LNPay©

A General Lightning Network Payment System for Small and Medium Merchants

Author: LNPay Team

June 2025
Version 2.0

A General Lightning Network Payment System for Small and Medium Merchants

Abstract

The traditional international payment system suffers from inherent limitations of high transaction costs, lengthy settlement times, and vulnerability to currency devaluation. We propose LNPay, a peer-to-peer Lightning Network-based payment solution specifically designed for small and medium merchants. By combining custom hardware terminals with advanced node software and protocol-layer innovations, LNPay enables not only instant, low-cost cryptocurrency payments but also creates a tokenized ecosystem that allows merchants to capture value from their transaction activities. The system features anti-inflation mechanisms, AI-driven routing optimization, easy deployment & maintenance, and a token economic model that distributes network value to participants based on their contribution. Our solution eliminates the trust requirements of traditional payment processors while providing merchants with practical tools to expand their business, reduce transaction costs, and mitigate local currency devaluation.

1. Background

The global economy faces mounting challenges, including a deepening government debt crisis, ineffective monetary policies, and eroding trust in the U.S. dollar as a stable reserve currency. As of 2024, the US federal debt has exceeded $36 trillion, with a debt-to-GDP ratio of 130% (US Treasury, 2024). Interest payments account for over 15% of the fiscal budget (approximately 3.3%); the Federal Reserve's sustained high interest rate policy (2024 benchmark rate of 5.25%-5.5%) exacerbates financing costs for the real economy, with manufacturing PMI below the expansion/contraction line for 18 consecutive months (ISM, 2024Q2); The Trump administration's "Global Reciprocal Tariff" policy (effective April 2025) drives up imported goods prices, maintaining US inflation at 4.1% in 2024 (BLS), with significant core service inflation stickiness; Central banks worldwide accelerate "de-dollarization," with the dollar's share of global foreign exchange reserves declining from 72% in 2000 to 58% in 2024 (IMF COFER), a 30-year low. These challenges are leading to high inflation, listless business, and a globally unstable economy.

Decentralised cryptocurrencies have matured into globally recognised assets, driving a paradigm shift in how value is stored, transferred, and secured. As transparent, borderless, and resilient systems, these cryptocurrencies empower individuals and institutions alike, offering flexible payment, financial sovereignty, and a hedge against traditional market vulnerabilities. For example, the first cryptocurrency, Bitcoin (BTC), also known as digital gold, has reached a historically high price of $110,000 per BTC, leading to a total market capitalisation of $2,143 trillion. In addition, the unique capabilities of blockchain technologies (decentralisation, high security, transparency) inspire and enable various financial innovations and applications, such as DeFin, GamingFin, SocialFin, CBDC (Central Bank Digitial Currency), RWA (Real World Assets), etc. However, cryptocurrencies, especially Bitcoin, have the following challenges:

- **Low scalability and high transaction fee vs. lightning network:** Despite Bitcoin's prominence, it faces significant scalability challenges, processing only about 7 transactions per second compared to Visa's 24,000, leading to network congestion and delays. This limitation often results in high transaction fees; for instance, during the April 2024 halving event, average fees surged to $91.89 – a 2,645% increase from the previous month. Such volatility and costs hinder Bitcoin's practicality for everyday transactions, highlighting the need for scalable blockchain solutions (Harvard Technology Review).

  The Lightning Network (LN) is a Layer 2 solution designed to address Bitcoin's scalability issues by enabling off-chain transactions. Built on the concept of payment channels, it allows users to conduct fast, low-cost transactions without burdening the main blockchain, significantly reducing fees and confirmation times. By aggregating multiple microtransactions into a single on-chain settlement, the Lightning Network enhances Bitcoin's efficiency, making it suitable for everyday use cases like micropayments and retail purchases. Today, As of June 2025, the Lightning Network comprises approximately 11,444 nodes and 42,290 channels, with a total network capacity of around 4,301.93 BTC, i.e. about $4.3 billion.

- **Connectivity with traditional financial systems vs. stablecoin**: Cryptocurrencies and fiat currencies are issued in different financial worlds. While traditional finance has a comprehensive system for issuing and administering fiat currencies with clear policies and regulatory laws, cryptocurrencies remain relatively new, lacking established financial policies and regulations, making it difficult to transfer assets between the two systems.

  Stablecoins are a special type of cryptocurrency designed to maintain a stable value by pegging their price to assets like fiat currencies, commodities, or algorithms. Combining the benefits of blockchain, such as transparency and security, with price stability, they are ideal for everyday transactions, remittances, and hedging against volatility. Stablecoins also facilitate cross-border payments, power decentralised finance (DeFi) applications, and bridge traditional and digital economies, driving broader blockchain adoption. Today, the stablecoin market capitalisation has reached $247.243 billion.

While LN and stablecoin help improve the blockchain's scalability and connectivity to the real world, they have not been widely adopted by people for daily business payments. For example, current Lightning Network channel capacity represents only 0.03% of the global cross-border payment market size ($150T) (World Bank), requiring 3,000-fold growth to meet demand. Except for Web3 regulation and education, one of the key reasons is the lack of cryptocurrency POS machines and an incentive ecosystem to encourage their use, which is what this project aims to address.

2. Vision and Mission

Driven by the restructuring of the global monetary system, weakening dollar credit, and Bitcoin's emergence as "digital gold," the Lightning Network, with its core characteristics of ultra-low cost, instant settlement, and censorship resistance, will become the backbone protocol for the next generation of global payment networks. The current infrastructure completeness is less than 10% (benchmarked against fiat payment systems). **We envision** the next 5 years will catalyse the following opportunities:

- Trillion-dollar Payment Channels: Supporting circulation demands for on-chain US dollar stablecoins and CBDCs;

- Hundred-billion Hardware and Service Markets: Covering node equipment, liquidity protocols, and compliance gateways;

- Geopolitical Economic Discourse Power Competition: Countries/enterprises that take the lead in building Lightning Network hubs will control cross-border payment pricing power.

LNPay is committed to becoming the infrastructure leader for global small and medium-sized merchant cryptocurrency payments, promoting the global popularisation and local adaptation of Bitcoin and stablecoin payments through customised hardware terminals and the underlying protocol layer innovation. **Our mission** is to increase the penetration rate of Lightning Network payments in the small and medium-sized merchant segment from the current less than 2% to 5% over the next five years (covering over 6 million merchants globally), building the commercial resilience moat of decentralized payment networks.

3. Project Overview

In an era of economic restructuring and currency trust crises, cryptocurrency payments have evolved from technical feasibility to a revolution in value distribution. LNPay drives this transformation by empowering small and medium-sized merchants to become active creators in crypto-economic networks, pioneering new business paradigms within Bitcoin's Lightning Network.

The innovation lies in LNPay's self-reinforcing value circulation system: every cryptocurrency transaction generates on-chain contribution proof, capturing network growth dividends through tokenization. This "transaction as equity" model allows merchants, from Argentine cafes to Vietnamese e-commerce businesses, to share value distribution rights once reserved for multinational institutions, driving a flywheel of mutual growth between merchants and the network.

LNPay disrupts traditional power structures by replacing centralized hubs like Visa and SWIFT with smart contracts that redistribute transaction fees to merchants. For instance, Philippine merchant Maria, processing 100 daily transactions, saves 83% on payment costs and accumulates ecosystem equity, sharing in future growth. This shift transforms tool users into ecosystem owners, pushing cryptocurrency payments beyond the early adopter stage.

Strategically, LNPay captures the evolution of the Lightning Network, integrating the fragmented needs of 6 million merchants into a decentralized liquidity pool. Beyond payments, LNPay connects DeFi, stablecoins, and the real economy, creating a seamless network for Salvadoran remittances and Indonesian e-commerce payments, forming a digital commercial federation.

LNPay's strategic potential lies in transforming Lightning Network's advantages into essential tools for merchants, aligning user and ecosystem value through token economics, and creating a crypto payment hub for small businesses. This marks the rise of digital economic city-states, redefining trust through code and consensus.

4. Market Analysis

5.1 Market Composition:

- Enterprise-level node equipment: $120 million (driven by cross-border payment demands)
- Mining-type hardware: $80 million (enterprise self-built node risk control needs)
- Operational services: $70 million (increased compliance requirements from EU MiCA regulation)
- Argentine e-commerce platform MercadoLibre deployed 300 nodes, achieving a 98% reduction in cross-border remittance costs (annual savings of $18 million, 2024 financial report)
- Global Lightning Network cross-border payment volume reached $12 billion in 2024 (Wise data), with enterprises needing to deploy nodes to reduce fees (traditional SWIFT average 1.5% vs. Lightning Network 0.01%).

4.2 Vendor Competitive Landscape:

Dimension	Blockstream Greenlight	Lightspark	Umbrel Pro	*LNPay*
Target Customer	Financial institutions, multinational corporations	Payment gateways, technical developers	Tech-savvy small merchants, individual developers	*Anti-inflation-driven small & medium merchants*
Core Features	○ Enterprise-grade node hosting, ○ Multi-signature cold wallets	○ AI dynamic routing optimization ○ Liquidity pool API	○ Open source node hardware ○ Plugin marketplace	○ *Multi-asset settlement POS terminals* ○ *Token incentive mining* ○ *Fiat exchange*
Pricing Model	Subscription fee $500+/month + transaction commission 0.05%	API call fee $0.001/call + liquidity monthly fee	Hardware one-time purchase $599 (no subsequent fees)	*Hardware one-time purchase $399 (no subsequent fees)*
Advantages	Institutional-grade stability (99.99% SLA)	Technical leadership (98% routing success rate)	Low cost, high flexibility (open source ecosystem)	*Anti-inflation necessity coverage, merchant revenue capitalization*
Disadvantages	Too costly for small merchants	Closed ecosystem, no direct merchant benefits	High usage threshold (requires technical foundation) Not customized for commercial scenarios	*Early network liquidity dependent on merchant density*
Differences from LNPay	Serves high-net-worth customers, lacks inclusivity	Tool attribute, no merchant economic model	Only geek-friendly, no commercial closed loop	*Complete ecosystem solution of hardware+protocol+token*

4.3 Market Opportunities

1) B-end Market Penetration Ladder (Source: Grand View Research 2024Q3)

Customer Type	Lightning Network Penetration	Annual Transaction Scale	Core Driving Factors
Multinational corporations	27%	$8.2 billion	Cross-border payment cost optimization (saving 1.2-3%)
Regional leading enterprises	18%	$3.5 billion	Supply chain finance efficiency improvement
Small and micro enterprises	4.7%	$920 million	Fragmented payment demand aggregation

2) Regional Demand Differences

- Southeast Asian Market: Indonesian/Vietnamese central banks require ≥30% localization rate for digital payment infrastructure by 2025, stimulating localized node deployment demand
- EU Market: MiCA regulation provides 15% tax credits for "critical payment nodes" but requires local data storage
- Latin American Market: Argentine central bank allows 30% of corporate foreign exchange income to be settled through the Lightning Network (Central Bank Resolution No.789-2024)

The Lightning Network has entered the scale commercialization stage in the enterprise merchant end (penetration rate 25%+), while the small merchant end is still in its early stages (<5%), but fragmented demands and regional policy dividends will create differentiated opportunities.

3) Target Customer Profile

- Emerging Market Merchants
- Southeast Asian e-commerce businesses with annual cross-border transactions above $50,000 (accounting for 62%)
- Retail store owners in Latin American countries with annual inflation rates exceeding 50%
- Cross-border traders needing daily currency exchange (saving 3-5% exchange rate losses)
- Channel Co-building:
- Collaborating with local payment gateways (such as Indonesia's Doku, Brazil's Pix)
- Agent profit-sharing mechanism: 15% of hardware sales price + transaction flow sharing
- Regulatory Sandbox:
- Establishing regulatory sandbox pilots in El Salvador and Puerto Rico
- Gifting BTC mining machine computing power to the top 100 merchants by transaction volume

5. Technical Solution

5.1 Solution Architecture

Figure 1 illustrates the technical architecture of this project. LNPay functions as a transaction hub, seamlessly connecting merchants, their clients, traditional banks, and the cryptocurrency ecosystem. Each LNPay system can include one or more LNPay devices. These devices support payments in both traditional currencies (e.g., USD, Euro, RMB) and cryptocurrencies (e.g., BTC, ETH, SOL, USDT). Upon receiving a payment, LNPay processes the transaction within seconds, automatically converting the received currency, wither fiat or cryptocurrency, into a pre-defined currency/cryptocurrency using the underlying Lightning Network or Uniswap/exchange services. The almost real-time settlement provides financial certainty and protection against the dynamic changes in currency exchange rates and the volatility of certain cryptocurrencies. All cryptocurrency transactions are securely recorded on the underlying blockchains to ensure transparency and reliability. The privacy of merchants and clients is safeguarded through cryptographic hash-based anonymous addresses.

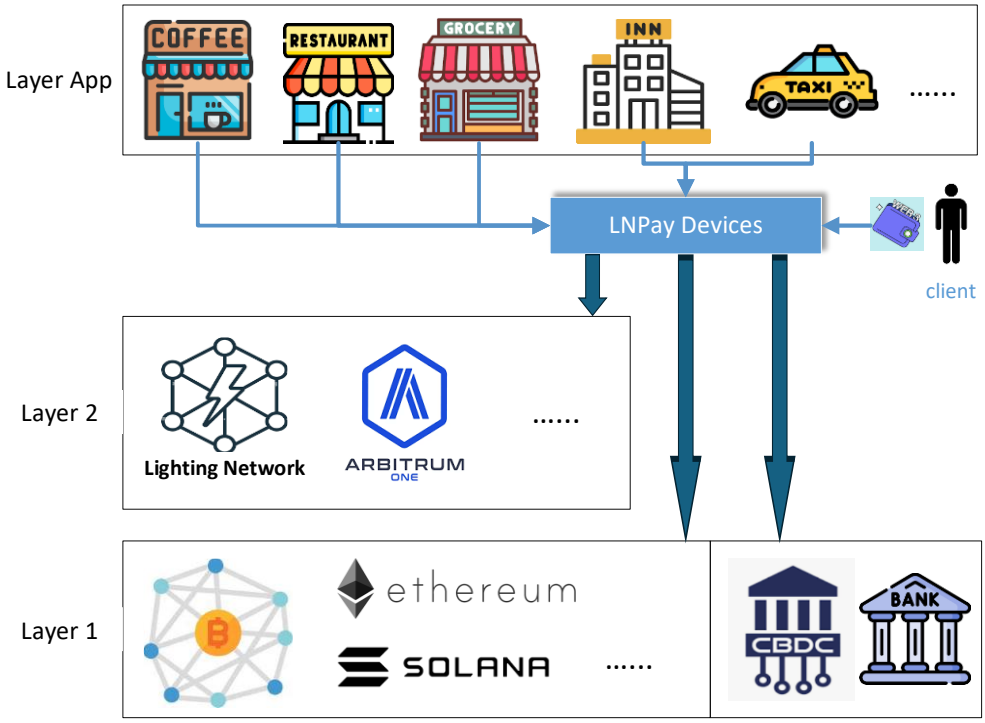

Figure 1. LNPay Architecture

In addition to its POS machine functionality, each merchant's LNPay device or node participates in a decentralized payment network, forming a collaborative transaction ecosystem. Merchants contribute transaction data and earn incentive rewards proportional to the volume of transactions their nodes facilitate. This system, called PayFin, introduces a Web3 financing model that leverages decentralization and transparency to promote fairness and inclusivity.

PayFin reduces reliance on traditional intermediaries, lowering transaction fees and improving efficiency. Its decentralized structure enhances resilience and scalability, while the incentive-driven model fosters active participation and innovation. By aligning with Web3 principles, PayFin empowers merchants and creates a sustainable, equitable financial ecosystem.

Our LNPay solution consists of the following three components:

- **Anti-inflation Payment Terminal:** Custom enterprise-grade POS hardware (compliant with PCI PTS 5.0 standards), supporting instant settlement of Bitcoin and Lightning Network US dollar stablecoins (such as USDT-LN), with per-transaction costs below $0.01 and settlement speeds <2 seconds, providing merchants with tools to hedge against fiat currency depreciation.
- **Smart Revenue Engine:** Integrated AI dynamic routing algorithm that analyses on-chain liquidity distribution and fee fluctuations in real-time, increasing channel fund utilisation by 3-5 times (according to BitMEX Research, traditional node fund idle rates exceed 70%), helping merchants maximise returns.
- **Ecosystem Linkage Services:** Built-in compliant fiat exchange gateway (exchange rate premium ≤2%), airdrop reward aggregator, and DeFi yield protocol access, allowing merchants to seamlessly capture Bitcoin ecosystem growth dividends while completing daily cashier operations.

5.2 Hardware Design

1) Hardware Specification

Component	Specification	Technical Advantage
Processor	Custom Lightning Network optimized chip + Intel N150 chip	Dedicated hardware accelerating Lightning Network transactions, improving signing speed by 300%
Memory	16GB LPDDR4X	Supporting 500+ concurrent payment channel requests
Storage	2TB NVMe SSD	Can store 3 years of transaction records (approximately 150 million transactions)
Display	8-inch 1920x1200 touchscreen	1000nit sunlight visibility, supporting gloved operation
Interfaces	NFC/Bluetooth 5.2/Wi-Fi 6/Ethernet/USB-C	Multi-mode connectivity ensuring payment terminal availability
Battery	10000mAh (24-hour operation)	Supporting QC4.0 fast charging, 50% charge in 30 minutes

2) Security Module Design

- Using NitroKey HSM hardware security module, FIPS 140-2 Level 3 certified
- Supporting Air-Gapped Signing technology for offline transaction signing
- Built-in physical self-destruct mechanism, automatically erasing keys during abnormal disassembly

3) Communication Protocol Specifications

- Lightning Network protocol: BOLT12 specification + Atomic Multi-path Payments (AMP)
- NFC payments: Compliant with EMV L2 standard, transaction response time <200ms

- Bluetooth Mesh networking: Supporting 20-device networking, a coverage radius of 100 meters

5.3 Software Design

1) Software Requirement Specification

Component	Specification	Technical Advantage
KYC	Dhere to local laws and regulations, such as the EU Anti-Money Laundering Directives (AMLD) or the U.S. Bank Secrecy Act (BSA) and Customer Identification Program (CIP), as well as international standards, including ISO 27001 and Data Privacy Standards.	To make individual merchants compliant with their local regulations and international standards.
Adopter(s)	Easy plug-in of various adapters for different lighting networks, L2 blockchains and traditional banks' APIs.	Supporting multiple payment channels
Smart Routing Engine	AI Trust model + Real-time monitoring to select the optimal payment channel	For the best trade-off between reliability and cost
Smart Revenue Engine	A smart contract to: • Capture all transaction data • Automatically distribute rewards • Automatically help merchants to stake if being authorised	To ensure real-time, automatic, and transparent incentives and investments.

2) Software Security Considerations

- Data Encryption - Use strong encryption protocols (e.g., AES-256) for data storage
- Data Communication - Ensure HTTPS for secure data transmission
- Multi-Factor Authentication (MFA) for merchant data access
- Logging and automatic fraud detection & monitoring
- Incident response plan (IRP)

6. Deployment Plan & Roadmap

6.1 Production Process Planning

Phase	Key Tasks	Milestone Indicators
2026 Q1 Trial Production Completion	• Completing the first production line debugging • Passing PCI PTS 5.0 hardware security	First batch of 50 fully inspected units delivered (measured yield rate 99.2%)
2026 Q2 System Adaptation	• Firmware and Lightspark routing engine integration testing • Multi-language cashier interface development (12 languages)	Software stress test pass rate 100% (peak 500TPS)
2026 Q3 Delivery Launch	• First shipment of 3,000 units to Philippines/El Salvador • Establishing regional spare parts centres (Singapore/Mexico City)	Customer acceptance qualification rate 98.7%
2026 Q4 Scale Delivery	• Monthly production capacity increased to 20,000 units • Initiating European CE/FCC certification	Cumulative delivery exceeding 50,000 units

Production Cost Optimisation Path:

- Adopting JIT (Just-In-Time) supply chain model, reducing raw material inventory cycle from 30 days to 18 days;
- Introducing domestic alternative chips, reducing BOM cost by 22%.

6.2 Operation Post-Sale Planning

Region	Repair Center	Spare Parts Warehouse	Response Time	Countries Covered
Northeast Asia	Hong Kong	Shenzhen/Singapore	≤4 hours	Mainland China, Japan, South Korea
Southeast Asia	Singapore	Jakarta/Bangkok	≤4 hours	Indonesia, Philippines, Vietnam, Malaysia
Latin America	Mexico City	São Paulo/Buenos Aires	≤8 hours	Mexico, Brazil, Argentina, Chile
Europe	Frankfurt	Warsaw/Istanbul	≤6 hours	EU 27 countries, Turkey, Ukraine

Service Capability Indicators:

- Spare parts adequacy rate ≥95% (based on historical failure rate prediction model);
- First-time fix rate (FFR) target 92% (industry average 78%).

6.3 Fault Emergency Handling Process

Full-link Tracking System:

- Intelligent Preliminary Inspection: Devices automatically upload daily health status (battery/storage/channel connectivity);
- Root Cause Analysis: Training fault prediction models based on historical data (accuracy ≥89%);
- Emergency Plans:
- When battery health is detected <80%, automatically limiting offline transaction frequency;
- When channels abnormally close, prioritise insurance fund compensation for merchant losses.
- Disaster Recovery Testing (DRP):
- Quarterly simulation of regional data centre failures (such as earthquakes causing Singapore nodes to go offline), verifying failover effectiveness ≤8 minutes;
- Signing an emergency logistics agreement with DHL, ensuring the global delivery of critical spare parts within 12 hours.

7. Risk Factors

While LNPay presents significant innovation in the cryptocurrency payment space, investors and stakeholders should carefully consider the following risk factors:

7.1 Technical Risks

1) Lightning Network Scalability Challenges

- Current Lightning Network capacity represents only 0.03% of global cross-border payment volumes
- Channel liquidity constraints may limit transaction sizes in early adoption phases
- Network congestion during peak usage could impact transaction routing success rates

2) Hardware Production Dependencies

- Supply chain disruptions could delay hardware terminal deliveries
- Reliance on semiconductor availability amid global chip shortages

3) Software Security Considerations

- Potential zero-day vulnerabilities in Lightning Network implementations
- Risk of malicious channel closures requiring watchtower service activation
- Private key management complexity for non-technical merchants

7.2 Market Risks

1) Merchant Adoption Barriers

- Cryptocurrency knowledge gap among traditional merchants
- Resistance to new payment technologies in established markets
- Potential price volatility of Bitcoin affecting merchant confidence

2) **Competitive Landscape**
    - Increasing competition from both traditional payment processors and crypto-native solutions
    - Large financial institutions developing proprietary Lightning Network implementations
    - Potential margin compression as the market matures
3) **Economic Environment Factors**
    - Global economic downturn could reduce merchant capacity for new technology investment
    - Exchange rate fluctuations impacting hardware cost projections
    - Uncertain recovery timeline for cross-border trade volumes post-pandemic

7.3 Regulatory Risks

1) **Cryptocurrency Regulatory Uncertainty**
    - Varied and evolving regulatory frameworks across different jurisdictions
    - Potential new requirements for cryptocurrency payment processors
    - AML/KYC compliance complexity in cross-border transactions
2) **Tax Implications**
    - Unclear tax treatment of cryptocurrency payments in many regions
    - Potential tax reporting burden on merchants
    - Risk of retrospective tax policy changes
3) **Banking Relationships**
    - Challenges in maintaining banking relationships for fiat currency on/off ramps
    - Restrictions on cryptocurrency businesses in certain banking systems
    - Regional limitations on currency exchange services

7.4 Operational Risks

1) **Global Service Network Challenges**
    - Potential delays in establishing service centers in all target regions
    - Spare parts logistics complications in remote markets
    - Technical support quality consistency across diverse markets
2) **Liquidity Management**
    - Initial dependency on LNPay's own liquidity provision until network effect materializes
    - Potential liquidity fragmentation across different geographic regions
    - Currency conversion spread risk in volatile markets

LNPay is actively working to mitigate these risks through robust technical design, phased rollout strategies, regulatory engagement, and building strong local partnerships. However, these risks could potentially impact project timelines and outcomes.

Legal Disclaimer

This whitepaper has been prepared by the LNPay team ("Company") for informational purposes only and does not constitute a prospectus, offering document, or solicitation for investment. The information contained herein is not intended to provide the basis for any investment decision and should not be considered as a recommendation to purchase any tokens or participate in any product or service offered by the Company.

Nature of Document

This whitepaper:
- Is not a financial promotion
- Does not constitute investment advice
- Is not an offer to sell or solicitation of an offer to buy any securities
- Does not represent a complete description of the Company's business model, technical specifications, or development plans

Forward-Looking Statements

This whitepaper contains forward-looking statements based on current expectations, estimates, and projections about the industry and markets in which LNPay operates. These statements involve known and unknown risks, uncertainties, and other factors that may cause actual results, performance, or achievements to be materially different from any future results, performance, or achievements expressed or implied by the forward-looking statements.

Forward-looking statements are identified by terms such as "believes," "anticipates," "expects," "intends," "plans," "will," "may," "should," "could," "would," "likely," "projects," "positioned," "target," "estimate," "forecast," and similar expressions.

No Guarantees of Future Performance

The financial and operational projections, market research data, and technical specifications contained in this whitepaper are estimates based on assumptions believed to be reasonable at the time of writing. However, there can be no guarantee that any projected results will be achieved. Future events and actual results could differ materially from those set forth in, contemplated by, or underlying the forward-looking statements.

- Software Functionality and Development Timeline: Please be advised that certain planned software functionalities described within this whitepaper, including but not limited to the LNPay token incentive mechanism (Transaction Mining Protocol) and specific ecosystem integrations, are subject to ongoing research, development, testing, and potential regulatory approvals. Consequently, these features are not guaranteed to be fully implemented or available upon the initial delivery of the physical LNPay hardware terminals. The Company intends to gradually introduce and enhance these software features through future software updates as development progresses and milestones are met. Timelines presented in the Development Roadmap section are targets and may be subject to change based on development progress, market conditions, and other factors.

Regulatory Compliance

This whitepaper has been prepared in accordance with the general informational requirements at the time of its writing. It is the responsibility of any prospective participant to satisfy themselves as to the full compliance of their participation with the applicable laws of their jurisdiction, including obtaining any required governmental or other consents and observing any other formalities prescribed in such jurisdiction.

No Liability

To the maximum extent permitted by applicable laws and regulations, the Company, its founders, team members, advisors, partners, and affiliates shall not be liable for any direct, indirect, special, incidental, consequential or other losses of any kind, in tort, contract or otherwise (including but not limited to loss of revenue, income or profits, and loss of use or data), arising out of or in connection with any reliance on this whitepaper or any part thereof.

Updates and Modifications

The Company reserves the right to update, modify or revise this whitepaper at any time without notice. Updated versions of this whitepaper will be published on the Company's official website, and the publication of a revised whitepaper will constitute notice of the modifications.

This whitepaper is the most current version as of 11 June 2025.