

BrainArk Hyperledger Besu Blockchain

A High-Performance Layer 1 Solution

Whitepaper Version 1.1 November 2025 BrainArk Core Team

Abstract

BrainArk represents a revolutionary approach to blockchain technology, delivering unprecedented speed and cost efficiency through innovative consensus mechanisms and optimized network architecture. Built on Hyperledger Besu with Istanbul Byzantine Fault Tolerance (IBFT) consensus, BrainArk achieves sub-2-second block times and transaction costs that are 99.95% lower than Ethereum mainnet, making it the ideal platform for high-frequency applications, DeFi protocols, and enterprise solutions.

The network's ultra-low gas price of 1,000 wei, combined with instant finality and EVM compatibility, enables a new generation of blockchain applications previously impossible due to cost and speed constraints. This whitepaper outlines BrainArk's technical architecture, economic model, and roadmap for becoming the leading blockchain platform for mass adoption.

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1. Introduction

1.1 The Blockchain Trilemma

The blockchain industry faces a fundamental trilemma: achieving scalability, security, and decentralization simultaneously. While first-generation blockchains like Bitcoin prioritized security and decentralization, they sacrificed scalability. Second-generation platforms like Ethereum improved programmability but still struggle with high fees and slow transaction times.

1.2 BrainArk's Innovation

BrainArk emerges as a third-generation blockchain solution that solves these challenges through:

- **Ultra-fast transactions:** 2-second block times with instant finality
- **Minimal costs:** 1,000 wei gas price (99.95% cheaper than Ethereum)
- **Enterprise-grade security:** IBFT consensus with Byzantine fault tolerance
- **Full EVM compatibility:** Seamless migration of existing Ethereum applications
- **Sustainable architecture:** Energy-efficient consensus mechanism

1.3 Vision Statement

To create a blockchain infrastructure that enables mass adoption of decentralized applications by eliminating the barriers of high costs and slow transaction speeds, while maintaining the security and decentralization principles that make blockchain technology revolutionary.

1.4 Mission

BrainArk's mission is to provide developers, enterprises, and users with a blockchain platform that combines the best aspects of existing technologies while introducing innovative solutions for scalability and cost-effectiveness.

2. Problem Statement

2.1 Current Blockchain Limitations

High Transaction Costs

- **Ethereum:** \$2-50 per transaction during peak usage
- **Bitcoin:** \$1-20 during network congestion
- **Impact:** Excludes micropayments and everyday use cases

Slow Transaction Speeds

- **Ethereum:** 15-second blocks, 15 transactions per second (TPS)
- **Bitcoin:** 10-minute blocks, 7 TPS
- **Impact:** Poor user experience for real-time applications

Network Congestion

- **Peak usage:** 10-100x fee spikes during high demand
- **Unpredictable costs:** Makes budgeting for dApps impossible
- **Scalability bottleneck:** Limits ecosystem growth

Energy Consumption

- **Bitcoin:** Consumes 150 TWh annually
- **Environmental impact:** Significant carbon footprint
- **Sustainability concerns:** Not viable for global adoption

2.2 Market Impact

These limitations have created barriers that prevent blockchain technology from achieving mainstream adoption:

- **DeFi Accessibility:** High fees exclude smaller investors
- **Micropayment Markets:** Impossible due to disproportionate transaction costs
- **Gaming Applications:** Poor user experience due to slow confirmations
- **Enterprise Adoption:** Unpredictable costs hinder business planning

3. BrainArk Solution

3.1 Core Innovation: Ultra-Low Cost Architecture

BrainArk introduces a revolutionary cost structure that makes blockchain transactions accessible to everyone:

Gas Price Comparison:

- BrainArk Gas Price: 1,000 wei (0.000000001 BAK)
- Ethereum Gas Price: 20,000,000,000 wei (20 gwei)
- **Cost Reduction: 99.995% lower than Ethereum**

Transaction Cost Analysis

Network	Gas Price	Standard Transfer	DeFi Swap	Contract Deploy
BrainArk	1,000 wei	\$0.000021	\$0.0001	\$0.00004
Ethereum	20 gwei	\$2.10	\$15-50	\$100
BSC	5 gwei	\$0.15	\$0.50	\$10

Polygon	30 gwei	\$0.01	\$0.05	\$2
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3.2 Speed Innovation: Sub-2-Second Finality

- **Block Time:** 2 seconds (consistent)
- **Finality:** Instant (no confirmations needed)
- **No reorganizations:** Eliminates chain reorganization risks
- **Theoretical TPS:** 10,500+ transactions per second
- **Practical TPS:** 1,000+ transactions per second

3.3 Compatibility and Accessibility

- **100% EVM Compatibility:** All Ethereum tools and contracts work seamlessly
- **MetaMask Integration:** Easy wallet connectivity for users
- **Developer Tools:** Full support for Remix, Truffle, Hardhat
- **Web3 Standards:** Complete compatibility with existing dApp interfaces

4. Technical Architecture

4.1 Consensus Mechanism: Istanbul Byzantine Fault Tolerance (IBFT)

IBFT is a practical Byzantine Fault Tolerance consensus algorithm specifically designed for blockchain networks. It provides:

- **Immediate finality:** No need for multiple confirmations
- **Byzantine fault tolerance:** Tolerates up to 1/3 malicious validators
- **Deterministic block production:** Predictable block times
- **Energy efficiency:** No computational waste like Proof of Work

IBFT Consensus Flow

1. **Block Proposal:** Validator proposes a new block 2. **Pre-prepare:** Block is broadcast to all validators 3. **Prepare:** Validators validate and vote on the block 4. **Commit:** Once 2/3+ validators agree, block is committed 5. **Finality:** Block is immediately final upon commitment

4.2 Network Architecture

Current Configuration (Phase 1):

- Validator Node 1: Primary block producer
- Validator Node 2: Secondary validator

- Validator Node 3: Tertiary validator
- Validator Node 4: Quaternary validator

Fault Tolerance:

- Can tolerate 1 Byzantine node (25% failure rate)
- Minimum consensus: 3 out of 4 nodes (75% agreement)

4.3 Hyperledger Besu Foundation

Technology Stack:

- **Java-based implementation:** Robust, battle-tested codebase
- **Modular design:** Pluggable consensus mechanisms
- **Enterprise features:** Privacy, permissioning, monitoring tools
- **100% Ethereum compatibility:** Existing contracts work without modification
- **Developer ecosystem:** Complete toolchain support

Key Advantages:

- Mature, production-ready platform
- Enterprise-grade reliability
- Strong security audit history
- Active development community
- Professional support available

5. Performance Analysis

5.1 Transaction Throughput Comparison

Metric	BrainArk	Ethereum	BSC	Polygon
Block Time	2 seconds	12 seconds	3 seconds	2 seconds
Finality	Instant	12+ minutes	15 seconds	2 seconds
TPS (Practical)	1,000+	12	60	300
TPS (Theoretical)	10,500+	15	160	7,200

5.2 Cost Savings Analysis

Transaction Type Comparisons

Simple Transfer (21,000 gas)

- BrainArk: \$0.00000004
- Ethereum: \$1.00
- **Savings: 99.96%**

DeFi Swap (150,000 gas)

- BrainArk: \$0.0000003
- Ethereum: \$7.50
- **Savings: 99.96%**

Contract Deployment (2,000,000 gas)

- BrainArk: \$0.000004
- Ethereum: \$100
- **Savings: 99.96%**

5.3 Performance Benchmarks

Stress Test Results (Internal Testing):

- Peak TPS achieved: 2,156 transactions/second
- Average block utilization: 65%
- Network latency: <100ms globally
- Uptime: 99.95% (since launch)

6. Economic Model & Tokenomics

6.1 BAK Token Specifications

Core Details:

- **Token Name:** BrainArk (BAK)
- **Token Standard:** Native Currency (Not ERC-20)
- **Total Supply:** 1,000,000,000 BAK (Fixed)
- **Circulating at Launch:** 600,000,000 BAK
- **Decimals:** 18
- **Initial Price:** \$0.02 USD
- **Network:** BrainArk Besu Chain
- **Chain ID:** 1236 (Mainnet)

6.2 Token Distribution Model

Primary Allocation (1,000,000,000 BAK Total):

Network Operations: 985,000,000 BAK (98.5%)

- Validator Rewards Pool: 500,000,000 BAK (50%)
 - Active Circulation: 100,000,000 BAK (10%) - **Time-Locked Reserve: 400,000,000 BAK (40%) FUNDED**

- Development Fund: 300,000,000 BAK (30%)
- Ecosystem Growth: 150,000,000 BAK (15%)
- Strategic Reserve: 35,000,000 BAK (3.5%)

Community Distribution: 15,000,000 BAK (1.5%)

- Airdrop Program: 10,000,000 BAK (1%)
- Referral Rewards: 5,000,000 BAK (0.5%)

Status Update (November 6, 2025):

- ValidatorTimelock contract deployed and funded
- 400M BAK secured in 30-year timelock
- Protected by 2-of-3 MultiSig wallet
- Monthly releases begin January 1, 2026

6.3 Validator Reward Time-Lock Mechanism

Long-Term Supply Control System OPERATIONAL

Objective: Ensure long-term network stability and controlled token inflation through a sophisticated time-lock mechanism.

Time-Lock Parameters:

- Total Validator Pool: 500,000,000 BAK
- Immediate Circulation: 100,000,000 BAK
- Time-Locked Reserve: 400,000,000 BAK **FUNDED**
- Lock Duration: 30 years (2026-2055)
- Annual Release: 13,333,333 BAK
- Monthly Release: 1,111,111 BAK
- Daily Release: ~36,496 BAK
- Per Block: ~18.25 BAK (2-second blocks)

Contract Details:

- **Address:** 0x2888eD340762958A8a6C02bdecB78715Ec117499
- **Owner:** 0x20Cc7A159968151171B2F8489e4A0935Fa91C8F3 (MultiSig 2-of-3)
- **Funding TX:** 0x34fd2460093bcfa547e0285321ff25dcefbd4472ae693b0d69b23dac8b4e8c1f
- **Funded Date:** November 6, 2025
- **Status:** Fully Operational

Benefits:

- ✓ Predictable Inflation: Fixed 1.33% annual increase
- ✓ Long-term Stability: 30-year network commitment

- ✓ Validator Sustainability: Guaranteed rewards
- ✓ Market Confidence: Transparent release schedule
- ✓ Deflationary Pressure: Burn mechanism counteracts inflation
- ✓ Supply Scarcity: 40% locked for three decades
- ✓ MultiSig Protection: 2-of-3 signatures required for emergency access
- ✓ Operational Security: 7-day emergency withdrawal delay

6.4 Fee Structure & Economic Incentives

Transaction Fee Model:

- Base Gas Price: 1,000 wei (0.000000001 BAK)
- Priority Fee: 0-500 wei (optional fast lane)
- Maximum Gas Price: 10,000 wei (congestion protection)
- Average Cost: ~\$0.00001 USD (99% cheaper than Ethereum)
- Fee Predictability: 99.9% use base price

Fee Distribution:

- Validator Rewards: 70% (Network security)
- Development Fund: 20% (Continuous improvement)
- Burn Mechanism: 10% (Deflationary pressure)

6.5 Long-Term Supply Projection

Year-by-Year Circulation Increase:

Year	Circulating Supply	Annual Inflation
Year 1	613.3M BAK	2.22%
Year 5	666.7M BAK	2.00%
Year 10	733.3M BAK	1.82%
Year 20	866.7M BAK	1.54%
Year 25	933.3M BAK	1.43%
Year 30	1B BAK	1.33%

6.6 Economic Security Model

Value Drivers:

- Transaction Demand: Higher usage increases validator rewards
- Staking Requirements: Validators must hold BAK for consensus

- Fee Burn: Gradual supply reduction creates scarcity
- Ecosystem Growth: dApps and services increase utility demand
- Time-Lock Scarcity: 40% of supply locked for 30 years

Risk Mitigation:

- Gradual Release: Prevents supply shocks
 - Burn Mechanism: Counteracts inflation pressure
 - Validator Alignment: Long-term commitment required
 - Fee Stability: Predictable transaction costs
 - Reserve Management: Strategic fund for crisis scenarios
-

7. Use Cases and Applications

7.1 Decentralized Finance (DeFi)

Revolutionary Cost Structure Enables:

- Micro-transactions for yield optimization
- High-frequency trading strategies
- Cost-effective yield farming for small investors
- Flash loans and arbitrage opportunities
- Automated portfolio rebalancing

Example: A \$10 yield farm harvest that costs \$30 on Ethereum costs \$0.0001 on BrainArk

7.2 Gaming and NFTs

Ultra-Low Fees Enable:

- Virtually free in-game item transfers
- Play-to-earn without fee erosion
- Real-time gaming transactions
- NFT marketplace operations
- Micro-rewards for achievements

Example: Moving 1,000 game items costs \$15,000 on Ethereum vs \$0.10 on BrainArk

7.3 Enterprise Applications

Fast Finality Supports:

- Supply chain tracking with real-time updates
- Authenticity verification systems

- Compliance reporting and audit trails
- Multi-party workflow automation
- IoT device management

7.4 Micropayments

Finally Viable Applications:

- Pay-per-article journalism
- Real-time creator rewards on social platforms
- Social media tipping
- Educational content micropayments
- Streaming service micro-subscriptions

7.5 Internet of Things (IoT)

Machine-to-Machine Commerce:

- Device-to-device automated payments
- Sensor data monetization
- Smart city infrastructure coordination
- Peer-to-peer energy trading
- Autonomous vehicle toll payments

7.6 Government & Identity

Secure Digital Infrastructure:

- Digital identity management
- Transparent voting systems
- Medical records with patient control
- Land title and property registration
- Educational credential verification

Impact: BrainArk enables 1000+ use cases across all major blockchain verticals with 99.95% cost reduction compared to traditional solutions.

8. Security and Decentralization

8.1 Security Architecture

Multi-Layer Security Model:

Consensus Level:

- Byzantine Fault Tolerance: Withstands up to 33% malicious validators

- Cryptographic Security: Keccak-256 hash functions, ECDSA signatures
- Block Validation: Every transaction verified by multiple validators
- Finality Guarantee: No possibility of transaction reversal

Network Level:

- TLS Encryption: All node communications secured
- Firewall Protection: Validators behind enterprise-grade security
- DDoS Protection: Network-level attack mitigation
- Geographic Distribution: Validators in multiple regions

Application Level:

- Smart Contract Audits: All core contracts professionally audited
- Formal Verification: Critical systems mathematically proven
- Bug Bounty Program: Ongoing security research incentives
- Emergency Response: Rapid incident response procedures

8.2 Decentralization Roadmap

Phase 1: Foundation (Current)

- 4 validators in secure data centers
- Geographic distribution across regions
- Foundation-operated for stability

Phase 2: Community Expansion (Q2 2025)

- 10 validators including community operators
- Staking requirements for validator participation
- On-chain governance implementation

Phase 3: Full Decentralization (Q4 2025)

- 25+ independent validators
- Community-driven validator selection
- Decentralized development funding

Phase 4: Mature Network (2026)

- 100+ validators globally distributed
- Fully autonomous governance
- Self-sustaining ecosystem

8.3 Governance Model

Initial Phase: Foundation Governance

- Core team makes technical decisions
- Community input through forums and surveys

- Transparent development process

Transition Phase: Hybrid Governance

- BAK token holders vote on key proposals
- Technical decisions remain with core team
- Community treasury management

Final Phase: Full DAO Governance

- All decisions made by token holder votes
 - Delegated governance for technical expertise
 - Decentralized protocol upgrades
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9. Roadmap and Future Development

9.1 Development Phases

Phase 1: Foundation (Q1-Q4 2025) COMPLETE

- IBFT consensus implementation
- 4-node validator network deployment
- EVM compatibility and testing
- Block explorer and developer tools
- MetaMask integration and wallet support
- Initial dApp deployments
- ValidatorTimelock contract deployed
- MultiSig protection implemented
- 400M BAK locked for 30 years
- Network live on Chain ID 1236

Phase 2: Optimization (Q1-Q2 2026) IN PROGRESS

- Performance optimization targeting 5,000 TPS
- Mobile wallet integration (iOS/Android)
- Developer tools enhancement and SDK release
- Cross-chain bridge development (EPO system operational)
- DeFi protocol partnerships
- First timelock release (February 2026)

Phase 3: Scaling (Q3-Q4 2025)

- Validator network expansion to 25 nodes
- Sharding implementation for horizontal scaling
- Layer 2 integration and rollup support

- Enterprise partnership program
- Institutional custody solutions

Phase 4: Ecosystem Maturity (2026)

- 100+ validator network globally distributed
- Advanced DeFi protocol suite
- NFT marketplace and gaming platform
- Global adoption initiatives
- Academic research partnerships

9.2 Technical Roadmap

Short Term (3-6 months):

- Block time optimization to 1 second
- Enhanced monitoring and analytics
- Automated validator management
- Smart contract template library

Medium Term (6-12 months):

- State channels for instant micropayments
- Private transaction capabilities
- Interchain communication protocols
- Advanced consensus optimizations

Long Term (1-3 years):

- Quantum-resistant cryptography
- Zero-knowledge proof integration
- Cross-chain atomic swaps
- Artificial intelligence integration

9.3 Partnership Strategy

Technology Partners:

- Cloud infrastructure providers
- Enterprise blockchain consultants
- Academic research institutions
- Open source developer communities

Business Partners:

- DeFi protocol developers
- Gaming and NFT platforms
- Enterprise software providers
- Financial services companies

Ecosystem Partners:

- Wallet providers and integrators
- Block explorer and analytics services
- Development tool creators
- Educational content providers

10. Technical Specifications

10.1 Network Configuration

Chain ID: 1236 (Mainnet)
Network ID: 1236
Consensus: IBFT (Istanbul Byzantine Fault Tolerance)
Block Time: 2 seconds
Gas Limit: 30,000,000 per block
Gas Price: 1,000 wei (minimum)
Validators: 4 nodes (expanding to 100+)
Currency: BAK (BrainArk Token - Native)
Current Status: Live and Operational

10.2 Performance Metrics

TPS (Sustained): 1,000+
TPS (Peak Tested): 2,156
TPS (Theoretical): 10,500+
Finality: Instant (single block confirmation)
Network Latency: <100ms globally
Block Propagation: <500ms
Uptime: 99.95% (target 99.99%)

10.3 Node Requirements

Validator Node Minimum Specifications:

- CPU: 8 cores, 3.0+ GHz
- RAM: 32 GB DDR4
- Storage: 1 TB NVMe SSD
- Network: 1 Gbps dedicated bandwidth
- OS: Ubuntu 20.04 LTS or higher

RPC Node Specifications:

- CPU: 4 cores, 2.5+ GHz
- RAM: 16 GB DDR4

- Storage: 500 GB SSD
- Network: 100 Mbps bandwidth
- OS: Ubuntu 18.04 LTS or higher

10.4 Network Endpoints

Mainnet:

- RPC: <https://rpc.brainark.online>
- WebSocket: <wss://ws.brainark.online>
- Explorer: <https://explorer.brainark.online>

Testnet:

- RPC: <https://testnet-rpc.brainark.online>
 - WebSocket: <wss://testnet-ws.brainark.online>
 - Explorer: <https://testnet-explorer.brainark.online>
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11. Community and Governance

11.1 Community Channels

Official Communication:

- Website: <https://brainark.online>
- Documentation: <https://docs.brainark.online>
- Blog: <https://blog.brainark.online>
- GitHub: <https://github.com/brainark>

Social Media:

- Twitter: [@sdogcoin1](#)
- Telegram: [@Brainark_Besu_BlockChain](#)
- Discord: BrainArk Community Server
- Reddit: [r/BrainArk](#)

Developer Resources:

- Developer Portal: <https://dev.brainark.online>
- API Documentation: <https://api.brainark.online>
- SDK and Tools: <https://tools.brainark.online>
- Developer Support: dev@brainark.online

11.2 Community Programs

Developer Incentives:

- Grant program: Up to \$100,000 per project
- Hackathons: Quarterly events with prizes
- Bug bounties: Security research rewards
- Open source contributions: Recognition and rewards

User Engagement:

- Airdrop program: 10,000,000 BAK distribution
- Referral rewards: 5,000,000 BAK allocation
- Community challenges: Regular engagement activities
- Educational content: Tutorials and guides

Validator Program:

- Staking requirements: Minimum BAK holding
- Technical requirements: Node operation standards
- Reward distribution: Transparent allocation
- Governance participation: Voting rights

11.3 Governance Framework

Decision Categories: 1. **Technical Protocol Changes:** Core team with community input 2. **Economic Parameters:** Community voting with expert guidance 3. **Treasury Management:** DAO governance with multisig execution 4. **Strategic Partnerships:** Hybrid decision making

Voting Mechanisms:

- Token-weighted voting for major decisions
- Quadratic voting for community funds
- Delegation system for technical expertise
- Time-locked voting to prevent manipulation

12. Conclusion

12.1 Revolutionary Impact

BrainArk represents a paradigm shift in blockchain technology, solving the fundamental barriers that have prevented mass adoption. By delivering 99.95% cost reduction and instant finality, we enable entirely new categories of applications previously impossible on traditional blockchains.

12.2 Technological Achievement

Our implementation demonstrates that it's possible to achieve the blockchain trilemma solution: high security through Byzantine Fault Tolerance, massive

scalability through optimized consensus, and true decentralization through community validator expansion.

12.3 Economic Innovation

The time-locked validator reward system ensures long-term network sustainability while providing predictable tokenomics. This economic model aligns all stakeholders - validators, developers, and users - toward the network's success.

12.4 Ecosystem Potential

With transaction costs reduced by over 99%, BrainArk unlocks:

- Micropayments for content and services
- High-frequency DeFi strategies for all users
- Real-time gaming and NFT interactions
- IoT device-to-device commerce
- Enterprise blockchain adoption at scale

12.5 Global Accessibility

BrainArk democratizes access to blockchain technology by removing economic barriers. A student in any country can now participate in DeFi, a small business can implement supply chain tracking, and developers can build without worrying about user transaction costs.

12.6 Future Vision

As we progress through our roadmap, BrainArk will become the foundation for a new generation of decentralized applications. Our commitment to maintaining ultra-low fees, while scaling to support millions of users, positions BrainArk as the infrastructure for the decentralized economy of the future.

12.7 Call to Action

The BrainArk network is live and ready for developers, enterprises, and users who want to experience blockchain technology as it was meant to be: fast, affordable, and accessible to everyone. Join us in building the future of decentralized technology.

Start building on BrainArk today:

- Connect MetaMask to our network
 - Deploy your smart contracts for pennies
 - Experience instant transaction finality
 - Join our growing ecosystem of innovators
-

Appendices

Appendix A: Token Contract Details

BAK Token: Native Currency (No contract address - built into chain)
ValidatorTimelock Contract: 0x2888eD340762958A8a6C02bdecB78715Ec117499
MultiSig Protection Contract: 0x20Cc7A159968151171B2F8489e4A0935Fa91C8F3 **EPO Contract:** 0x0135F1401A14D821b8581c1fF491E0f9391069B5 **Cross-Chain EPO:** 0x1Df35D8e45E0192cD3C25B007a5417b2235642E5 **Airdrop Contract:** 0x49e3E46D036b0d1C420Aa2fD4B91f4DD4A7f8c64 **Genesis Account:** 0x0Ac00d552Ef4B7e9326Fe5094707419daF4E4169

Appendix B: Network Configuration

MetaMask Network Configuration:

```
json
{
  "chainName": "BrainArk Mainnet",
  "chainId": "0x4D4",
  "rpcUrls": ["https://rpc.brainark.online"],
  "nativeCurrency": {
    "name": "BrainArk",
    "symbol": "BAK",
    "decimals": 18
  },
  "blockExplorerUrls": ["https://explorer.brainark.online"]
}
```

Note: Chain ID 1236 (decimal) = 0x4D4 (hexadecimal)

Appendix C: References and Resources

1. Hyperledger Besu Documentation 2. Istanbul Byzantine Fault Tolerance Specification 3. Ethereum Virtual Machine Specification 4. Smart Contract Security Best Practices 5. Blockchain Scalability Research Papers

Document Information:

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- **Authors:** BrainArk Core Team
- **License:** Creative Commons Attribution 4.0 International
- **Contact:** brainarkbesuchain@gmail.com

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- **v1.0** (January 2025): Initial whitepaper release
- **v1.1** (November 2025): Updated with ValidatorTimelock funding, corrected Chain

ID, added contract addresses, updated roadmap progress

This whitepaper is a living document and will be updated as the BrainArk ecosystem evolves. For the latest version, please visit <https://brainark.online/whitepaper>

Latest Updates:

- ValidatorTimelock funded with 400M BAK (Nov 6, 2025)
- 30-year controlled release mechanism activated
- MultiSig protection operational
- Network live on Chain ID 1236
- All core contracts deployed and operational