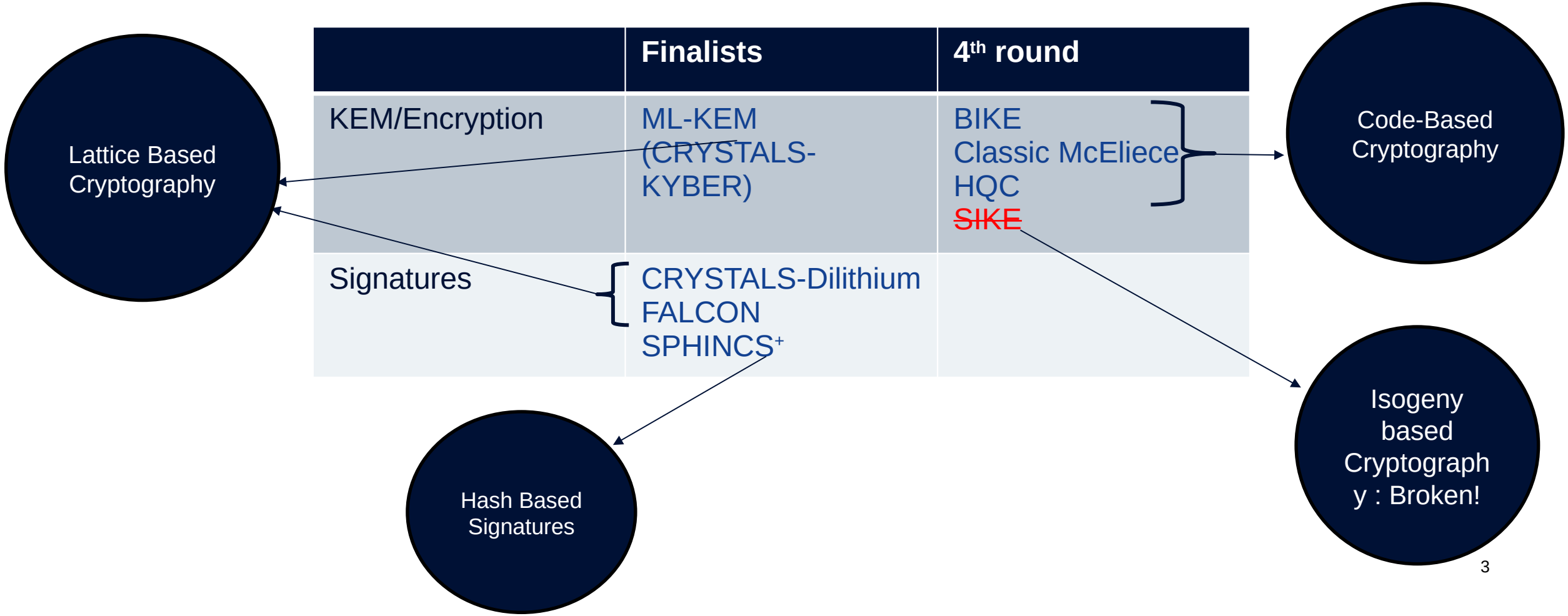




Peter Shor

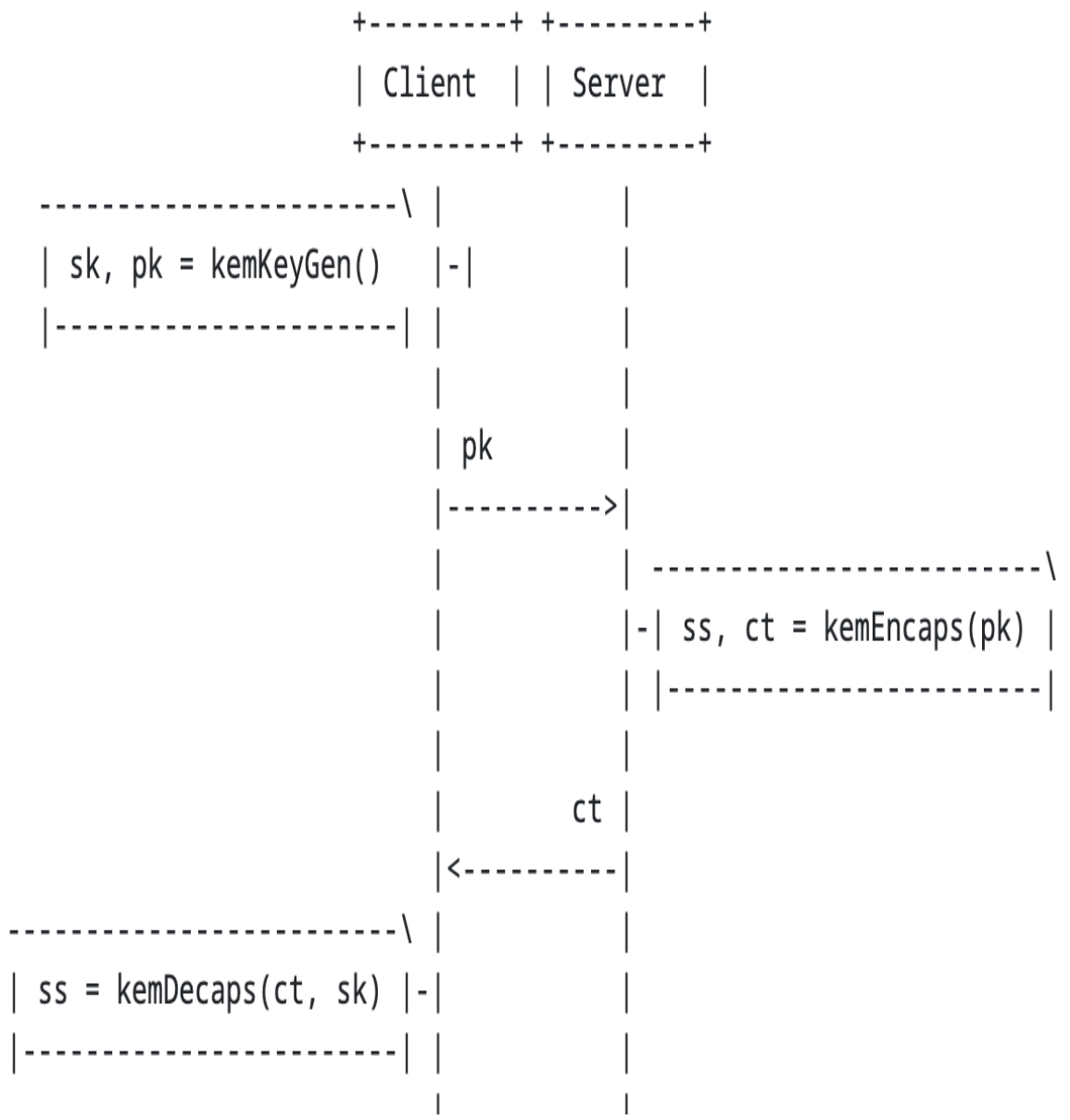
Algorithm for prime factorization of large integers

NIST Candidates Selected for Standardization

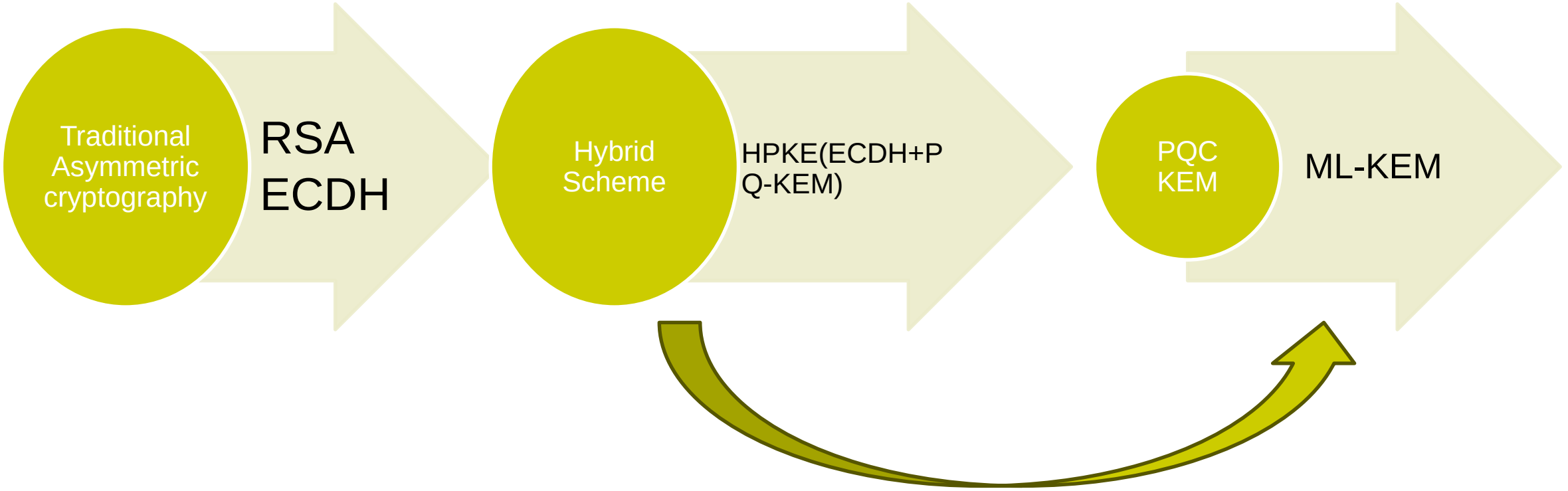


	Finalists	4th round
KEM/Encryption	ML-KEM (~~CRYSTALS-~~KYBER)	BIKE Classic McEliece HQC ~~SIKE~~
Signatures	CRYSTALS-Dilithium FALCON SPHINCS+	

KEM


Client
Server
sk, pk = kemKeyGen()
pk
ss, ct = kemEncaps(pk)
ct
ss = kemDecaps(ct, sk)

Transition path



FIPS 203 standard (ML-KEM) is a new CNSA 2.0 standard for PQ-KEM via lattice-based key establishment mechanism.
ML-KEM has been around 7 years and gone through many rounds of analysis
Hybrids can' be used when CRQC arrive and adds to computational cost.

PQ-KEM Encapsulation

- (SS', CT) = kemEncaps(recipPubKey)
- SS = KDF(SS', SSLen)

PQ-KEM Decapsulation

- SS' = kemDecaps(recipPrivKey, CT)
- SS = KDF(SS', SSLen)

Ciphersuite Registration

alg	Description
MLKEM512-SHAKE128	ML-KEM-512 + SHAKE128
MLKEM768-SHAKE256	ML-KEM-768 + SHAKE256
MLKEM1024-SHAKE256	ML-KEM-1024 + SHAKE256

Figure 1: Direct Key Agreement: Algorithms.

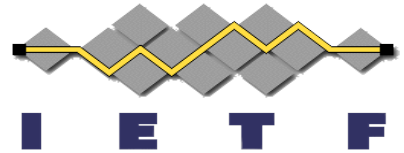
alg	Description
MLKEM512-SHAKE128-AES128KW	ML-KEM-512 + SHAKE128 + AES128KW
MLKEM768-SHAKE256-AES256KW	ML-KEM-768 + SHAKE256 + AES256KW
MLKEM1024-SHAKE256-AES256KW	ML-KEM-1024 + SHAKE256 + AES256KW

Figure 2: Key Agreement with Key Wrapping: Algorithms.

PQ KEM in COSE

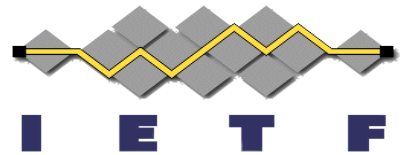
- PQ-KEM in a single recipient setup
- PQ-KEM in a multiple recipient setup

Single Recipient / One Layer Structure



- The plaintext will be encrypted using the CEK. The resulting ciphertext is either included in the COSE_Encrypt0 or is detached.

Multiple Recipients / Two Layer Structure

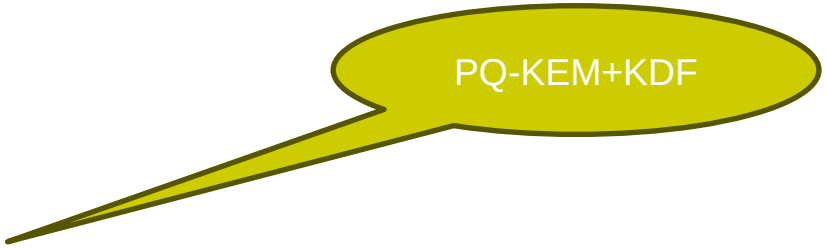


- Layer 0 contains the content (plaintext) encrypted with the CEK.
- Layer 1 (corresponding to a recipient structure) contains parameters needed for PQ-KEM to generate a shared secret used to encrypt the CEK.
  - The output ('ct') from the PQ KEM Encaps algorithm in the 'encapsulated_key' header parameter
  - The encrypted CEK in the encCEK structure.

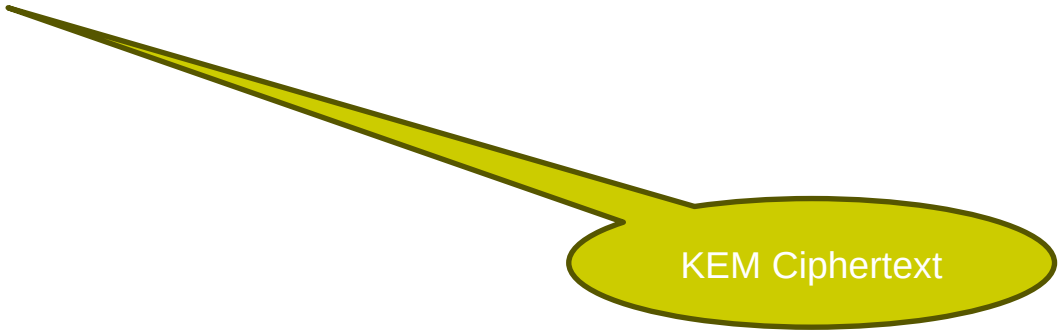
PQ KEM in JOSE

- Direct Key Agreement
- Key Agreement with Key Wrapping

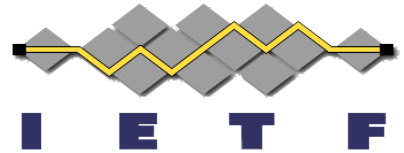
Direct Key Agreement




```
{
  "alg": "MLKEM768-SHAKE256",
  "kid": "urn:ietf:params:oauth:jwk-thumbprint:sha-
56:adjwW6fyyZ94ZBjGjx_OpDEKHLG",
  “kem-ct": "yDVZLsO7-ecy_GCgEluwn9U723TCHNAzeYRRQPOfpHM",
  "enc": "A256GCM"
}
```



Key Agreement with Key Wrapping




```
{
  "protected": "eyJlbmMiOiJBMTI4R0NNIn0",
  "ciphertext": "S0qqrM3xXPUavbmL9LQkgUKRBu8BZ7DQwoT-mdNIZVU-ip_V-
fbMokiGwp2aPM57DX3cXCK3TKHqdhZ8rSNduUja",
  "iv": "AzaXpooLg3ZxEASQ",
  "aad": "8J-SgCBhYWQ",
  "tag": "S0omWw35S0H7tyEHsmGLDw",
  "recipients": [
    {
      "encrypted_key": "yDVZLsO7-ecy_GCgEluwn9U723TCHNAzeYRRQPOfpHM",
      "header": {
        "kid": "urn:ietf:params:oauth:jwk-thumbprint:sha-256:adjwW6fyyZ94ZBjGjx_OpDEKHLG",
        "alg": "MLKEM768-SHAKE256",
       “kem-ct": "yDVZLsO7-ecy_GCgEluwn9U723TCHNAzeYRRQPOfpHM"
      }
    }
 ]
}
```

{"enc": "A128GCM"}

KEM Ciphertext

PQ-KEM+KDF

Next Steps

- Consider for WG adoption
- Comments and suggestions are welcome