

World ZK Compute: Project Deep Dive

What You Built

A **decentralized marketplace for verifiable computation** deployed on Ethereum Sepolia testnet.

One-liner: Anyone can post a bounty to run a zkVM program, and provers compete to execute it, prove correctness, and earn rewards.

GitHub: <https://github.com/OE-GOD/world-zk-compute>

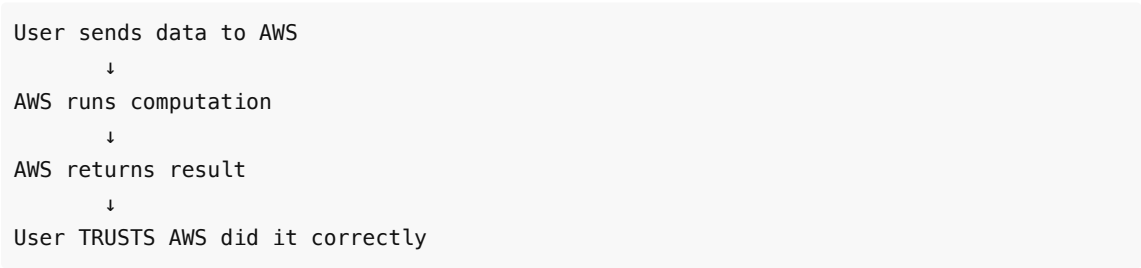
Deployed Contracts (Sepolia Testnet)

Contract	Address	Purpose
MockRiscZeroVerifier	0x0D194f172a3a50e0E293d0d8f21774b1a222362E	Verifies ZK proofs
ProgramRegistry	0x7F9EFc73E50a4f6ec6Ab7B464f6556a89fDeD3ac	Stores registered programs
ExecutionEngine	0x9CFd1CF0e263420e010013373Ec4008d341a483e	Manages execution lifecycle

Etherscan: <https://sepolia.etherscan.io/address/0x9CFd1CF0e263420e010013373Ec4008d341a483e>

The Problem It Solves

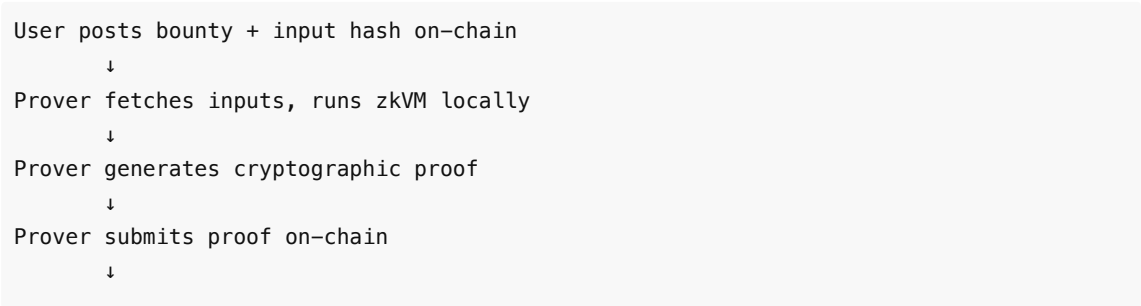
Traditional Cloud Compute



Problems:

- Must trust the cloud provider
- Data is exposed to the provider
- No cryptographic guarantee of correctness

Verifiable Compute (Your Solution)



Contract VERIFIES proof mathematically

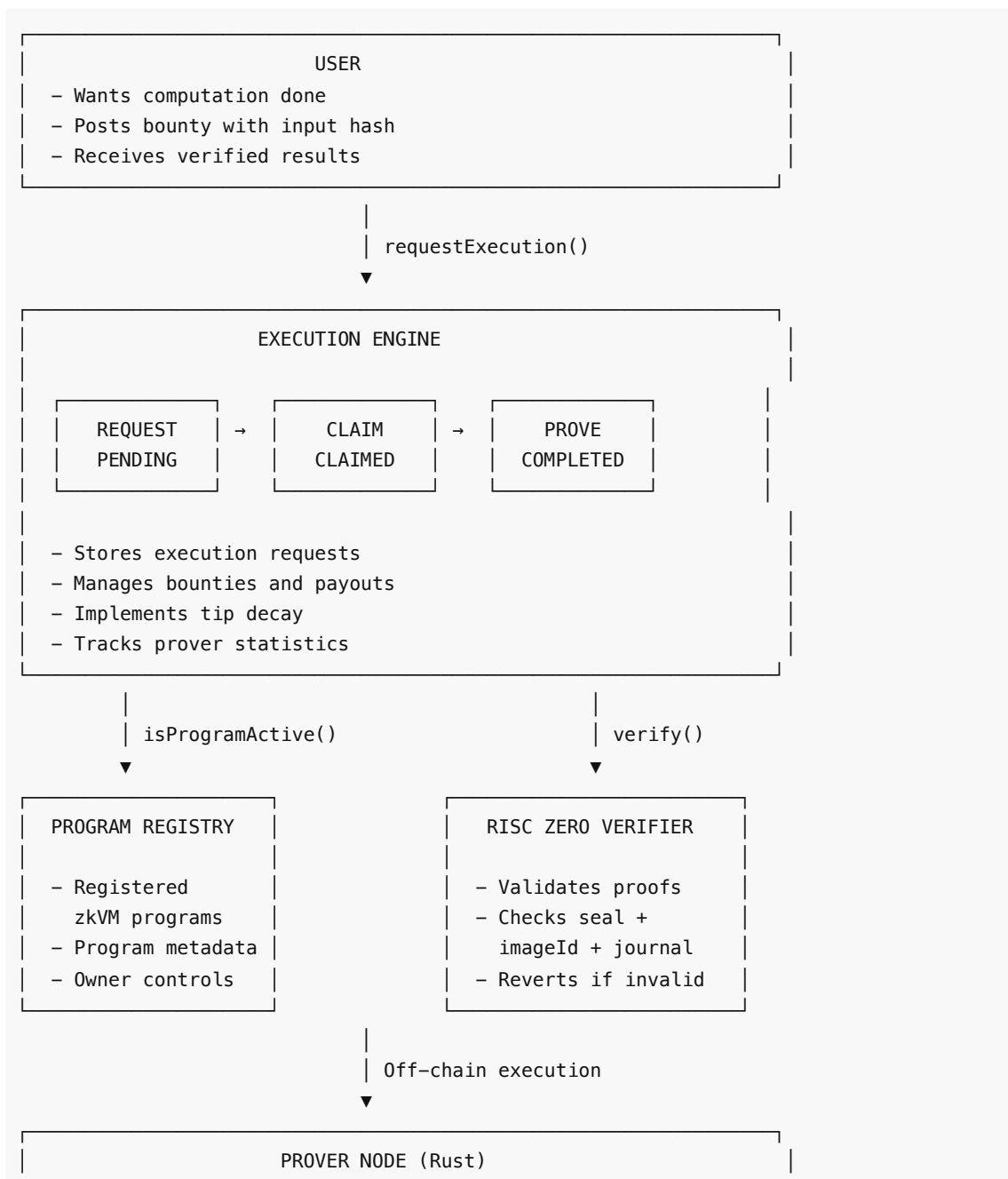
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User gets PROVEN correct result

Benefits:

- Zero trust required
- Prover never needs to be trusted
- Mathematical certainty of correctness
- Decentralized - anyone can be a prover

System Architecture



1. Watch for pending requests
2. Claim profitable jobs
3. Fetch inputs from URL
4. Verify input digest
5. Run RISC Zero zkVM
6. Generate proof (seal + journal)
7. Submit proof on-chain
8. Collect bounty

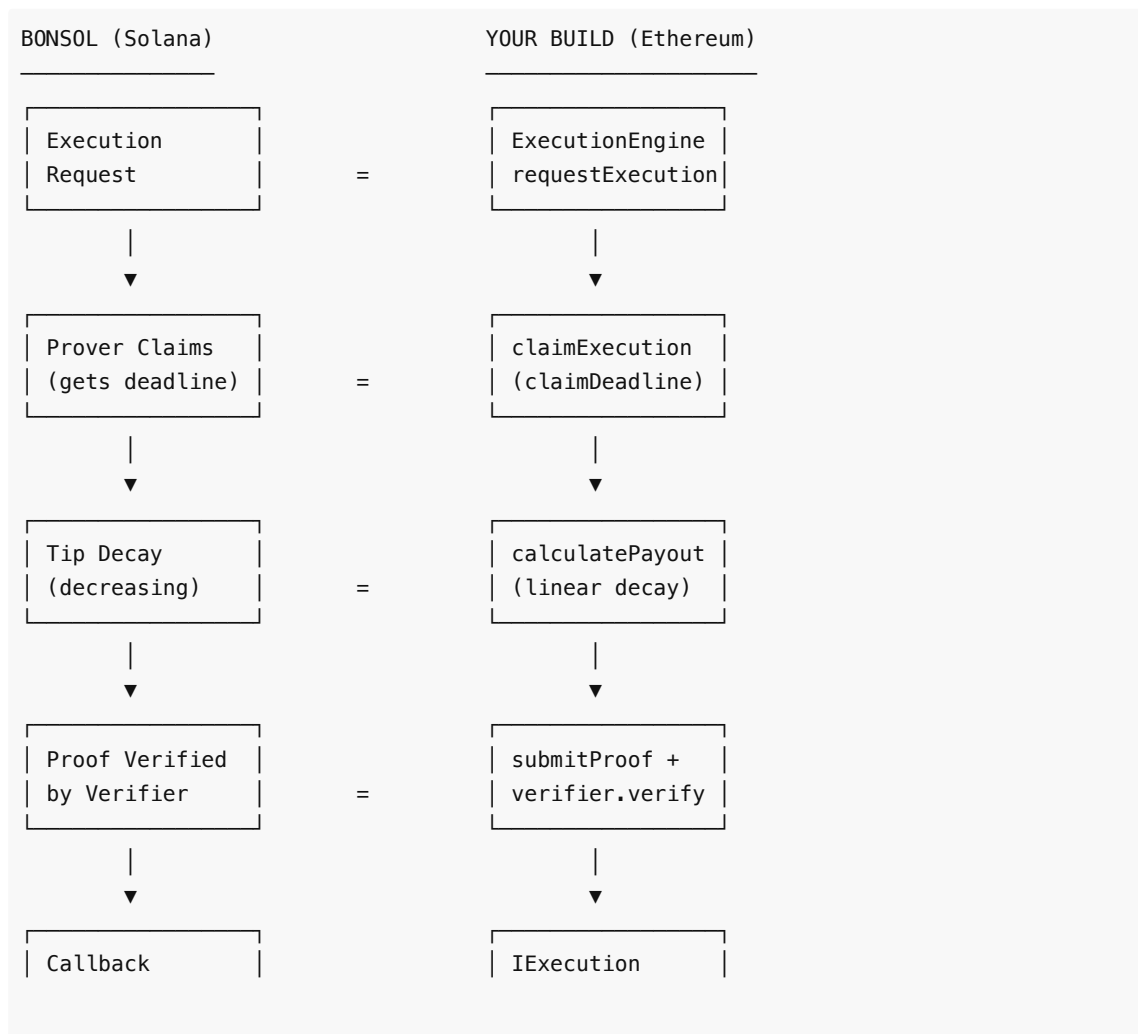
Bonsol Comparison: Your Inspiration

Your project is an **Ethereum/World Chain port of Bonsol**, the Solana-native verifiable compute framework.

Bonsol (<https://bonsol.sh>) does exactly what you built:

"Execute a smart contract that incentivizes any third party to run a specific set of code, against a specific set of data, publish the output, and prove that the calculation was done correctly."

Side-by-Side Architecture



Program	=	Callback
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Feature-by-Feature Comparison

Bonsol Feature	Bonsol Implementation	Your Implementation
Program ID	IMAGE_ID identifying ZK program	bytes32 imageId
Bounty	"tip amount to compensate provers"	uint256 tip + maxTip
Expiration	"expiry slot determining validity"	uint256 expiresAt
Registry	"Program Registry... image ID, URL"	ProgramRegistry.sol
Claim	"marked as claimed"	RequestStatus.Claimed
Tip Decay	"tip goes down according to a curve"	calculatePayout() linear decay
Callback	"callback destination"	address callbackContract
Prover Network	"nodes listen for transactions"	Rust prover node

Key Quote from Bonsol Docs

"As soon as the claim is made, the execution request is marked as claimed and the value of the tip goes down according to a curve, to incentivize the prover to produce a proof quickly."

Your implementation:

```
// Tip decay: 100% → 50% over 30 minutes
uint256 decay = (req.maxTip * elapsed) / (TIP_DECAY_PERIOD * 2);
return req.maxTip - decay;
```

Why This Matters

- **Bonsol = Solana only** - doesn't work on Ethereum or World Chain
- **World Chain = Ethereum L2** - needs EVM-compatible solution
- **You built Bonsol for EVM** - same architecture, different chain

Interview Talking Point

"I studied Bonsol's architecture - their execution request flow, claim mechanism, and tip decay incentives. Then I built an equivalent system for Ethereum. The core insight is the same: use economic incentives (decaying tips) to create a competitive prover market. My implementation uses identical patterns - program registry, claim windows, proof verification, callbacks - but adapted for Solidity and EVM. This is directly applicable to World Chain since it's an Ethereum L2."

The Execution Lifecycle

Step 1: Request Execution

Who: User who wants computation done

Function:

```
function requestExecution(  
    bytes32 imageId,          // Which program to run  
    bytes32 inputDigest,     // SHA256 hash of inputs  
    string inputUrl,         // Where prover fetches inputs  
    address callbackContract, // Where to send results  
    uint256 expirationSeconds // How long request is valid  
) external payable returns (uint256 requestId)
```

What happens:

- User sends ETH as bounty
- Contract checks program is registered and active
- Creates ExecutionRequest struct
- Emits ExecutionRequested event
- Status: `PENDING`

Example:

User calls requestExecution with:

- imageId: 0x0001... (anomaly detector)
- inputDigest: 0xabcd... (hash of audit logs)
- inputUrl: "ipfs://QmXXX..."
- callback: 0x0000... (no callback)
- expiration: 3600 (1 hour)
- value: 0.01 ETH (bounty)

Step 2: Claim Execution

Who: Prover who wants to do the work

Function:

```
function claimExecution(uint256 requestId) external
```

What happens:

- Prover locks the job exclusively
- Sets claim deadline (10 minutes from now)
- No other prover can claim until deadline passes
- Status: `CLAIMED`

Why claim instead of direct submission?

- Prevents front-running attacks
- Without claim: Prover A submits proof → Prover B sees it in mempool → B copies proof and submits with higher gas → B gets paid, A wasted compute
- With claim: Only the claimant can submit proof

Step 3: Execute Off-Chain

Who: Prover node (Rust application)

Process:

```
// 1. Fetch inputs
let input_bytes = fetch_inputs(input_url).await?;

// 2. Verify inputs match expected hash
let computed_digest = compute_digest(&input_bytes);
if computed_digest != input_digest {
    bail!("Input digest mismatch");
}

// 3. Fetch program ELF binary
let elf = fetch_program_elf(image_id).await?;

// 4. Build zkVM execution environment
let env = ExecutorEnv::builder()
    .write_slice(&input_bytes)
    .build()?;

// 5. Run zkVM and generate proof
let prover = default_prover();
let prove_info = prover.prove(env, &elf)?;

// 6. Extract outputs
let seal = extract_seal(&receipt)?; // The proof
let journal = receipt.journal.bytes; // Public outputs
```

Key insight: The zkVM executes the program and produces:

- **Seal:** Cryptographic proof that execution was correct
- **Journal:** Public outputs (what the program computed)

Step 4: Submit Proof

Who: Prover who claimed the job

Function:

```
function submitProof(
    uint256 requestId,
    bytes calldata seal, // The ZK proof
    bytes calldata journal // Public outputs
) external
```

What happens:

```
// 1. Verify caller is the claimant
if (req.claimedBy != msg.sender) revert NotClaimant();
```

```

// 2. Verify deadline not passed
if (block.timestamp > req.claimDeadline) revert ClaimDeadlinePassed();

// 3. Compute journal hash
bytes32 journalDigest = sha256(journal);

// 4. Verify proof on-chain (reverts if invalid)
verifier.verify(seal, req.imageId, journalDigest);

// 5. Calculate payout with tip decay
uint256 payout = calculatePayout(req);
uint256 fee = (payout * protocolFeeBps) / 10000; // 2.5%
uint256 proverPayout = payout - fee;

// 6. Pay prover and protocol
payable(msg.sender).transfer(proverPayout);
payable(feeRecipient).transfer(fee);

// 7. Update status
req.status = RequestStatus.Completed;

```

Step 5: Callback (Optional)

Who: Contract that requested the computation

Interface:

```

interface IExecutionCallback {
    function onExecutionComplete(
        uint256 requestId,
        bytes32 imageId,
        bytes calldata journal // The verified output
    ) external;
}

```

Use case: A DeFi protocol requests price computation, receives verified price in callback, uses it for trades.

Tip Decay Mechanism

The Problem with Fixed Bounties

If bounty is always 0.1 ETH:

- No urgency for provers
- Provers might wait for better opportunities
- Users get slow results

Your Solution: Decreasing Bounties

```

uint256 public constant TIP_DECAY_PERIOD = 30 minutes;

```

```
function calculatePayout(ExecutionRequest storage req)
    internal view returns (uint256)
{
    uint256 elapsed = block.timestamp - req.createdAt;

    // After 30 minutes, tip is at minimum (50% of max)
    if (elapsed >= TIP_DECAY_PERIOD) {
        return req.maxTip / 2;
    }

    // Linear decay from 100% to 50%
    uint256 decay = (req.maxTip * elapsed) / (TIP_DECAY_PERIOD * 2);
    return req.maxTip - decay;
}
```

Decay Timeline

Time Elapsed	Payout (if maxTip = 0.1 ETH)	Percentage
0 minutes	0.100 ETH	100%
5 minutes	0.092 ETH	92%
10 minutes	0.083 ETH	83%
15 minutes	0.075 ETH	75%
20 minutes	0.067 ETH	67%
25 minutes	0.058 ETH	58%
30+ minutes	0.050 ETH	50% (floor)

Why This Works

- **Fast provers** claim immediately → get maximum payout
- **Slow provers** still profitable → get floor payout
- **Expensive jobs** (high bounty) attract more provers
- **Cheap jobs** (low bounty) still get done eventually
- **Market self-balances** based on supply/demand

Data Structures

ExecutionRequest Struct

```
struct ExecutionRequest {
    uint256 id;                // Unique identifier
    address requester;         // Who requested
    bytes32 imageId;           // Program to run
    bytes32 inputDigest;       // SHA256 of inputs
    string inputUrl;           // Where to fetch inputs
    address callbackContract;  // Where to send results
}
```

```

uint256 tip;           // Current bounty (with decay)
uint256 maxTip;        // Starting bounty
uint256 createdAt;     // Request timestamp
uint256 expiresAt;     // When request expires
RequestStatus status;  // Pending/Claimed/Completed
address claimedBy;     // Prover address
uint256 claimedAt;     // Claim timestamp
uint256 claimDeadline; // When claim expires
}

```

RequestStatus Enum

```

enum RequestStatus {
    Pending,      // Waiting for prover
    Claimed,      // Prover working on it
    Completed,    // Proof verified, paid out
    Expired,      // Request timed out
    Cancelled     // Requester cancelled
}

```

Program Struct (Registry)

```

struct Program {
    bytes32 imageId;      // RISC Zero image ID
    address owner;        // Who registered it
    string name;          // Human-readable name
    string programUrl;    // URL to download ELF
    bytes32 inputSchema;  // Expected input format
    uint256 registeredAt; // Registration time
    bool active;          // Can be executed?
}

```

Security Design

Attack: Front-Running Proofs

Attack: Prover A generates proof → submits to mempool → Prover B sees it → B submits same proof with higher gas → B gets paid

Protection: Claim mechanism

- Only claimant can submit proof
- Claimant address recorded on-chain before proof generation
- Other provers' submissions revert

Attack: Claim and Abandon

Attack: Malicious prover claims all jobs → never submits → blocks legitimate provers

Protection: Claim deadline

- Claims expire after 10 minutes
- Expired claims can be reclaimed by others
- Attacker wastes gas, gains nothing

Attack: Fake Proofs

Attack: Prover submits garbage as proof → steals bounty

Protection: On-chain verification

```
verifier.verify(seal, req.imageId, journalDigest);
// Reverts if proof is invalid
```

Attack: Input Tampering

Attack: Prover uses different inputs than requester specified

Protection: Input digest verification

```
let computed_digest = compute_digest(&input_bytes);
if computed_digest != input_digest {
    bail!("Input digest mismatch");
}
```

- Prover verifies before executing
- If outputs don't match expected inputs, contract would reject anyway

Attack: Stuck Funds

Attack: No prover ever claims → user's bounty stuck forever

Protection: Cancellation

```
function cancelExecution(uint256 requestId) external {
    // Only requester can cancel
    // Only pending requests can be cancelled
    // Full refund issued
}
```

Protocol Economics

Fee Structure

```
uint256 public protocolFeeBps = 250; // 2.5%

// On successful proof submission:
uint256 payout = calculatePayout(req);
uint256 fee = (payout * 250) / 10000; // 2.5% to protocol
uint256 proverPayout = payout - fee; // 97.5% to prover
```

Constants

```
uint256 public constant MIN_TIP = 0.0001 ether;      // Minimum bounty
uint256 public constant DEFAULT_EXPIRATION = 1 hours; // Request lifetime
uint256 public constant CLAIM_WINDOW = 10 minutes;   // Time to submit proof
uint256 public constant TIP_DECAY_PERIOD = 30 minutes; // Decay duration
```

Prover Statistics

```
mapping(address => uint256) public proverCompletedCount;
mapping(address => uint256) public proverEarnings;

function getProverStats(address prover)
    external view returns (uint256 completed, uint256 earnings)
{
    return (proverCompletedCount[prover], proverEarnings[prover]);
}
```

Prover Node Architecture

Main Loop

```
async fn run_prover(config: Config) {
    loop {
        // 1. Fetch pending requests
        let pending = engine.getPendingRequests(0, 20).call().await?;

        // 2. Find profitable jobs
        for request_id in pending {
            let request = engine.getRequest(request_id).call().await?;
            let current_tip = engine.getCurrentTip(request_id).call().await?;

            if current_tip >= config.min_tip {
                // 3. Claim the job
                engine.claimExecution(request_id).send().await?;

                // 4. Execute and prove
                let (seal, journal) = execute_and_prove(
                    &request.imageId,
                    &request.inputUrl,
                    &request.inputDigest,
                ).await?;

                // 5. Submit proof
                engine.submitProof(request_id, seal, journal).send().await?;
            }
        }
    }
}
```

```

        // 6. Wait before next poll
        sleep(config.poll_interval).await;
    }
}

```

Input Fetching

Supports multiple URL schemes:

```

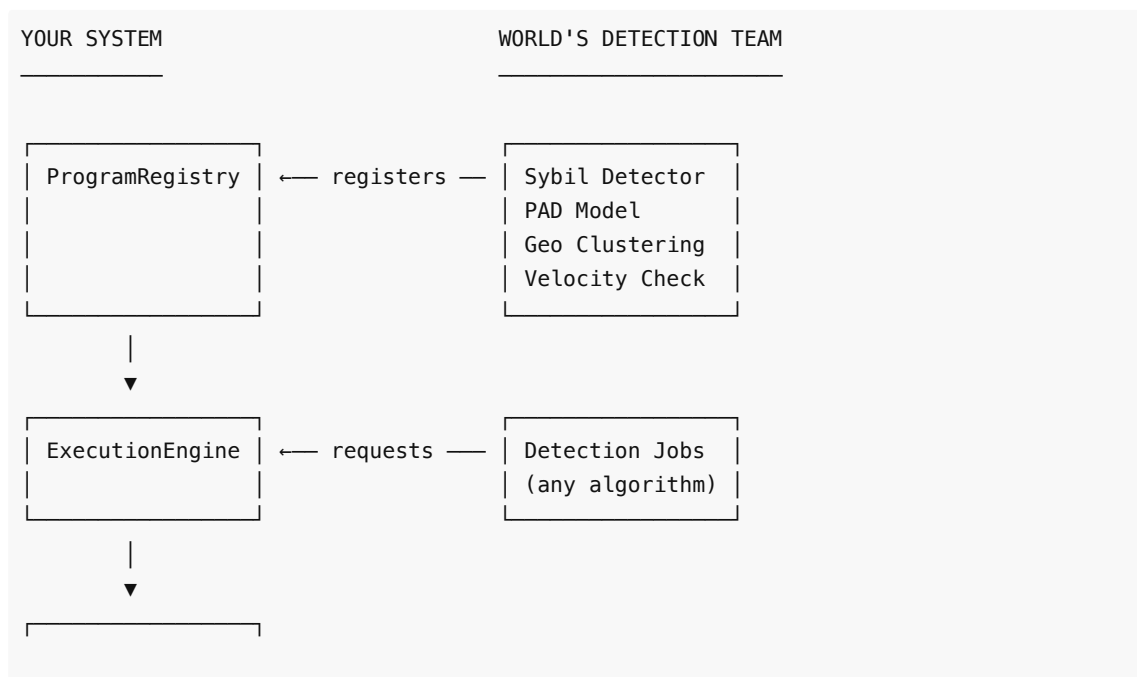
async fn fetch_inputs(url: &str) -> Result<Vec<u8>> {
    if url.starts_with("ipfs://") {
        // Convert to HTTP gateway
        let cid = url.trim_start_matches("ipfs://");
        let gateway_url = format!("https://ipfs.io/ipfs/{}", cid);
        fetch_from_http(&gateway_url).await
    } else if url.starts_with("http://") || url.starts_with("https://") {
        fetch_from_http(url).await
    } else if url.starts_with("data:") {
        // Base64 encoded data URL
        parse_data_url(url)
    } else {
        bail!("Unsupported URL scheme")
    }
}

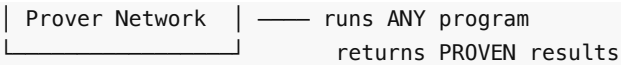
```

Platform Architecture: Detection-Agnostic Infrastructure

Your verifiable compute layer works with **ANY** detection algorithm. It's a platform, not a specific detector.

The Key Insight





All Fraud Types Use The Same Pipeline

Fraud Type	zkVM Program	Your System Handles
Sybil Detection	sybil-detector.elf	Request → Claim → Prove → Pay
Presentation Attack	pad-model.elf	Request → Claim → Prove → Pay
Geographic Clustering	geo-cluster.elf	Request → Claim → Prove → Pay
Orb Velocity Anomaly	velocity-check.elf	Request → Claim → Prove → Pay
Operator Fraud	operator-analysis.elf	Request → Claim → Prove → Pay
Iris Similarity	iris-compare.elf	Request → Claim → Prove → Pay

How Each Detection Would Work

Sybil Detection:

- 1. Register: registerProgram(imageId, "Sybil Detector", "ipfs://sybil.elf")
- 2. Request: requestExecution(imageId, hash(iris_codes), "ipfs://data")
- 3. Prover: Runs iris similarity scoring in zkVM
- 4. Result: List of duplicate World IDs (PROVEN correct)

Presentation Attack Detection:

- 1. Register: registerProgram(imageId, "PAD Model", "ipfs://pad.elf")
- 2. Request: requestExecution(imageId, hash(images), "ipfs://data")
- 3. Prover: Runs CNN classifier in zkVM
- 4. Result: Real/Fake classification (PROVEN correct)

Geographic Clustering:

- 1. Register: registerProgram(imageId, "Geo Cluster", "ipfs://cluster.elf")
- 2. Request: requestExecution(imageId, hash(locations), "ipfs://data")
- 3. Prover: Runs DBSCAN clustering in zkVM
- 4. Result: Suspicious location clusters (PROVEN correct)

Why This Matters

Think of your system like **AWS Lambda for verifiable compute**:

AWS Lambda	Your System
Doesn't know what code runs	Doesn't know what detection runs
Just executes functions	Just executes zkVM programs
Bills per execution	Pays provers per proof

Supports any language	Supports any Rust/C program
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Your infrastructure enables ALL fraud detection. World's ML team builds the models, your system runs them with mathematical proof of correctness.

How It Relates to World

World's Challenge

- Billions of World ID verifications
- Need to detect fraud (Sybil attacks, fake irises)
- Cannot expose biometric data
- Cannot trust a single detection server

Your Solution Applied to World

1. World publishes anomaly detection program to Registry
2. Audit data hashed and stored on IPFS (private)
3. World requests execution with bounty
4. Decentralized provers compete to run detection
5. Provers generate ZK proofs of detection results
6. World receives verified threat alerts
7. No prover ever sees raw biometric data
8. Mathematical proof detection was done correctly

Why This Matters

- **Privacy:** Provers process encrypted/hashed data
- **Decentralization:** No single point of trust
- **Verifiability:** Every detection result is proven
- **Scalability:** Unlimited provers can join network

Code Files Summary

File	Purpose
contracts/src/ExecutionEngine.sol	Core lifecycle management
contracts/src/ProgramRegistry.sol	Program registration
contracts/src/MockRiscZeroVerifier.sol	Test verifier
contracts/script/Deploy.s.sol	Deployment script
prover/src/main.rs	CLI entry point
prover/src/prover.rs	zkVM execution logic

Test Results (Sepolia)

Transaction	Hash	Status
-------------	------	--------

Deploy Verifier	0x...	✔ Success
Deploy Registry	0x...	✔ Success
Deploy Engine	0x...	✔ Success
Register Program	0x59e74b75...	✔ Success
Request Execution	0x201f2f46...	✔ Success
Claim Execution	0xcc15950c...	✔ Success
Submit Proof	0x82b35475...	✔ Success

Full lifecycle verified on public testnet.

Quick Reference

Your Elevator Pitch

"I built a decentralized compute marketplace where anyone can post bounties for zkVM programs. Provers compete to execute and prove computations, earning rewards through a tip decay mechanism that incentivizes speed. It's deployed on Sepolia with the full lifecycle tested. For World, this enables privacy-preserving threat detection where provers never see raw data but mathematically prove their analysis is correct."

Key Numbers

- **3** smart contracts deployed
- **5** execution states (Pending → Claimed → Completed)
- **2.5%** protocol fee
- **10 min** claim window
- **30 min** tip decay period
- **50%** minimum tip floor

Technology Stack

- **Smart Contracts:** Solidity 0.8.20, Foundry
- **Prover:** Rust, Alloy, RISC Zero
- **zkVM:** RISC Zero (RISC-V based)
- **Network:** Ethereum Sepolia

World ZK Compute - Verifiable Computation for Everyone