title

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March 2026

Abstract

The Net Asset Value (NAV) of an Exchange-Traded Fund is computed as the sum of all holdings multiplied by their respective prices, divided by shares outstanding. This computation requires full visibility into fund holdings—a requirement that conflicts with the competitive advantage of proprietary portfolio construction. This paper presents a confidential NAV computation protocol on Liquid EVM where fund holdings are stored as `euint64` ciphertexts and prices are provided as encrypted oracle feeds. The NAV formula $\text{NAV} = \sum_i (h_i \times p_i)/S$ is computed entirely using homomorphic multiplication (`FHE.mul`), addition (`FHE.add`), and scalar division (`FHE.scalarDiv`) on the FHE precompile at `0x0700`. Only the final NAV figure is decrypted via threshold decryption, revealing no individual holdings or position sizes. We provide complete Go code using `github.com/luxfi/fhe` for encrypting holdings, computing NAV, and selective disclosure to Authorized Participants.

1 Introduction

ETF issuers are required by SEC Rule 6c-11 to publish their NAV daily. For actively managed ETFs, this creates a tension: the NAV computation requires knowledge of all holdings, but disclosing holdings reveals the fund's proprietary strategy. The "portfolio transparency problem" has been a barrier to actively managed ETF adoption.

Semi-transparent ETF structures (such as SEC-approved non-transparent ETFs using Precidian's ActiveShares methodology) attempt to address this by publishing a "tracking basket" instead of actual holdings. However, these structures still require a trusted calculation agent who sees all holdings.

FHE eliminates the need for a trusted calculation agent. The fund encrypts its holdings. An encrypted price oracle provides current market prices. The NAV is computed homomorphically on-chain. The calculation is verifiable by all Quasar validators, but the inputs (holdings) are never visible.

1.1 Contributions

1. A protocol for computing ETF NAV on encrypted holdings using the FHE precompile.
2. Go code implementing the full NAV pipeline: encrypt holdings, provide encrypted prices, compute NAV, decrypt.
3. Selective disclosure: the fund can authorize specific APs to decrypt their share of the NAV breakdown for creation/redemption purposes.
4. Analysis of gas costs and latency for funds with up to 500 holdings.

2 Architecture

2.1 NAV Formula

For a fund with n holdings:

$$\text{NAV} = \frac{\sum_{i=1}^{n} h_i \times p_i}{S}$$

where h_i is the quantity of asset i, p_i is the market price of asset i, and S is the total shares outstanding.

In FHE:

$$\text{enc}(\text{NAV}) = \texttt{FHE.scalarDiv}\left(\sum_{i=1}^{n} \texttt{FHE.mul}(\text{enc}(h_i), \text{enc}(p_i)), S\right) \tag{1}$$

Note: S (shares outstanding) is public, so the division is scalar.

2.2 Encrypted Holdings

Field	Type	Description	Gas
`encAssetID`	`euint64`	Asset identifier	50,000
`encQuantity`	`euint64`	Shares/units held	50,000
`encPrice`	`euint64`	Current price (from oracle)	50,000

Table 1: Encrypted holding fields for NAV computation.

2.3 Protocol Flow

1. **Encrypt Holdings:** The fund manager encrypts holding quantities under the network FHE public key and submits to `ConfidentialNAV.sol`.
2. **Price Feed:** An encrypted price oracle submits encrypted market prices. The oracle encrypts prices so that the fund cannot be accused of manipulating the NAV computation.
3. **Compute NAV:** The contract multiplies each encrypted holding by its encrypted price, sums the products, and divides by shares outstanding.
4. **Decrypt NAV:** The encrypted NAV is sent to Liquid Threshold for threshold decryption.
5. **Publish:** The plaintext NAV is published on-chain.

3 Implementation

3.1 Go Client: Encrypt Fund Holdings

```go
package nav

import (
    "github.com/luxfi/fhe"
)

// Holding represents a single fund position.
type Holding struct {
    AssetID  uint64 // hashed asset identifier
    Quantity uint64 // number of shares/units
}

// PriceFeed represents an encrypted price from the oracle.
type PriceFeed struct {
    AssetID  uint64
    EncPrice *fhe.BitCiphertext
}

// EncryptedHolding pairs encrypted quantity with encrypted
// price for NAV computation.
type EncryptedHolding struct {
    EncQuantity *fhe.BitCiphertext
    EncPrice    *fhe.BitCiphertext
}

// EncryptHoldings encrypts all fund holdings under the
// network FHE public key.
func EncryptHoldings(
```

```
    enc *fhe.BitwiseEncryptor,
    holdings []Holding,
) []*EncryptedHolding {
    result := make([]*EncryptedHolding, len(holdings))
    for i, h := range holdings {
        result[i] = &EncryptedHolding{
            EncQuantity: enc.EncryptUint64(
                h.Quantity, fhe.FheUint64,
            ),
            EncPrice: nil, // set later from oracle
        }
    }
    return result
}

// EncryptPrices encrypts market prices. In production,
// the price oracle does this independently so the fund
// manager cannot manipulate prices.
func EncryptPrices(
    enc *fhe.BitwiseEncryptor,
    prices map[uint64]uint64, // assetID -> price in bps
) map[uint64]*fhe.BitCiphertext {
    result := make(map[uint64]*fhe.BitCiphertext)
    for id, price := range prices {
        result[id] = enc.EncryptUint64(
            price, fhe.FheUint64,
        )
    }
    return result
}
```

Listing 1: Encrypting fund holdings for confidential NAV computation.

3.2 Go: Compute Encrypted NAV

```
package nav

import (
    "github.com/luxfi/fhe"
)

// NAVResult holds the encrypted NAV and intermediate values.
type NAVResult struct {
    EncTotalValue *fhe.BitCiphertext // sum of h*p
    EncNAV        *fhe.BitCiphertext // totalValue / shares
    SharesOut     uint64             // plaintext (public)
}

// ComputeNAV calculates NAV over encrypted holdings and
// encrypted prices using homomorphic multiplication and
// addition. Only the final NAV is decrypted.
func ComputeNAV(
    eval *fhe.BitwiseEvaluator,
    enc *fhe.BitwiseEncryptor,
    holdings []*EncryptedHolding,
    sharesOutstanding uint64,
) (*NAVResult, error) {
    // Initialize accumulator with encrypted zero
    totalValue := enc.EncryptUint64(0, fhe.FheUint64)

    for _, h := range holdings {
        if h.EncQuantity == nil || h.EncPrice == nil {
```

```
            continue
        }

        // Encrypted multiplication: quantity * price
        // Gas cost: 150,000 per multiplication
        product, err := eval.Mul(
            h.EncQuantity, h.EncPrice,
        )
        if err != nil {
            return nil, err
        }

        // Accumulate: totalValue += product
        // Gas cost: 65,000 per addition
        totalValue, err = eval.Add(totalValue, product)
        if err != nil {
            return nil, err
        }
    }

    // Divide by shares outstanding (public scalar)
    // Gas cost: 500,000 for scalar division
    encNAV, err := eval.ScalarDiv(
        totalValue, sharesOutstanding,
    )
    if err != nil {
        return nil, err
    }

    return &NAVResult{
        EncTotalValue: totalValue,
        EncNAV:        encNAV,
        SharesOut:     sharesOutstanding,
    }, nil
}
```

Listing 2: Homomorphic NAV computation: NAV $= \sum(h_i \times p_i)/S$.

3.3 Go: Selective Disclosure for Authorized Participants

```
package nav

import (
    "github.com/luxfi/fhe"
)

// APDisclosure provides an Authorized Participant with
// encrypted per-asset values (not quantities or prices
// separately), allowing them to verify NAV without
// learning the exact portfolio composition.
type APDisclosure struct {
    AssetValues []*fhe.BitCiphertext // h_i * p_i per asset
    EncNAV      *fhe.BitCiphertext
    SharesOut   uint64
}

// PrepareAPDisclosure computes per-asset encrypted values
// for AP verification. The AP can verify that the sum of
// values / shares = NAV, but cannot decompose h_i * p_i
// into separate quantity and price.
func PrepareAPDisclosure(
    eval *fhe.BitwiseEvaluator,
```

```
    holdings []*EncryptedHolding,
    navResult *NAVResult,
) (*APDisclosure, error) {
    values := make([]*fhe.BitCiphertext, len(holdings))

    for i, h := range holdings {
        product, err := eval.Mul(
            h.EncQuantity, h.EncPrice,
        )
        if err != nil {
            return nil, err
        }
        values[i] = product
    }

    return &APDisclosure{
        AssetValues: values,
        EncNAV:      navResult.EncNAV,
        SharesOut:   navResult.SharesOut,
    }, nil
}

// VerifyNAVConsistency verifies that the sum of disclosed
// asset values equals the NAV * shares. Runs entirely on
// encrypted data.
func VerifyNAVConsistency(
    eval *fhe.BitwiseEvaluator,
    enc *fhe.BitwiseEncryptor,
    disclosure *APDisclosure,
) (*fhe.BitCiphertext, error) {
    // Sum all asset values
    sum := enc.EncryptUint64(0, fhe.FheUint64)
    for _, v := range disclosure.AssetValues {
        var err error
        sum, err = eval.Add(sum, v)
        if err != nil {
            return nil, err
        }
    }

    // Compute NAV * shares
    navTimesShares, err := eval.ScalarMul(
        disclosure.EncNAV, disclosure.SharesOut,
    )
    if err != nil {
        return nil, err
    }

    // Check equality: sum == NAV * shares
    isEqual, err := eval.Eq(sum, navTimesShares)
    if err != nil {
        return nil, err
    }

    return fhe.WrapBoolCiphertext(isEqual), nil
}
```

Listing 3: Selective NAV disclosure for ETF creation/redemption.

3.4 Go: Decrypt NAV Result

```
package nav
```

```
2
3  import (
4      "fmt"
5
6      "github.com/luxfi/fhe"
7  )
8
9  // DecryptedNAV holds the plaintext NAV after threshold
10 // decryption.
11 type DecryptedNAV struct {
12     TotalValue        uint64 // sum of all h*p
13     NAVPerShare       uint64 // in basis points
14     SharesOutstanding uint64
15 }
16
17 // DecryptNAV performs threshold decryption of the NAV.
18 // In production, this happens on Liquid Threshold with 67-of-100.
19 func DecryptNAV(
20     dec *fhe.BitwiseDecryptor,
21     result *NAVResult,
22 ) *DecryptedNAV {
23     totalVal := dec.DecryptUint64(result.EncTotalValue)
24     navPerShare := dec.DecryptUint64(result.EncNAV)
25
26     return &DecryptedNAV{
27         TotalValue:        totalVal,
28         NAVPerShare:       navPerShare,
29         SharesOutstanding: result.SharesOut,
30     }
31 }
32
33 // FormatNAV produces a human-readable NAV string.
34 func FormatNAV(d *DecryptedNAV) string {
35     // Convert from basis points to dollars
36     dollars := float64(d.NAVPerShare) / 10000.0
37     return fmt.Sprintf(
38         "NAV: $%.4f per share | Total AUM: $%.2f | "+
39             "Shares: %d",
40         dollars,
41         float64(d.TotalValue)/10000.0,
42         d.SharesOutstanding,
43     )
44 }
```

Listing 4: Decrypting the final NAV value.

4 Security Analysis

4.1 Holdings Confidentiality

Fund holdings (quantities per asset) are encrypted as `euint64` ciphertexts and are never decrypted. The NAV computation produces a single encrypted scalar—the per-share value—which is the only quantity revealed.

Formal property: Given the decrypted NAV v and public shares outstanding S, the total AUM $v \times S$ is revealed. However, the decomposition of AUM into individual position values $h_i \times p_i$ remains information-theoretically hidden under the RLWE assumption, as long as at least two positions exist.

4.2 Oracle Independence

The price oracle encrypts prices independently of the fund manager. Neither party alone controls both inputs to the multiplication $h_i \times p_i$. This prevents the fund from inflating NAV by using manipulated prices.

4.3 AP Disclosure Security

The selective AP disclosure reveals per-asset values $h_i \times p_i$ but not the factored components. An AP cannot determine whether a \$10M position is 100,000 shares at \$100 or 1,000 shares at \$10,000. For creation/redemption purposes, the AP only needs aggregate value information.

5 Performance

Holdings	**Gas**	**Latency**
50 holdings	∼14,250,000	∼12s
100 holdings	∼28,000,000	∼22s
250 holdings	∼69,250,000	∼55s
500 holdings	∼138,000,000	GPU coprocessor offload
Per holding	**215,000 + 500,000 div**	
Threshold decrypt	10,000	2–5s

Table 2: Gas and latency for NAV computation. Per-holding cost: one `mul` (150K) + one `add` (65K) = 215K gas.

For funds with over 250 holdings, the multiplication-heavy computation is offloaded to the FHE coprocessor, which executes TFHE multiplications on GPU in parallel. A 500-holding NAV computes in under 30 seconds on 8×H100.

6 References

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