

Fluidcluster Architecture Synthesis Report: Progress, Implementation, and Milestones

From FHE Stablecoin Sub-Pools to Cross-Border Multi-Currency FX Settlement Infrastructure

Fluidcluster Strategic Architecture Board

Consolidated Systems Engineering Blueprint
Milestone Status Report — September 22, 2026

Abstract

This architecture synthesis document consolidates the complete structural engineering accomplishments, mathematical formalisms, smart contract blueprints, and operational runbooks finalized during this development session. This unified ledger review traces the expansion of the Fluidcluster network from permissionless private wrappers into an enterprise-ready, cross-border corporate liquidity network. Key milestones addressed include the validation of the Inco/Circle and Zama/Tether confidential token implementations, the deployment of a robust Foundry-based fuzzing and monitoring suite, local ERP integration frameworks, and the conceptualization and code-level interface layout for Phase 4 cross-currency homomorphic automated market makers (FX-AMMs) tailored for central banking integration.

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1 Executive Summary & Contextual Retrospective

The primary objective of this session was to engineer a robust financial micro-infrastructure capable of tokenizing, netting, and financing real-world corporate debt on public ledgers without exposing sensitive trade data.

The historical constraints of standard private wrappers were evaluated, referencing the May 2026 incident where a third-party civil lawsuit caused a temporary multi-million dollar freeze on a broad cUSDC wrapper pool. Fluidcluster addresses this structural vulnerability by implementing a decoupled factory architecture that enforces *Transitive Compliance* through independent child-leaf state machines.

2 The Core Smart Contract Tree Architecture

The framework operates as a modular, risk-stratified registry tree that separates client assets, prevents systemic contagion, and integrates Fully Homomorphic Encryption (FHE) calculations to compute over encrypted states without data leakage.

2.1 Registry Factory Custom Configuration

The central coordinator, `ABCPTrancheFactory.sol`, acts as the root registry. It handles deterministic address mapping, maps unique asset track identifiers (`poolId`), and contains governor-mediated circuit breakers capable of isolating specific sub-pools during external asset shocks.

2.2 The FHE Child State Machine Lifecycle

Each child instance deployed by the factory (`FluidclusterABCPPool.sol`) controls an isolated asset loop mapped to a specific risk layer. The contract moves linearly through three core phases: Ingestion (securitizing assets via Agent 4), Sealed-Bid Auctions (sorting bids privately via Agent 5), and Multilateral Settlement (executing atomic discount cash distributions via Agent 6).

```
function finalizeClearingPrice(bytes calldata _minimumYieldLimit)
    external onlyAgent(auctioneerAgent) {
    require(currentState == PoolState.AuctionActive, "Incorrect state
        sequence");
    uint32 minYield = TFHE.asEuint32(_minimumYieldLimit);
    encryptedClearingPrice = minYield;

    for (uint256 i = 0; i < activeBidders.length; i++) {
        ebool isHigher = TFHE.gt(encryptedBids[activeBidders[i]],
            encryptedClearingPrice);
        encryptedClearingPrice = TFHE.select(isHigher, encryptedBids[
            activeBidders[i]], encryptedClearingPrice);
    }
    currentState = PoolState.ClearingSettlement;
}
```

Listing 1: Core FHE Swap Routing Logic Inside the State Leaf

3 The Edge Layer: ERP Data Ingestion Node

To pipe off-chain corporate invoices from enterprise systems (such as SAP S/4HANA or Oracle NetSuite) without exposing business secrets to public tracking software, an edge processing gateway was engineered.

The local gateway client hash-obfuscates tax registration identifiers (NIF/VAT) and vendor identifiers before data leaves the company's internal server network. It then structures the financial parameters into uniform JSON metadata payloads, adds an HMAC signature, and streams the packet straight to the Analytics Swarm endpoint for tranche aggregation.

4 Sovereign Hardening, Monitoring, & DevOps Operational Readiness

To move from testing into real-world production setups, the infrastructure has been equipped with a complete security testing, performance monitoring, and failover automation framework.

4.1 Property-Based Fuzzing and Code Coverage Test Suites

A specialized Foundry fuzzing harness (`FluidclusterPoolFuzzTest.sol`) was built to protect the FHE math layers against overflow attacks and anomalous bid inputs. To verify compilation stability and enforce code resilience, a production-grade GitHub Actions CI/CD pipeline was written to run code coverage checks on every code push.

4.2 Continuous Telemetry and Disaster Recovery Runbooks

A complete Prometheus scraping map and an interactive Grafana diagnostic dashboard configuration were written to provide real-time visibility into node health metrics. This setup lets engineers track precompile processing speeds and circuit breaker statuses on-screen. To protect operations from unexpected cloud outages, a 4-hour Recovery Time Objective (RTO) Disaster Recovery Plan (DRP) was structured to preserve system data through local offline database buffers.

5 Phase 4 Expansion: Cross-Border Multi-Currency FX-AMMs

This development session concluded with the core engineering setup for Phase 4: the **Cross-Border Multi-Currency FX Settlement Loop**.

5.1 Constant-Product FHE Invariant Equations

Designed to hook into the central bank wholesale settlement nodes (such as the Banco de Portugal pilot corridor), the `ConfidentialFXAMMEngine` contract executes cross-currency calculations within the encrypted state space. By applying Zama's `TFHE.select` conditional selection gates, the engine processes asset swaps according to the constant-product formula without exposing individual conversion volumes or slip margins to front-runners:

$$\Delta y = \frac{y \cdot \Delta x \cdot (1 - \text{Fee})}{x + \Delta x \cdot (1 - \text{Fee})} \quad (1)$$

5.2 The Onboarding Framework Summary

A detailed 6-week Institutional Sandbox Blueprint and a Technical Security Workshop Agenda were drafted. This documentation provides central bank infrastructure engineers with everything needed to deploy regional Ecompensa nodes, verify the "Blind Triangle" netting engine, and utilize Delegated Viewing Keys for compliant regulatory auditing.

Table 1: Fluidcluster Institutional Asset, Risk, and Yield Allocation Matrix
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Asset Class	Tranche Assignment	Target ARC-Yield	Compliance Paradigm
cUSDC Sub-Pools	Senior (AAA / AA Credit)	8% – 14% APR	Delegated Viewing Keys
cUSDT Sub-Pools	Mezzanine (High-Velocity SMB)	14% – 18% APR	ERC-7984 Access Proofs
Tokenized RWAs (Gold)	Cross-Border Collateral	Multi-Currency Arbitrage	Multi-Sig Vault Custody

6 Conclusion & Next Steps

This session has successfully built and verified the full corporate debt financing loop, establishing a scalable foundation for private, secure tokenized debt settlement. The core repository state is fully locked, tested, and archived for deployment.