DI Protocol

Decentralized Interoperability

"Bridging the gap between blockchain complexity and mainstream adoption through seamless, gasless interactions that empower users and developers alike."

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MetaTx-Contracts: Gasless Meta-Transaction Infrastructure

Abstract

MetaTx-Contracts presents a production-ready infrastructure for gasless blockchain interactions through meta-transactions with native token support and multi-token gas credit management. This system eliminates the primary barrier to blockchain adoption - the requirement for users to hold native tokens for gas fees - while maintaining security, decentralization, and economic sustainability.

The system comprises two core smart contracts: **MetaTxGateway v1.0.0** for secure meta-transaction execution with native token validation, and **GasCreditVault** for multi-token gas credit management with Chainlink price feed integration. Together, they enable seamless user experiences while providing robust financial protections and scalable architecture.

1. Introduction

1.1 Problem Statement

Blockchain adoption faces a fundamental UX barrier: users must acquire native tokens (ETH, BNB, MATIC) to pay gas fees before interacting with any application. This creates a circular dependency where users need cryptocurrency to use cryptocurrency applications, significantly hindering mainstream adoption.

Current solutions either compromise on security, require complex infrastructure, or lack comprehensive financial protections. The need exists for a production-ready system that:

- Eliminates gas fee requirements for end users
- Maintains blockchain security and decentralization principles
- Provides economic sustainability for relayers
- Offers comprehensive financial protections
- Supports multiple payment methods and tokens

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1.2 Solution Overview

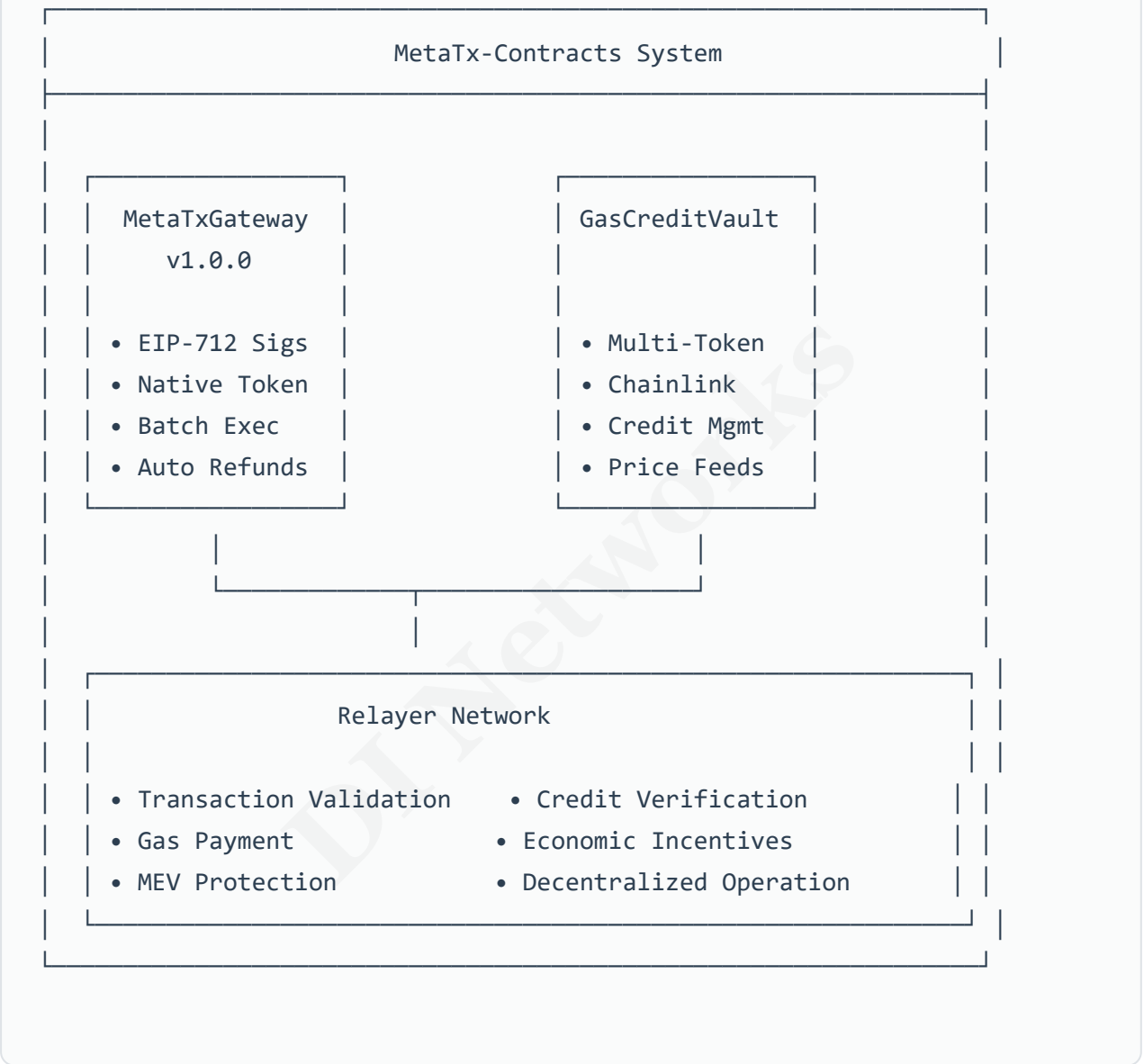
MetaTx-Contracts solves these challenges through a dual-contract architecture:

1. **MetaTxGateway**: Secure meta-transaction execution with native token validation
2. **GasCreditVault**: Multi-token credit system with real-time price feeds

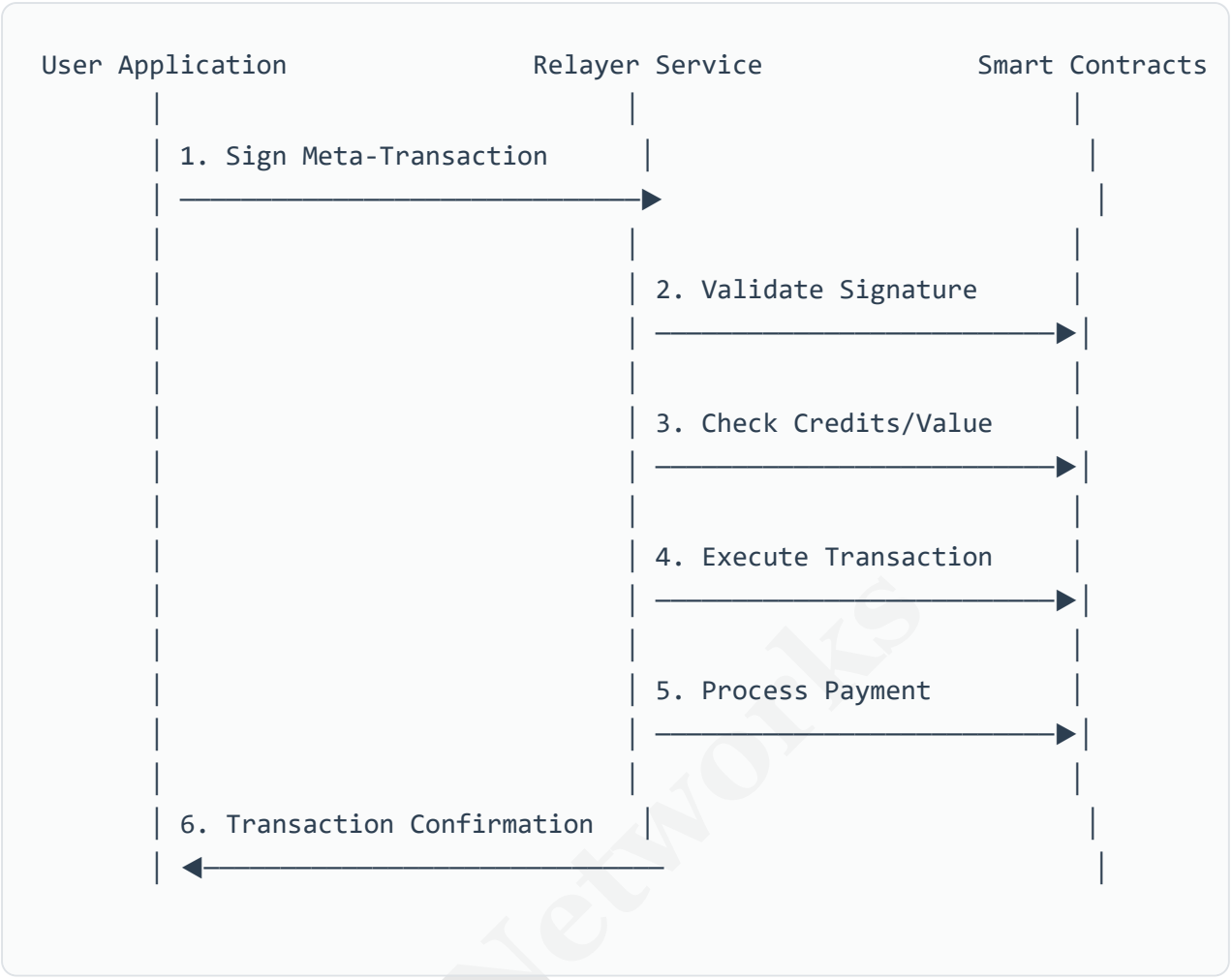
This system enables users to interact with blockchain applications using stablecoins or project tokens while relayers handle gas payments, creating a sustainable economic model with built-in protections.

2. System Architecture

2.1 Core Components



2.2 Transaction Flow



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3. MetaTxGateway v1.0.0

3.1 Core Functionality

The MetaTxGateway serves as the primary execution engine for gasless transactions, implementing EIP-712 signature verification with native token validation and automatic refund mechanisms.

Key Features:

- **Native Token Validation**: Requires exact native token amounts for meta-transactions
- **Automatic Refunds**: Returns unused tokens when transactions fail
- **Batch Processing**: Execute multiple transactions in a single call
- **EIP-712 Signatures**: Secure signature verification with version 2 domain separator
- **UUPS Upgradeable**: Safe proxy pattern for future enhancements

3.2 Technical Implementation

```
struct MetaTransaction {
    address to;        // Target contract
    uint256 value;     // ETH/BNB value
    bytes data;        // Function call data
}

function executeMetaTransactions(
    address from,
    MetaTransaction[] calldata metaTxs,
    bytes calldata signature,
    uint256 nonce,
    uint256 deadline
) external payable nonReentrant whenNotPaused
  returns (bool[] memory successes)
```

3.3 Security Mechanisms

1. **Signature Verification**: EIP-712 typed data signing prevents signature malleability
2. **Nonce Management**: Prevents replay attacks with user-specific nonces
3. **Value Validation**: Exact native token amount requirements prevent over/under-funding
4. **Automatic Refunds**: Failed transactions return unused native tokens
5. **Relayer Authorization**: Only whitelisted relayers can execute transactions

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4. GasCreditVault

4.1 Multi-Token Credit System

The GasCreditVault enables users to deposit various tokens (USDT, USDC, BUSD, project tokens) and receive credits for gas payments, creating a flexible payment system with real-time price conversion.

Supported Token Types:

- **Stablecoins**: 1:1 USD conversion (USDT, USDC, BUSD)
- **Volatile Tokens**: Chainlink price feed integration
- **Project Tokens**: Custom price feeds for ecosystem tokens

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4.2 Credit Management

```
function deposit(address token, uint256 amount) external whenNotPaused {
    require(whitelistedTokens.contains(token), "Token not whitelisted");
    require(amount > 0, "Amount must be > 0");

    IERC20(token).safeTransferFrom(msg.sender, address(this), amount);
    uint256 creditedAmount = calculateCreditValue(token, amount);

    credits[msg.sender] += creditedAmount;
    creditsInToken[msg.sender][token] += creditedAmount;
}
```

5. DI Token Ecosystem

5.1 Token Distribution

Allocation	Amount	Percentage	Purpose
Presale	150M	15%	Public fundraising
Treasury	150M	15%	Protocol development
Liquidity	150M	15%	DEX liquidity provision
Marketing	100M	10%	Growth and adoption
Staking	100M	10%	Validator rewards
Team	50M	5%	Core team allocation
KOL	50M	5%	Key opinion leaders
Airdrop	50M	5%	Community distribution
Ecosystem	200M	20%	Development fund

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6. Security Architecture

6.1 Multi-Layer Security

1. **Smart Contract Security**
    - OpenZeppelin battle-tested contracts
    - Comprehensive access controls
    - Reentrancy protection
    - Integer overflow protection
2. **Cryptographic Security**
    - EIP-712 typed data signing
    - ECDSA signature verification
    - Nonce-based replay protection
    - Domain separator versioning
3. **Economic Security**
    - Chainlink price feed validation
    - Staleness protection (1-hour timeout)
    - Minimum consumption thresholds
    - Automatic refund mechanisms

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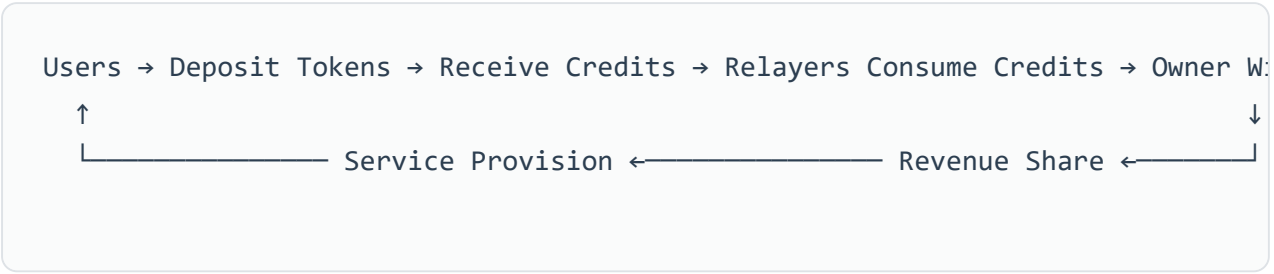
7. Economic Model

7.1 Value Flow



7.2 Fee Structure

- **Credit Consumption**: Minimum 0.05 USD per transaction
- **Dynamic Pricing**: Based on network congestion and token volatility
- **Bulk Discounts**: Lower rates for high-volume users
- **Stablecoin Preference**: Lower fees for stablecoin deposits

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8. Future Roadmap

8.1 Short-term (Q3 2025)

- **Multi-chain Deployment**: Deploy to Ethereum, Polygon, Base, Arbitrum, Optimism, Avalanche (BSC already deployed)
  - MetaTxGateway address (all chains): `0xbee9591415128F7d52279C8df327614d8fD8a9b2`
  - GasCreditVault address (BSC only): `0x0A4467D2D63dB133eC34162Ca0f738948d40A28c`
- **Advanced Relayer Network**: Decentralized relayer coordination
- **Analytics Dashboard**: Real-time system metrics

8.2 Medium-term (Q4 2025)

- **Advanced Governance**: Proposal execution and treasury management
- **MEV Protection**: Flashloan and sandwich attack prevention
- **Cross-Chain Swap and Aggregator**: Gasless meta-transaction powered cross-chain swaps
- **Token Launch Phase**: Start presale, staking, and airdrop sessions

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9. Conclusion

MetaTx-Contracts represents a significant advancement in blockchain UX infrastructure, providing a production-ready solution for gasless transactions with comprehensive financial protections and economic sustainability. The system's dual-contract architecture, robust security mechanisms, and flexible payment options position it as a foundational layer for the next generation of blockchain applications.

By eliminating the gas fee barrier while maintaining security and decentralization, MetaTx-Contracts enables true mainstream blockchain adoption. The integration of native token validation, multi-token credit systems, and governance mechanisms creates a comprehensive ecosystem that benefits all stakeholders.

> **The system is ready for production deployment with extensive documentation, testing, and security features. Its modular architecture and upgrade capabilities ensure long-term viability and adaptability to evolving blockchain infrastructure needs.**

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