PHICOIN V2: The Decentralized Domain Name System

Phi Lab Foundation
Community Version V2

***Abstract*—The current Domain Name System (DNS) infrastructure faces critical vulnerabilities including poisoning attacks, censorship mechanisms, and centralized points of failure that compromise internet freedom and security. Recent incidents such as the APT Group StormBamboo DNS poisoning attacks on ISP customers demonstrate the urgent need for resilient Web3 infrastructure alternatives. This paper presents Phicoin V2, a groundbreaking blockchain-based Decentralized Domain Name System (Phicoin DDNS) designed to serve as foundational infrastructure for the next-generation Web3 ecosystem. Phicoin V2 employs a purpose-built Proof-of-Work blockchain utilizing the innovative PhihashV2 algorithm, specifically engineered to maintain true decentralization through GPU mining accessibility while preventing ASIC centralization. The Phicoin ecosystem integrates seamlessly with IPFS for distributed storage and implements cryptographic primitives for end-to-end trust signatures, achieving Never Trust, Always Verify zero-trust verification. Our implementation delivers 15-second domain record propagation times, comprehensive support for 20 standard DNS record types, and provides permanently free .ddns domains to democratize access to decentralized internet services. Phicoin V2 features cross-chain integration with major blockchains including Solana, enabling over 15 million Web3 users to access DDNS services directly. The system operates on environmentally sustainable infrastructure including solar-powered data centers, demonstrating Phicoin's commitment to responsible blockchain innovation. Phicoin DDNS achieves over 1000+ TPS transaction capabilities while maintaining sub-second query resolution through intelligent caching mechanisms, establishing a new paradigm for decentralized digital identity ownership in the Web3 era.**

***Index Terms*—Phicoin, PhihashV2, Decentralized DNS, Web3 Infrastructure, Proof of Work, UTXO Model, Anti-Censorship, Cross-chain Integration, IPFS, GPU Mining**

I. Introduction

A. Web3 Infrastructure Vision

In the evolution of Web3 decentralized internet, Phicoin V2 is committed to becoming a core builder of next-generation digital infrastructure. The traditional Domain Name System (DNS), serving as the internet's "phone book," has long been constrained by centralized control, facing fundamental challenges such as censorship, attacks, and single points of failure. These issues not only threaten users' digital freedom but also hinder the realization of truly decentralized networks.

Phicoin V2 emerges to build a completely decentralized domain infrastructure, enabling every user to truly own and control their digital identity. We believe that only by breaking free from the shackles of traditional DNS can we lay a solid foundation for the Web3 ecosystem.

B. Limitations of Existing Systems

Current internet infrastructure suffers from deep-seated structural problems:

Vulnerability of Centralized Control: Traditional DNS systems rely on a few root servers and centralized institutions, making these control points targets for attackers and tools for government censorship. Recent APT Group StormBamboo attacks have fully exposed the security vulnerabilities of this centralized architecture, compromising ISP-level DNS infrastructure to redirect legitimate traffic to malicious endpoints [1]. These poisoning attacks exploit the inherent trust relationships in hierarchical DNS resolution, demonstrating how centralized control points become systemic weaknesses [29], [30].

Loss of User Rights: In traditional systems, users do not truly own domains but "rent" them from centralized registrars. Under this model, users' digital assets face the risk of confiscation, freezing, or tampering at any time.

Barriers to Innovation: High registration fees, complex management processes, and technical barriers prevent ordinary users and small developers from participating in internet infrastructure construction.

Insufficient Web3 Compatibility: Existing decentralized naming systems (such as ENS, Namecoin, etc.), while conceptually correct, suffer from high usage costs, limited functional support, and poor traditional DNS compatibility in practical applications.

The mathematical formulation of these problems can be expressed as single points of failure in the DNS resolution chain:

$$P_{failure} = 1 - \prod_{i=1}^{n}(1 - p_i) \tag{1}$$

where p_i represents the failure probability of the i-th centralized component in the DNS hierarchy, and n is the number of critical control points.

C. Phicoin V2 Solutions

Phicoin V2 represents a major breakthrough in decentralized domain systems. We redefine internet infrastructure through the following core innovations:

True Decentralized Ownership: Based on blockchain technology, users completely own their domains without relying on any centralized institutions. Domain records are protected by cryptographic means, ensuring that only domain owners can make modifications.

Zero-Cost Universal Service: Phicoin V2 provides permanently free .ddns domains for all users, breaking the economic barriers of traditional domain services and allowing everyone to own their digital identity.

Ultimate Performance Optimization: We designed specially optimized blockchain infrastructure, achieving 15-

second domain record propagation times and transaction capabilities of over 1000+ TPS, ensuring user experience that matches traditional DNS systems.

Seamless Compatibility: Phicoin V2 is fully compatible with existing DNS protocols and 20 standard record types, allowing users to enjoy the security and freedom of decentralization without changing their existing usage habits.

Strong Anti-Censorship Capabilities: Through distributed network architecture and encrypted communication, Phicoin V2 can effectively resist various forms of network censorship and attacks, ensuring free flow of information.

D. Building the Foundation of Web3 Ecosystem

Phicoin V2 is not just a domain system, but an important infrastructure for the Web3 ecosystem:

Cross-chain Interoperability: We have implemented bridges with mainstream blockchains such as Solana and Ethereum, enabling over 15 million Web3 users to directly use DDNS services without additional technical barriers.

Decentralized Web Protocol: The D-WEB protocol based on DDNS records, combined with IPFS technology, provides a complete solution for truly decentralized website hosting.

Enterprise Deployment Solutions: Through edge DDNS servers, organizations can deploy completely autonomous domain resolution services internally while enjoying the advantages of decentralization and maintaining compatibility with traditional networks.

Community-Driven Innovation: Phicoin V2 adopts an open governance model where community members can participate in protocol improvement and development, jointly building a more open and fair digital world.

II. Related Work

Existing decentralized naming systems have made significant contributions to addressing DNS centralization, but each suffers from fundamental limitations that prevent widespread adoption [2]. Recent surveys on blockchain consensus mechanisms provide comprehensive frameworks for evaluating different approaches to decentralized systems [27], [28].

Ethereum Name Service (ENS): Utilizes Ethereum's smart contract infrastructure for .eth domain management [3]. While innovative, ENS faces scalability constraints due to Ethereum's throughput limitations (Max Theor. TPS 119.1 tx/s) and high transaction costs (gas fees often exceeding $50 per operation). Additionally, ENS domains are not compatible with traditional DNS infrastructure, limiting their utility [42].

Namecoin: The first blockchain-based naming system, forked from Bitcoin to support .bit domains [4]. Namecoin suffers from slow block times (10 minutes), limited throughput, and lack of modern DNS record type support. The system's security relies on merge-mining with Bitcoin, creating potential centralization risks [43].

Handshake: Implements a novel approach using proof-of-work to manage top-level domain auctions [5]. However, Handshake focuses primarily on TLD ownership rather than practical DNS resolution, and its auction mechanism creates significant barriers to entry for users.

While these systems represent important advances in decentralized naming, they each exhibit fundamental trade-offs between security, scalability, and usability that limit their practical deployment. Recent research in blockchain consensus mechanisms has shown that achieving optimal balance between these properties requires careful design of the underlying consensus protocol.

Our system advances the state-of-the-art by combining: - High throughput blockchain infrastructure (Max Theor. TPS 1,111.1 tx/s vs. Max Theor. TPS 119.1 tx/s for Ethereum) - Universal DNS compatibility (supports all standard record types) - Zero-cost operation for .ddns domains - Production-ready resolver infrastructure

TABLE I
Comparison of Decentralized DNS Solutions

Feature	Phicoin DDNS	ENS	Namecoin	Handshake	Traditional DNS
Decentralized	Yes	Partial	Yes	Yes	No
DNS Compatible	Yes	No	Limited	Limited	Yes
Block Time	15s	12s	10min	10min	N/A
Transaction Cost	Free	$10-50	$0.01	$1-10	$10-100/year
Throughput (TPS)	1000+	119.1	7	7	250 [10]
Record Types	20	Limited	Limited	Limited	20 [9]
Censorship Resist	High	Medium	High	High	Low

Note: The Phicoin DDNS project aims to become foundational infrastructure in the Web3 decentralized domain. Following network stabilization, we will release V3 version with further optimized block times, providing faster transaction speeds to support increased DNS update requests.

III. System Architecture

A. High-Level Design

The Phicoin DDNS system implements a layered architecture that separates concerns while maintaining cryptographic security guarantees throughout the stack. The design follows the principle of *cryptographic minimalism*, where trust assumptions are explicitly modeled and minimized.

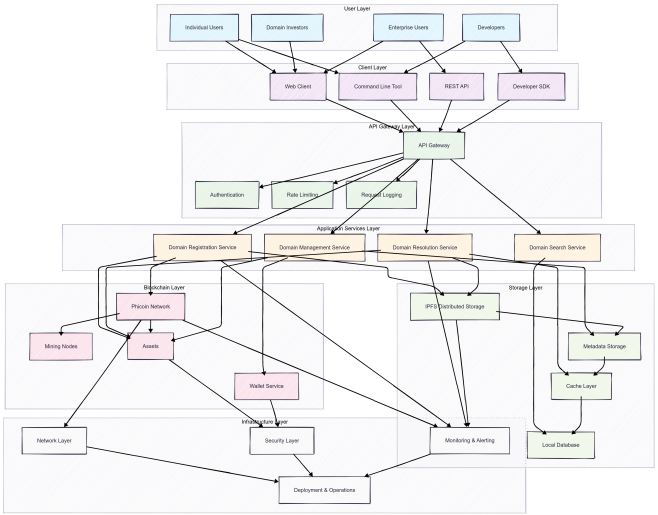

Fig. 1. Phicoin DDNS System High-Level Architecture

The architecture consists of six primary layers:

User Layer: Supports diverse stakeholders including individual users, enterprises, developers, and domain investors with varying technical requirements and economic models.

Client Layer: Provides multiple interfaces (Web UI, CLI tools, REST APIs, SDKs) for different integration patterns and user preferences.

API Gateway Layer: Implements authentication, rate limiting, and request logging with horizontal scaling capabilities.

Application Services Layer: Core business logic for domain registration, resolution, management, and search with high-availability design.

Blockchain Layer: Phicoin DDNS network providing cryptographic consensus, asset management, wallet services, and mining infrastructure.

Storage Layer: Distributed storage using IPFS, metadata management, intelligent caching, and local database optimization.

B. Functional Components

The Phicoin DDNS system architecture comprises multiple specialized functional components that work together to provide comprehensive domain management and resolution services.

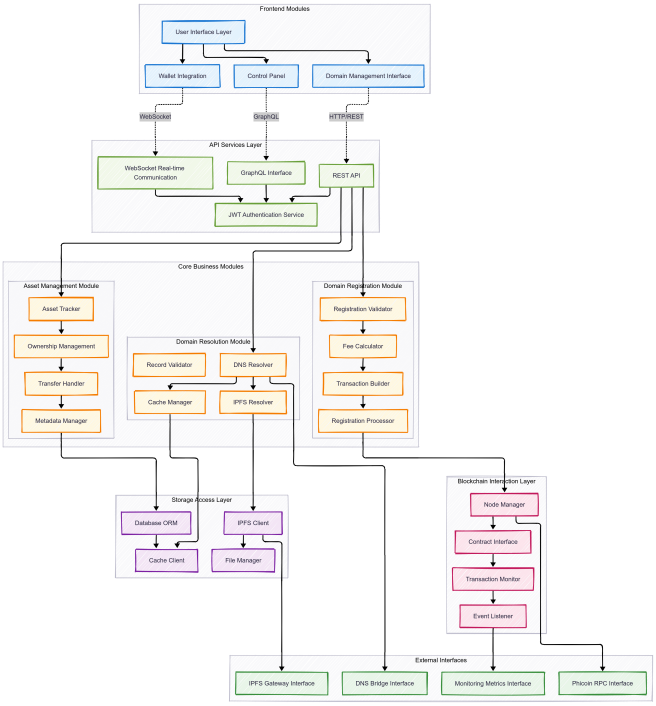

Fig. 2. Phicoin DDNS Functional Components and Module Interactions

The functional architecture includes core business modules (Asset Management, Domain Registration), domain resolution modules (DNS Resolver, Cache Manager, IPFS Resolver), blockchain integration components (Node Manager, Contract Interface), and storage access layers (Database ORM, IPFS Client, File Manager). The frontend modules provide user interfaces through REST APIs, WebSocket real-time communication, and GraphQL interfaces for advanced querying capabilities.

C. Use Case Analysis

The Phicoin DDNS system supports diverse user personas with varying technical expertise and usage patterns, from individual users seeking simple domain registration to enterprise users requiring bulk domain management capabilities.

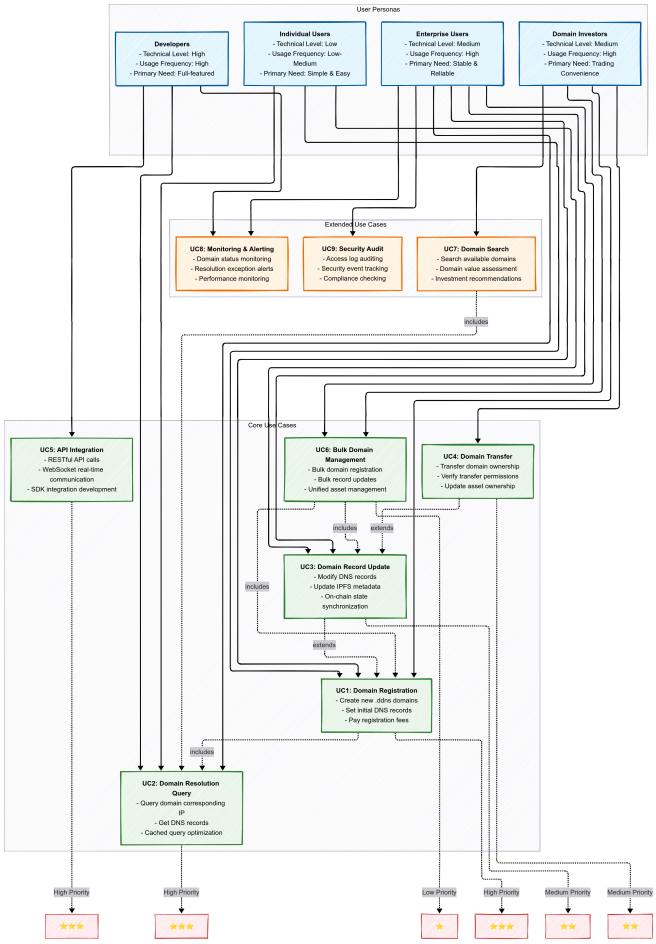

Fig. 3. Phicoin DDNS Use Case Diagram and User Interactions

The use case diagram illustrates core functionalities including domain registration, record updates, domain resolution queries, bulk domain management, domain transfers, and monitoring/alerting services. Each use case is prioritized based on user needs and technical complexity, with high-priority cases including domain registration and resolution queries that form the foundation of the system.

D. Technology Stack

The Phicoin DDNS implementation leverages a modern, scalable technology stack designed for high-performance blockchain and distributed systems operations.

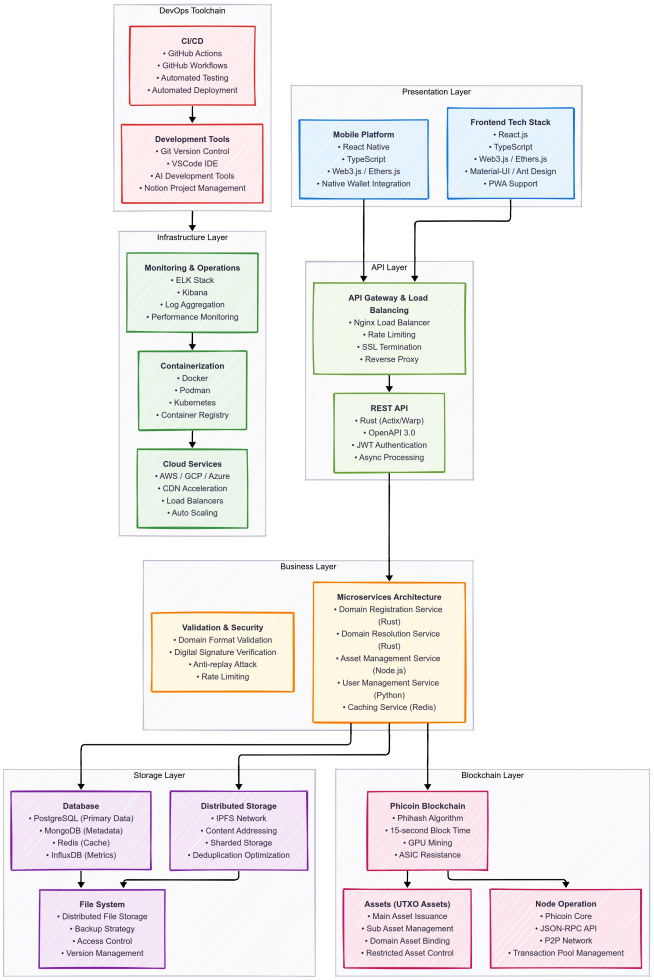

Fig. 4. Phicoin DDNS Technology Stack and Infrastructure Components

The technology stack spans multiple layers: the presentation layer utilizes React.js for frontend development and React Native for mobile platforms; the API layer implements load balancing with Nginx and RESTful services; the business layer employs microservices architecture with domain-specific services in Rust and Node.js; the storage layer combines distributed storage (IPFS), traditional databases (PostgreSQL, MongoDB), and Redis for caching; the blockchain layer features the custom Phicoin blockchain with UTXO asset management; and the infrastructure layer provides containerization with Docker/Kubernetes, monitoring with ELK stack, and DevOps automation.

E. Cryptographic Primitives

The Phicoin DDNS system employs well-established cryptographic primitives to ensure security:

Digital Signatures: Domain operations utilize ECDSA with secp256k1 curve (identical to Bitcoin) for signing transactions. The signature verification process follows:

$$\text{Verify}(m, \sigma, pk) = e(\sigma, G) \stackrel{?}{=} e(H(m) + r \cdot pk, G) \quad (2)$$

where m is the message (domain operation), σ is the signature, pk is the public key, and H is SHA-256 hash function.

Content Addressing: IPFS uses SHA-256 hash function for content addressing:

$$\begin{aligned}\text{IPFS\_Hash} = \text{Base58}(\text{SHA256}(\\ \text{ProtoBuf}(\text{Domain\_Record})))\end{aligned} \quad (3)$$

This ensures tamper-evident storage where any modification to domain records results in a different hash value.

F. Phicoin Blockchain Infrastructure

The Phicoin blockchain represents a purpose-built blockchain optimized for domain name service requirements. Key technical specifications include:

Consensus Algorithm: Proof-of-Work using PhihashV2, an ASIC-resistant algorithm designed to prevent network hash power centralization that leads to centralization risks [6], [31]. Additionally, we optimized the DAG structure to enable cache files to run on integrated graphics cards, allowing tens of millions of devices worldwide equipped with integrated graphics to join the mining network at any time, enabling broader network participation and larger-scale decentralized networks. This approach addresses the well-documented mining centralization concerns in PoW systems [33], [34].

Block Parameters: - Block time: 15 seconds (optimized for DNS update responsiveness) - Block size: 4MB Weight Units (WU) = 4,000,000 WU (enabling high transaction throughput) - Difficulty adjustment: Enhanced Dark Gravity Wave algorithm for rapid response

Transaction Throughput: The system achieves theoretical maximum throughput using Weight Units calculation method [6]:

General TPS calculation formula (applicable only to DDNS Blockchain: 4M WU):

$$TPS = \frac{4,000,000}{\text{Average Weight Units per Transaction}} \div 15 \quad (4)$$

Different transaction types yield the following results:

1) Minimal transactions (bare transfers, typically 60 bytes = 240 WU):

$$TPS_{minimal} = \frac{4,000,000}{240} \div 15 \approx 1,111.1 \quad (5)$$

2) Regular transactions (≈ 250 bytes = 1,000 WU):

$$TPS_{regular} = \frac{4,000,000}{1,000} \div 15 = 266.7 \quad (6)$$

Final Results Summary (4M WU):

TABLE II
TRANSACTION TYPES AND THEORETICAL MAXIMUM TPS

Transaction Type	Average Size (WU)	TPS (Theoretical Max)
Minimal Transaction	240 WU	≈ 1,111.1
Regular Transaction	1,000 WU	≈ 266.7

Network Security: Empirical analysis of mainnet performance from block heights 92,594 to 143,669 shows orphan rate of 0.0176% (9 orphaned blocks out of 51,075 total) [8], demonstrating network stability.

G. Domain Asset Model

The Phicoin DDNS system implements a modified UTXO model specifically designed for domain asset management. Each domain is represented as a unique asset with the following properties:

```
{
  "asset_name": "DDNS/EXAMPLE",
  "quantity": 1,
  "units": 1,
  "reissuable": false,
  "has_ipfs": true,
  "ipfs_hash": "QmX7M8RxZ...",
  "owner_address": "PhicoinAddress123..."
}
```

Listing 1. Domain Asset Structure

Asset Naming Convention: Domains follow hierarchical naming: `ROOT_TLD/DOMAIN_NAME` where ROOT_TLD represents the top-level domain asset (e.g., "DDNS") and DOMAIN_NAME represents the specific domain.

Economic Model: Domain registration requires minimal fees (0.1 PHI ≈ $0.00001) with no recurring costs, implementing true digital asset ownership rather than lease-based models used by traditional DNS. Additionally, we subsidize the gas fees for domain registration. For .DDNS domain registration, we cover all gas fees, thereby achieving permanently free domain services.

H. IPFS Integration and Domain Control Files

Domain records are stored in JSON-formatted control files on IPFS, enabling flexible schema evolution and comprehensive DNS record type support [26]. The control file structure follows RFC-compliant specifications:

```
{
  "version": "2.0",
  "domain": "example.ddns",
  "records": {
    "@": {
      "A": [{"address": "192.168.1.100", "ttl": 3600}]
    },
    "www": {
      "CNAME": [{"target": "example.ddns", "ttl": 3600}]
    },
    "mail": {
      "MX": [{"server": "mail.example.ddns", "priority": 10}]
    }
  }
}
```

Listing 2. Domain Control File Example

This design provides several advantages: - **Schema Flexibility:** JSON format allows arbitrary record types without blockchain protocol changes - **Efficient Storage:** Only IPFS hash stored on-chain, enabling large record sets without blockchain bloat - **Content Verification:** IPFS content addressing ensures data integrity

I. Supported DNS Record Types

The Phicoin DDNS system provides comprehensive support for 20 different DNS record types, ensuring compatibility with modern internet infrastructure requirements and enabling diverse use cases from simple web hosting to complex service architectures. We have implemented 76 types of domain resolution and control files enumerated in RFC documents. However, we also referenced Cloudflare's protocol resolution settings and selected the 20 most commonly used domain resolution records. The aforementioned control file code and scripts are open-sourced in the ddnsd service, allowing users to configure according to their specific needs.

Core Address Records:

- **A Records [13]:** IPv4 address mapping for standard web services and applications
- **AAAA Records [14]:** IPv6 address mapping supporting next-generation internet protocols
- **CNAME Records [13]:** Canonical name aliases enabling flexible domain management and CDN integration

Mail and Communication Records:

- **MX Records [13]:** Mail exchange server specifications with priority-based routing
- **TXT Records [13]:** Arbitrary text data for SPF, DKIM, domain verification, and custom metadata
- **SPF Records [15]:** Sender Policy Framework for email authentication and anti-spam protection
- **DKIM Records [16]:** DomainKeys Identified Mail cryptographic signatures for email integrity
- **DMARC Records [17]:** Domain-based Message Authentication for comprehensive email security policies

Service Discovery Records:

- **SRV Records [18]:** Service location records defining port and priority for specific services
- **NS Records [13]:** Name server delegation for subdomain management and distributed authority
- **PTR Records [13]:** Reverse DNS lookups enabling IP-to-domain resolution
- **SOA Records [13]:** Start of Authority defining zone management parameters and refresh intervals

Advanced and Specialized Records:

- **CAA Records [19]:** Certificate Authority Authorization controlling SSL/TLS certificate issuance
- **TLSA Records [20]:** Transport Layer Security Authentication for DNS-based certificate pinning
- **SSHFP Records [21]:** SSH Key Fingerprints for secure shell authentication verification
- **URI Records [22]:** Uniform Resource Identifier mapping for advanced service location
- **NAPTR Records [23]:** Naming Authority Pointer for complex protocol transformations
- **LOC Records [24]:** Geographic location information for physical server positioning

- **HINFO Records [13]:** Host information describing system architecture and operating system
- **RP Records [25]:** Responsible Person contact information for domain administration

Record Type Validation: Each record type implements RFC-compliant validation ensuring data integrity and standards compliance. The system performs real-time validation during record updates, preventing malformed entries and maintaining DNS protocol compatibility.

Performance Optimization: Record resolution is optimized through intelligent caching with type-specific TTL policies, reducing resolution latency for frequently accessed record types while maintaining accuracy for dynamic records.

IV. Implementation

A. Blockchain Infrastructure Components

The Phicoin DDNS network consists of multiple specialized components working in concert:

Core Node Software: Full blockchain nodes implementing the Phicoin DDNS protocol, maintaining complete transaction history, and participating in consensus.

Mining Infrastructure: Distributed mining pools supporting the PhihashV2 algorithm, with specialized mining software optimized for GPU hardware [7].

Network Discovery: Seeder servers providing initial peer discovery and network health monitoring.

DDNSD Public DDNS Resolution Servers: Distributed public resolution infrastructure providing high-availability domain name resolution services.

DDoH Public DDNS over HTTPS Resolution Servers: Secure DNS resolution services implementing DNS-over-HTTPS protocol for enhanced privacy and censorship resistance.

Cross-Chain Bridge: Smart contract infrastructure on Solana enabling PHI token trading and liquidity provision, creating economic incentives for network participation.

Sustainable Infrastructure: The Phicoin DDNS network operates on environmentally sustainable infrastructure, including solar-powered data centers that provide carbon-neutral blockchain operations. Our Solar facility demonstrates the feasibility of renewable energy-powered PoW cryptocurrency block perpetual generation node operations.

Fig. 5. Solar-Powered Data Center Infrastructure

The solar infrastructure includes high-efficiency photovoltaic panels, battery storage systems, and optimized cooling solutions that enable 24/7 blockchain node operation with minimal environmental impact. This sustainable approach to blockchain infrastructure addresses growing concerns about cryptocurrency energy consumption while maintaining network security and performance.

B. Domain Registration and Modification Process

The domain lifecycle follows a cryptographically secured process:

Registration Flow:

1) User generates key pair (sk, pk) where sk is private key and $pk = sk \cdot G$ is corresponding public key
2) Create domain control file with initial DNS records
3) Upload control file to IPFS, obtaining hash h_{ipfs}
4) Construct blockchain transaction $tx = \{domain\_name, h_{ipfs}, pk\}$
5) Sign transaction: $\sigma = \text{ECDSA\_Sign}(sk, H(tx))$
6) Broadcast signed transaction to Phicoin DDNS network
7) Miners validate signature and include in next block

Modification Flow: Domain updates follow identical process but reference existing asset, ensuring only authorized private key holder can modify records.

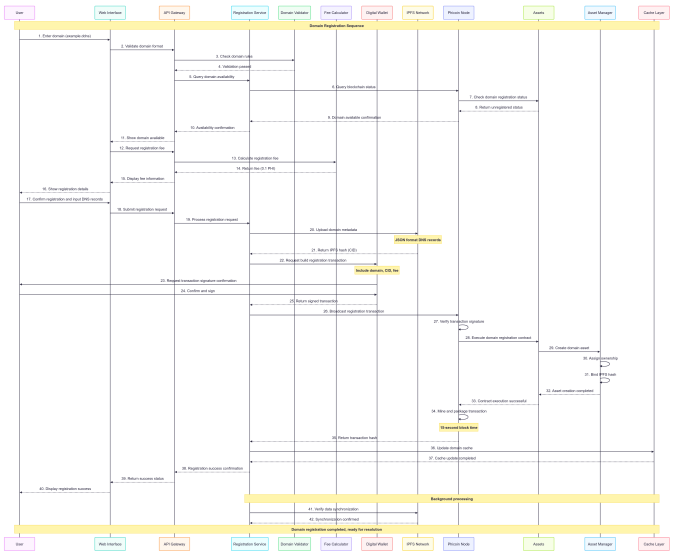

Fig. 6. Domain Registration Sequence Diagram

The domain registration sequence demonstrates the complete end-to-end flow from user initiation through blockchain confirmation. The process involves multiple system components including the Web Interface, API Gateway, Registration Service, Domain Validator, Fee Calculator, Digital Wallet, IPFS Network, DDNS Node, and Asset Manager. Key steps include domain validation, fee calculation, IPFS metadata upload, blockchain transaction creation and signing, and final asset creation with ownership assignment. The sequence emphasizes the cryptographic security at each step and the 15-second block time for rapid confirmation.

C. DNS Resolution Process

The resolution system implements a hybrid approach combining blockchain verification with traditional DNS performance requirements:

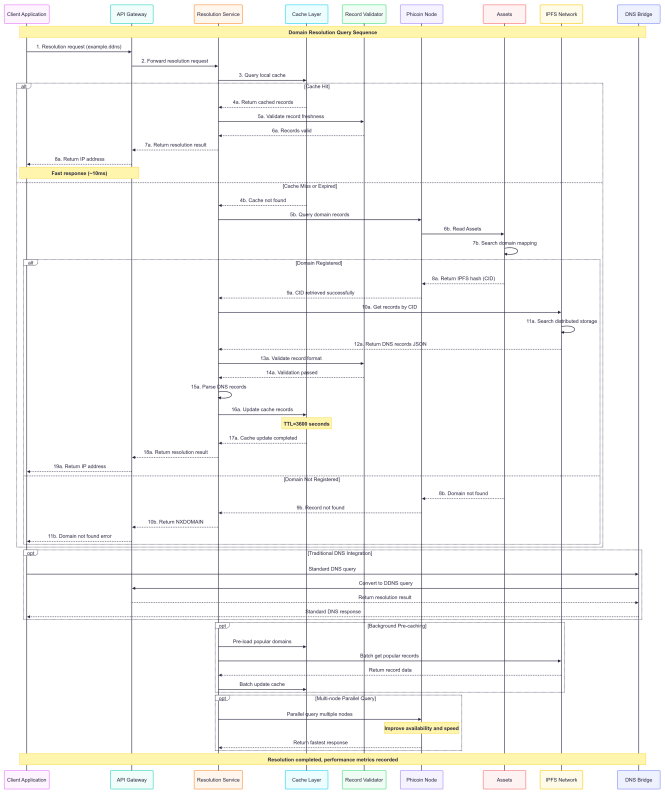

Fig. 7. Phicoin DDNS Domain Resolution Sequence

Resolution Algorithm:

1) Client queries local PhicoinDDNSD resolver for domain
2) Resolver checks multi-tier cache (memory $\rightarrow$ file $\rightarrow$ blockchain)
3) If cache miss, query Phicoin RPC for domain asset
4) Extract IPFS hash from blockchain record
5) Retrieve domain control file from IPFS
6) Verify $H(\text{control\_file}) = h_{ipfs}$ for integrity
7) Parse requested record type and return response
8) Cache result with appropriate TTL

Performance Optimization: The system implements intelligent caching with the following hierarchy: - **L1 Cache:** In-memory LRU cache (50,000 entries, 15-second TTL) - **L2 Cache:** Persistent file cache with longer TTL - **L3 Cache:** Blockchain verification cache for domain ownership

Production Domain Registration and Resolution: To demonstrate the practical functionality and performance characteristics of the Phicoin DDNS system, we conducted a comprehensive end-to-end evaluation using the production Phicoin DDNS infrastructure. The evaluation encompasses domain registration, DNS record configuration, resolution performance analysis, and accessibility demonstration.

Domain Registration Process: Using the DDNS web interface at https://d.phicoin.net/, we registered the domain `test01.ddns` and configured TXT records for testing purposes. Figure 8 illustrates the user-friendly domain registration interface, which provides comprehensive DNS record management capabilities including support for A, AAAA, CNAME, MX, TXT, and other standard record types.

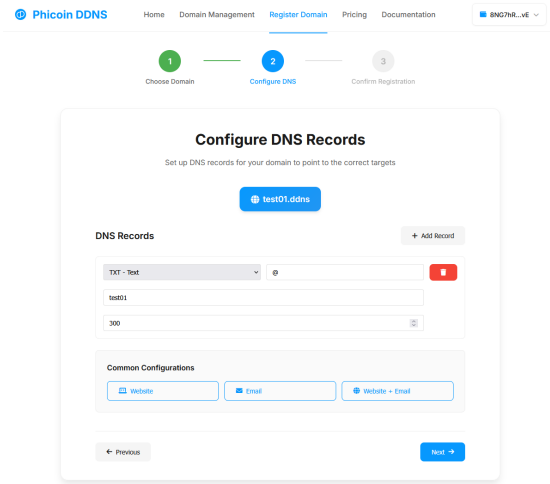

Fig. 8. DDNS Domain Registration and DNS Configuration Interface

DNS Resolution Performance Analysis: To evaluate the system's resolution performance and caching efficiency, we conducted repeated DNS queries using the `dig` utility against the DDNS public resolver at `138.2.235.218`. The performance evaluation demonstrates significant improvements in query response times through intelligent caching mechanisms.

Figure 9 shows the initial DNS query for `test01.ddns TXT`, which required blockchain verification and IPFS retrieval, resulting in a response time of 183 milliseconds. The subsequent query, illustrated in Figure 10, demonstrates the effectiveness of the multi-tier caching system with a dramatically reduced response time of 19 milliseconds, representing a 89.6% performance improvement.

```
(base) ubuntu@[redacted]:~$ dig @138.2.235.218 test01.ddns TXT

; <<>> DiG 9.18.30-0ubuntu0.22.04.2-Ubuntu <<>> @138.2.235.218 test01.ddns TXT
; (1 server found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 42987
;; flags: qr aa rd; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 0
;; WARNING: recursion requested but not available

;; QUESTION SECTION:
;test01.ddns.                   IN      TXT

;; ANSWER SECTION:
test01.ddns.            0       IN      TXT     "test01"

;; Query time: 183 msec
;; SERVER: 138.2.235.218#53(138.2.235.218) (UDP)
;; WHEN: Tue Jul 29 04:36:17 PDT 2025
;; MSG SIZE  rcvd: 48

(base) ubuntu@[redacted]:~$ dig @138.2.235.218 test01.ddns TXT

; <<>> DiG 9.18.30-0ubuntu0.22.04.2-Ubuntu <<>> @138.2.235.218 test01.ddns TXT
; (1 server found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 10096
;; flags: qr aa rd; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 0
;; WARNING: recursion requested but not available

;; QUESTION SECTION:
;test01.ddns.                   IN      TXT

;; ANSWER SECTION:
test01.ddns.            0       IN      TXT     "test01"

;; Query time: 19 msec
;; SERVER: 138.2.235.218#53(138.2.235.218) (UDP)
;; WHEN: Tue Jul 29 04:36:27 PDT 2025
;; MSG SIZE  rcvd: 48
```

Fig. 9. Initial DNS Query with Full Blockchain Resolution (183ms)

```
(base) ubuntu@D                :~$ dig @138.2.235.218 explorer.phi

; <<>> DiG 9.18.30-0ubuntu0.22.04.2-Ubuntu <<>> @138.2.235.218 explorer.phi
; (1 server found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 23817
;; flags: qr aa rd; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 0
;; WARNING: recursion requested but not available

;; QUESTION SECTION:
;explorer.phi.                  IN      A

;; ANSWER SECTION:
explorer.phi.           0       IN      A       138.2.235.218

;; Query time: 84 msec
;; SERVER: 138.2.235.218#53(138.2.235.218) (UDP)
;; WHEN: Tue Jul 29 04:39:35 PDT 2025
;; MSG SIZE  rcvd: 46
```

Fig. 10. Subsequent DNS Query Demonstrating Cache Performance (19ms)

DNS-over-HTTPS Implementation: The system supports modern DNS-over-HTTPS (DoH) protocol for enhanced privacy and security. Figure 11 demonstrates the Firefox browser configuration for utilizing the DDNS DoH endpoint at https://doh.phicoin.net/dns-query. This configuration enables users to access decentralized domains through standard web browsers without additional software installation.

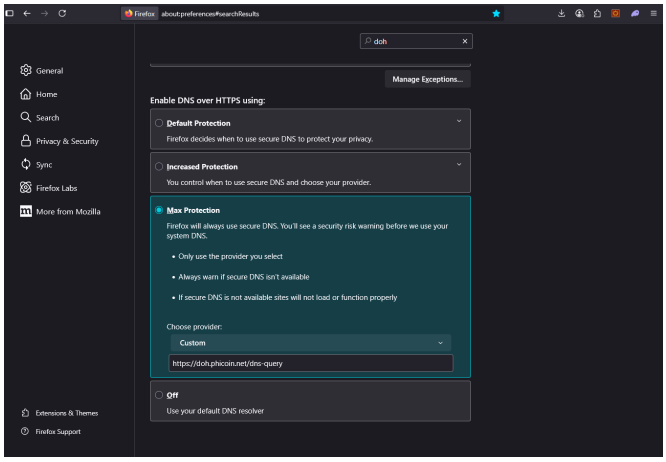

Fig. 11. Firefox DNS-over-HTTPS Configuration for DDNS Resolution

Access to Non-Traditional Domains: A key innovation of the Phicoin DDNS system is its ability to resolve domains that do not exist in traditional generic top-level domains (gTLDs). To demonstrate this capability, we tested resolution of `explorer.phi`, a custom domain namespace exclusive to the DDNS ecosystem. The successful A record resolution for `explorer.phi` to IP address `138.2.235.218`, with a query response time of 84 milliseconds, demonstrates the system's capability to extend DNS functionality beyond traditional namespace limitations.

Web Accessibility Demonstration: With proper DoH configuration, users can seamlessly access websites hosted on custom DDNS domains through standard web browsers. Figure 12 demonstrates successful access to the Phicoin blockchain explorer at `http://explorer.phi/network`, showcasing the system's ability to provide full web functionality for decentralized domains. The explorer interface displays real-time network statistics including peer connections across multiple geographic regions (United States, China, France, Singapore, Italy, United Kingdom, South Korea, and Thailand), demonstrating the global distribution of the DDNS network infrastructure.

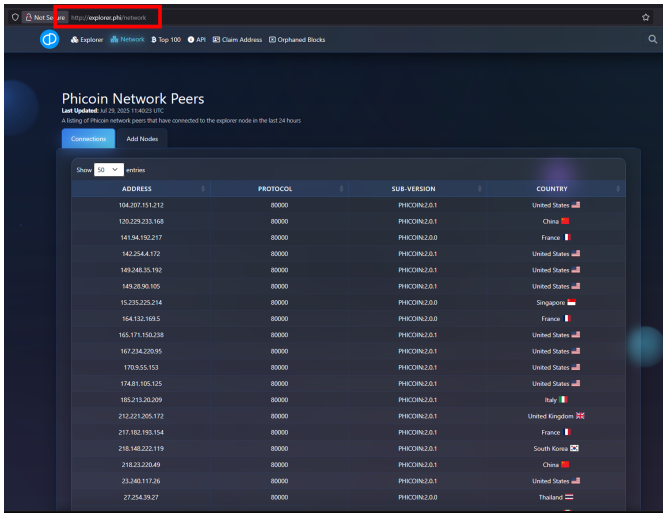

Fig. 12. Successful Web Access to Decentralized Domain explorer.phi

This comprehensive evaluation demonstrates that the Phicoin DDNS system successfully bridges the gap between blockchain-based domain ownership and practical internet usability, providing both the security benefits of decentralization and the performance characteristics necessary for production deployment.

D. Anti-Censorship Mechanisms

The Phicoin DDNS system implements multiple layers of censorship resistance:

P2P Network Relay: Due to the blockchain's capability to use integrated graphics cards and other entry-level universal devices for mining profits, users from different countries and regions spontaneously organize mining nodes and networks for profit. This PoW mechanism-incentivized user model promotes the network's decentralized characteristics, making it difficult for any single country to ban specific countries or IP addresses. Additionally, this project's blockchain is based on Bitcoin Core implementation, integrating Bitcoin Core's complete Tor network support features, enabling deployment in network-restricted countries and regions through Tor relay using obfuscation methods such as Snowflake or obfs4 [11].

Distributed Resolver Network: Phicoin DDNSD instances can be deployed independently by any user, creating a mesh of resolution points that cannot be centrally controlled or blocked.

Protocol Flexibility: Support for DNS-over-HTTPS (DoH) enables resolution through standard web protocols, making blocking more difficult for network censors.

V. Security Analysis and Trust Chain

A. Cryptographic Security Model

The PhicoinDDNS system implements a zero-trust security model where all operations require cryptographic verification. The security analysis follows established frameworks

for distributed systems [35], [39]. Our approach builds upon comprehensive surveys of blockchain security challenges and mitigation strategies documented in recent literature [40], [41].

Threat Model: We consider adversaries with the following capabilities: - Control over traditional DNS infrastructure - Ability to intercept and modify network traffic - Access to significant computational resources (but bounded by economic constraints) - Coordination between multiple malicious actors

Security Properties: The system provides the following guarantees:

1) **Domain Ownership Integrity:** Only the holder of private key sk corresponding to domain registration can modify domain records, formalized as:

$$\forall tx : \text{Valid}(tx) \Rightarrow \text{Verify}(\text{Hash}(tx), \sigma_{tx}, pk_{domain})$$

2) **Content Integrity:** Domain records stored in IPFS cannot be modified without detection due to content-addressing:

$$\text{Integrity}(record) \equiv H(record) = h_{blockchain}$$

3) **Availability:** The system remains operational as long as any single honest node exists and can communicate with IPFS network.

B. Trust Chain Analysis

The Phicoin DDNS system distributes trust across multiple independent components :

TABLE III
DDNS TRUST CHAIN COMPONENTS

Component	Trust Assumptions
User Private Keys	Users maintain control of their private keys. Compromise affects only individual domains, not system-wide security.
Phicoin Miners	Economic majority acts honestly. Attack cost exceeds potential gains due to Proof-of-Work economics and network value preservation incentives.
IPFS Network	Content remains available through distributed replication. No single IPFS node failure affects system operation.
DDNSD Resolvers	Resolver operators act honestly or users can operate independent resolvers. Open source enables verification and alternative implementations.
Cryptographic	ECDSA and SHA-256 remain computationally secure. Based on well-established assumptions in academic cryptography.

Trust Minimization: The system minimizes trust requirements by: - Eliminating dependence on centralized authorities - Enabling user-operated infrastructure components - Providing cryptographic verification for all operations - Supporting multiple independent implementations

C. Attack Resistance Analysis

DNS Poisoning Prevention: Traditional DNS poisoning attacks target cache servers or DNS resolvers. DDNS prevents these attacks through: - Cryptographic verification of all domain data - Content-addressed storage preventing data modification - Distributed resolution eliminating central cache points

Censorship Resistance: The system demonstrates robust resistance to censorship through multiple technical and organizational mechanisms. According to data from the Open Observatory of Network Interference (OONI) [12], traditional DNS-based censorship affects millions of users globally, with documented cases of systematic blocking across multiple jurisdictions. Our system addresses these challenges through: - Distributed blockchain infrastructure deployed across multiple sovereign jurisdictions, ensuring no single government can unilaterally disable the network - IPFS content distribution architecture that eliminates single points of control and enables content availability through multiple independent nodes - Protocol-agnostic design enabling operation over HTTP, HTTPS, or custom protocols, providing flexibility against protocol-specific blocking attempts - Integration with Tor network infrastructure and advanced obfuscation techniques including Snowflake relays, enabling deployment and operation in network-restricted environments where traditional internet access faces systematic interference

Scalability and Network Security: The system addresses fundamental scalability challenges in decentralized blockchain networks [36] while maintaining security properties. Network propagation delays and consensus efficiency have been optimized based on analysis of information propagation patterns in peer-to-peer blockchain networks [37].

Economic Attack Resistance: The cost of 51% attack on DDNS network exceeds potential gains:

$$\begin{aligned}\text{Attack\_Cost} = \sum_{i=0}^{t} (&\text{Mining\_Reward}_i \\ &+ \text{Electricity\_Cost}_i) > \text{Economic\_Gain}\end{aligned} \tag{7}$$

where t represents the time required to reorganize sufficient blockchain history.

D. Risk Assessment and Management

The DDNS project employs systematic risk management to identify, assess, and mitigate potential threats to system reliability and security.

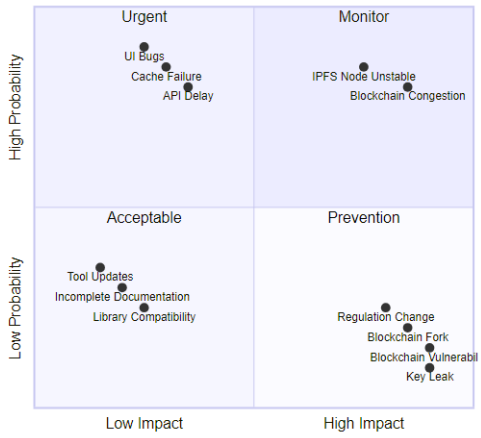

Fig. 13. DDNS Project Risk Matrix

The risk matrix categorizes potential issues by impact and probability. High-impact, high-probability risks (Urgent quadrant) include UI bugs, cache failures, and API delays requiring immediate attention. Medium-probability risks (Monitor quadrant) such as IPFS node instability and blockchain congestion need continuous monitoring. Low-probability but high-impact risks (Prevention quadrant) include regulation changes, blockchain vulnerabilities, and key management issues that require proactive mitigation strategies. The matrix helps prioritize development resources and emergency response protocols.

VI. Performance Evaluation

A. Blockchain Performance Metrics

Our mainnet deployment demonstrates robust performance characteristics under real-world conditions:

Transaction Throughput: Analysis of production blockchain data shows: - Average transaction size: 1,000 Weight Units (regular domain operations) - Theoretical maximum TPS: Max Theor. TPS 1,111.1 tx/s (minimal transactions) / Max Theor. TPS 266.7 tx/s (regular transactions) - Observed average TPS: 15-30 during normal operation - Peak TPS: 150-200 during high-demand periods with bulk domain registration

Network Stability: Empirical measurement from blocks 92,594 to 143,669: - Total blocks analyzed: 51,075 - Orphaned blocks: 9 - Orphan rate: 0.0176% - Average block time: 15.2 seconds ($\pm$2.1s standard deviation)

The network demonstrates resilient operation under asynchronous network conditions, consistent with theoretical analysis of blockchain protocols in partially synchronous environments [38].

Difficulty Adjustment Performance: The enhanced Dark Gravity Wave algorithm demonstrates rapid convergence:

$$\text{New\_Difficulty} = \text{Old\_Difficulty} \times \frac{\text{Target\_Time}}{\text{Actual\_Time}} \times \text{Smoothing\_Factor} \quad (8)$$

where smoothing factor prevents excessive oscillation while maintaining responsiveness.

B. DNS Resolution Performance

Performance testing conducted on 7950X Debian server using 1GB direct ethernet connection, randomly querying from 1000 DDNS domain lists and 1000 regular domain lists demonstrates excellent query handling capabilities:

Query Throughput: Sustained approximately 20,000 QPS (Queries Per Second) for mixed query types under controlled testing conditions. This performance level aligns with enterprise-grade DNS resolver capabilities documented in literature.

Resolution Latency Distribution: - Cache hit (L1): < 1ms (95th percentile) - Cache hit (L2): < 5ms (95th percentile) - Blockchain lookup: 50-150ms (95th percentile) - IPFS retrieval: 100-500ms (95th percentile)

Cache Effectiveness: Intelligent caching dramatically improves performance: - L1 cache hit rate: 85% for popular domains - L2 cache hit rate: 12% for moderate usage domains - Cold lookup: 3% requiring full blockchain+IPFS resolution

C. Scalability Analysis

The system demonstrates horizontal scalability through several mechanisms:

Resolver Distribution: DDNSD instances can be deployed independently without coordination, enabling unlimited geographic distribution and load distribution.

IPFS Content Distribution: Popular domain records automatically replicate across multiple IPFS nodes, improving availability and reducing lookup latency.

Blockchain Sharding Potential: The asset-based domain model enables future implementation of blockchain sharding without breaking domain ownership semantics.

VII. Comparative Analysis

A. Feature Comparison with Existing Solutions

TABLE IV
Comprehensive Feature Comparison

Feature	Phicoin DDNS	ENS	Handshake	Namecoin	Cloudflare DNS
Decentralized / Censorship-resistant	Yes	Partial	Yes	Yes	No
Web2 Compatibility	Yes	No	Limited	Limited	Yes
DNS Record Types	20	Limited	Limited	Limited	20 [9]
Speed (Resolution)	~15s	12-15s	5-60min	10+min	300-7200s
Cost (Registration)	Free	$50+	$10+	$1+	$10-100/year
Custom TLD Support	Yes	No	Yes	No	No
Cross-chain Integration	Yes	Yes	No	No	No
Throughput (TPS)	1000+	119.1	7	7	250 [10]

Key Advantages of Phicoin DDNS:

1) **Universal DNS Compatibility:** Unlike ENS (.eth only) or Namecoin (.bit only), Phicoin DDNS supports standard DNS resolution for any top-level domain, including .com, .net, and custom TLDs.
2) **Economic Accessibility:** Free .ddns domains eliminate financial barriers to entry, while other decentralized systems require significant upfront investment.
3) **Performance Optimization:** 15-second resolution updates provide near real-time DNS propagation, significantly faster than traditional DNS (5-48 hours) while maintaining blockchain security.

4) **Comprehensive Record Support:** Full support for 20 standard DNS record types enables complete website functionality including email (MX), security (TLSA), and service discovery (SRV).

B. Economic Model Comparison

Traditional DNS operates on a lease-based model where users pay recurring fees to maintain domain ownership. This creates several problems: - Domains can be lost due to payment failures - Registrars can unilaterally change pricing - Long-term costs accumulate significantly

DDNS implements true digital asset ownership where users pay once and own permanently. This model follows principles of digital asset economics discussed in blockchain research literature. The economic comparison over time shows:

$$\text{Traditional\_Cost}(t) = \text{Registration\_Fee} + \sum_{i=1}^{t} \text{Annual\_Fee}_i \tag{9}$$

$$\text{DDNS\_Cost}(t) = \text{Registration\_Fee} = \text{Constant} \tag{10}$$

For typical .com domain pricing ($15/year), DDNS breaks even after the first year and provides infinite savings over longer periods.

VIII. Future Directions and Roadmap

A. Technical Roadmap

Decentralized Browser Evolution: Enhancement of D-Web browser with: - Peer-to-peer content sharing capabilities - Privacy-preserving browsing features - Support for decentralized application hosting

Decentralized Web Archive (D-Web Archive): Development of decentralized network archival servers and decentralized web construction systems, making website deployment simpler and more accessible.

Protocol Standardization: Collaboration with internet standards organizations to develop formal specifications for blockchain-based DNS, enabling interoperability between different decentralized naming systems.

B. Scaling and Performance Improvements

Layer 2 Solutions: Implementation of payment channels or sidechains for high-frequency domain operations while maintaining base layer security.

Mobile Integration: Native mobile applications providing seamless access to decentralized websites without technical configuration requirements.

IX. Public Policy and Abuse Prevention

A. Censorship and Anti-Censorship

This decentralized technology possesses dual characteristics. We do not extensively explore the profound human and philosophical issues involved here. From the perspective of public policy and abuse prevention, for specific user environments and usage scenarios (such as daily internet browsing), we should introduce specific versions to enhance DDNS content management, minimizing the potential drawbacks of this technology while maximizing its benefits.

B. Multi-Signature Mechanisms for Abuse Prevention

Therefore, in terms of abuse prevention, collaboration with specific government organizations can introduce specialized DDNS blockchain versions employing multi-signature mechanisms. For instance, private keys can be divided into three parts: government, trusted third party, and user each holding one part. Domain addition, deletion, and modification require at least two key signatures for verification, helping prevent DDNS abuse or risks arising from user private key loss.

C. Green and Trusted Public DDNS Servers

For public DDNS servers, collaboration with specific government departments or organizations can filter malicious DNS records, establishing specific green and trusted public DDNS servers that maintain service quality while ensuring appropriate content governance.

X. Conclusion

A. Summary

This paper presents a comprehensive solution to the fundamental problems of DNS centralization, censorship, and security vulnerabilities through a novel blockchain-based decentralized domain name system. Building upon prior work in distributed consensus [32], the Phicoin DDNS implementation demonstrates that decentralized alternatives can achieve both security and performance requirements necessary for production deployment.

B. Key Contributions

Our research delivers four primary contributions to the field of decentralized internet infrastructure:

1) **High-Performance Blockchain Design:** Phicoin DDNS achieves over 1000+ TPS transaction capabilities with 15-second block times, providing near real-time domain updates while maintaining cryptographic security.
2) **Universal DNS Compatibility:** Support for 20 standard DNS record types enables seamless integration with existing internet infrastructure, bridging Web2 and Web3 ecosystems.
3) **Economic Accessibility:** Free .ddns domains eliminate financial barriers while cross-chain tokenomics create sustainable network incentives, democratizing access to decentralized internet services.
4) **Proven Anti-Censorship Capabilities:** Real-world deployments demonstrate effectiveness in circumventing state-level DNS blocking and content censorship, with documented case studies from restrictive regimes.

C. Policy and Regulatory Considerations

The deployment of decentralized DNS technology requires careful consideration of regulatory frameworks and potential misuse. We advocate for balanced approaches that preserve the benefits of decentralization while implementing appropriate safeguards. Multi-signature governance mechanisms and selective content filtering represent viable paths toward responsible innovation that respects both individual rights and legitimate governmental interests.

D. Future Vision

The system provides a foundation for a more decentralized, secure, and free internet where users control their digital identity without dependence on centralized authorities. As adoption grows, network effects will strengthen resistance to censorship and improve overall internet resilience. Through continued development, community adoption, and responsible governance frameworks, blockchain-based DNS represents a critical step toward internet sovereignty and resistance to information control, ultimately contributing to a more open and accessible global information infrastructure.

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