Pangea Virtual Nation and LEOS Currency Whitepaper

v1.0.3

STICHTING TONOMY

LEOS offering of up to 1,250,000,000 (2.5%) at an Issue Price of $0.002 USD per coin

This crypto-asset white paper has not been approved by any competent authority in any Member State of the European Union. The offeror of the crypto-asset is solely responsible for the content of this crypto-asset white paper

The management body (Executive Board) of the offeror confirms that this crypto-asset white paper complies with Title II of the Markets in Crypto Assets Regulation (MiCAR, REGULATION (EU) 2023/1114 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 31 May 2023) and that, to the best of the knowledge of the management body, the information presented in the crypto-asset white paper is fair, clear and not misleading and the crypto-asset white paper makes no omission likely to affect its import.

Summary

This document serves as the official White Paper for the public offering and potential trading admission of LEOS, the native crypto-asset of the Pangea Virtual Nation. It provides essential information about LEOS, designed to help prospective holders make informed decisions regarding their investment.

The Pangea project aims to establish a sovereign virtual nation leveraging advanced Web 4.0 technologies to facilitate global cooperation and governance without physical borders. Within this framework, LEOS functions as the primary medium of exchange, enabling transactions and access to a wide array of public services within the Pangea ecosystem.

This Whitepaper amalgamates content from three existing papers from the website, supplemented with additional information to ensure full compliance with the EU's Markets in Crypto Assets Regulation (MiCAR) and Dutch laws. It details LEOS's characteristics, uses, and regulatory compliance, emphasising its role and utility within the innovative Pangea project. By presenting this information in transparent, non-technical language, we aim to equip potential investors with all the necessary details to support their participation in this offering, compliant with EU and Dutch regulatory frameworks.

Warning

This summary:

a. should be read as an introduction to the White paper;
b. the prospective holder should base any decision to purchase the crypto-asset (LEOS) on the content of the White paper as a whole and not on the summary alone;
c. the offer to the public of the crypto-asset (LEOS) does not constitute an offer or solicitation to purchase financial instruments and that any such offer or solicitation can be made only by means of a prospectus or other offer documents pursuant to the applicable national law;
d. this White paper does not constitute a prospectus as referred to in Regulation (EU) 2017/1129 of the European Parliament and of the Council (36) or any other offer document pursuant to Union or national law.

Stichting Tonomy is the issuer and offeror of the LEOS and is a foundation, established and operating under the laws of the Netherlands, with its statutory seat in Amsterdam, the Netherlands. The Foundation is registered with the Dutch commercial trade register under number 86537288 and its Legal Entity Identifier (LEI) is 724500NEH6AVYV4INR79. The Foundation's address is Nydia Ecurystraat 31 D, 1087 VV Amsterdam the Netherlands, its telephone number is +31 294 799 023, its e-mail address is contact@tonomy.foundation and its website is https://tonomy.foundation.

The foundation Stichting Tonomy (hereinafter also referred to as: the “Foundation”) is offering up to 7,500,000,000 LEOS, subject to applicable regulatory laws and regulations and on the terms set out in this document, referred to as the “Whitepaper”. The LEOS and the Offering are governed by and shall be construed in accordance with Dutch law. The LEOS will be created in accordance with Dutch law and the articles of association of the Foundation (the Articles of Association).

This Whitepaper has been notified to the Netherlands Authority for the Financial Markets (Stichting Autoriteit Financiële Markten, the “AFM”) pursuant to section 8 of the Markets in Crypto Assets Regulation (MiCAR, REGULATION (EU) 2023/1114 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 31 May 2023).

The validity of this Whitepaper shall expire on 1 August 2026.

Pursuant to section 10 MiCAR it is relevant whether a time limit is set on the offer:

- If so, the offeror shall publish on its website the result of the offer to the public within 20 working days of the end of the subscription period
- If no, the offeror shall publish on its website on an ongoing basis, at least monthly, the number of units of the crypto-assets in circulation.

Pursuant to section 12 MiCAR the offeror shall modify the Whitepaper and, where applicable, its published marketing communications, whenever there is a significant new factor, material mistake or material inaccuracy that is capable of affecting the assessment of the crypto-assets (LEOS). That requirement shall apply for the duration of the offer to the public or for as long as the crypto-asset is admitted to trading. The modified Whitepaper and – if applicable – must be notified to the AFM as well.

The investor could lose all or part of the invested capital. Where a claim relating to the information contained in, or incorporated by reference into, the Whitepaper is brought before a court, the plaintiff investor might, under the national legislation of the Member States of the European Economic Area (each a Relevant Member State), have to bear the costs of translating the Whitepaper and any documents incorporated by reference therein before the legal proceedings can be initiated. Civil liability attaches only to those persons who have tabled the summary including any translation thereof, but only if the summary is misleading, inaccurate or inconsistent when read together with the other parts of the Whitepaper, or it does not provide, when read together with the other parts of the Whitepaper, key information in order to aid investors when considering whether to invest in the LEOS.

Issuer Key Corporate Information

The LEOS cryptocurrency is issued by the Stichting Tonomy, a non-profit organisation registered and operating under the laws of the Netherlands. For comprehensive information about the foundation, stakeholders can visit the official website (https://tonomy.foundation). The organisation is registered in the Dutch commercial trade register with the KVK (Chamber of Commerce) number 86537288.

Stichting Tonomy is governed by a three-person Executive Board responsible for strategic decisions and overall management. A three-person Management Team manages the operational aspects. The organisation benefits from the diverse skills and dedication of 17 contributors and the strategic guidance of 4 advisors, enhancing its capability to achieve its objectives and drive the Pangea project forward.

Issuer Key Financial Information

The Tonomy Foundation maintains a robust financial stance with a working capital of €10,702 and a healthy current ratio of 1.43. The total contributor capital is €47,048, reflecting strong community and stakeholder support.

The balance sheet reveals a stable financial structure with sufficient liquidity to cover short-term obligations and operations, evidenced by the current ratio.

The monthly cash flow statement details the financial activity, showing an approximate cash inflow of €4,977 against a cash outflow of €7,330. This snapshot provides insight into the foundation's operational liquidity and cash management in March 2024.

The financial forecast includes projections for cash flow, balance sheet, and an official income statement. Key factors influencing these projections are the ongoing token sale and the operational scale, indicated by the number of employees and contributors projected to reach 55. The total expected raise from the token sale is anticipated to be $55M USD.

These financial projections confirm that the Tonomy Foundation is solvent and well-prepared for its future development and the scaling of the Pangea project.

Key Risks Specific to the Issuer

This section of the Whitepaper outlines the principal risks associated with Stichting Tonomy, which could significantly impact operational and financial health. These risks include but are not limited to, financial instability, market volatility, and regulatory changes that may adversely affect our ability to operate effectively within the fast-evolving landscape of digital currencies and blockchain technology. While we strive to mitigate these risks through robust management practices and compliance strategies, potential investors should be aware of the challenges we may encounter. This transparency builds investor confidence by providing a clear view of the possible hurdles and our preparedness to address them.

External Audit

To ensure the highest levels of **legal compliance** in the still unclear regulatory environment of Web 3, **cryptocurrency specialists at international law firm Taylor Wessing** (https://www.taylorwessing.com) were consulted to advise the LEOS currency sale. Their expert globally recognised advice has also led the LEOS currency sale to comply with the upcoming EU regulation Markets in Crypto Assets regulations. **LEOS will be one of the first MiCAR-compliant coins on the European market.**

Read more about the Taylor Wessing advice here:
https://pangea.web4.world/news/pangeas-leos-token-a-mica-compliant-pioneer-with-expert-legal-guidance-from-taylor-wessing

Due to the importance of the LEOS currency, a **full audit of the tokenomics** was conducted by experts at the **Swiss company Brightnode** (https://brightnode.io), a reputable global tokenomics service provider.

Read more about the Brightnode advice here:
https://pangea.web4.world/news/navigating-the-future-insights-from-brightnodes-audit-of-leos-tokenomics

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Defined Terms

Admission	the admission of the LEOS to listing and trading on [exchange]
Admission Date	the date of Admission
AFM	the Netherlands Authority for the Financial Markets (Stichting Autoriteit Financiële Markten)
Articles of Association	the articles of association (statuten) of the Foundation as at the date of the Whitepaper
CET	Central European Time
Foundation	Stichting Tonomy
Dutch Civil Code or DCC	the Dutch Civil Code (Burgerlijk Wetboek)
EEA	the European Economic Area
EU	the European Union
EUR, euro or €	the single currency introduced at the start of the third stage of the European Economic and Monetary Union pursuant to the Treaty European Union or EU
Executive Board	the executive board (bestuur) of the Foundation
Executive Board Meeting	a meeting of the Executive Board
Executive Director	a member of the Executive Board
FTE	full time equivalent
LEOS	The token/crypto asset issued by the Foundation as set out in this Whitepaper
Management Team	the management team of the Foundation
Member State	a Member State of the European Union
MiCAR	Markets in Crypto Assets Regulation
Offering	the offering of LOES to investors who are eligible persons to subscribe for LEOS against the Issue Price
Whitepaper	This document

Pangea Virtual Nation - Non-Technical Paper

This document presents an accessible overview of Pangea, a sovereign virtual nation utilising Web 4.0 technologies to enhance global cooperation and governance without physical borders. It emphasises Pangea's commitment to radical transparency, digital security through the Pangea Passport, and decentralised democratic processes, appealing to a broad audience without requiring specialised technical knowledge.

- **Pangea Virtual Nation Paper v1.3** (38 minute read)
- Appendix Document: Appendix 1: Pangea Virtual Nation
- GitHub Link: https://github.com/Tonomy-Foundation/documentation/blob/2a77606e68d4d8cff2d36adaea5d3d203a06149f/whitepapers/Pangea%20Virtual%20Nation%20Whitepaper%20v1.3.pdf?raw=true
  Checksum (sha256):
  1493513055a2eee3778602481661201da3e24da559a16935e16747dcc55e275e

This Github link contains a hash (cryptographic information) that prevents the Tonomy Foundation from modifying this document hosted by Github.

The Checksum contains a hash (cryptographic information) that prevents Github from modifying this document. See How to Check a File Checksum: A Step-by-Step Guide.

LEOS Tokenomics - Crypto-Asset Paper

This detailed paper outlines the economic structure and utility of the LEOS token within the Pangea ecosystem. LEOS is designed as the primary currency for transactions, and access to public services, driving economic activity and incentivising participation within Pangea. The document explains tokenomics, including distribution strategies, use cases, token sales, and long-term sustainability plans, which are crucial for stakeholders and potential customers.

- **LEOS Tokenomics Paper v1.2.1** (19 minute read)
- Appendix Document: Appendix 2: LEOS Tokenomics
- GitHub Link: https://github.com/Tonomy-Foundation/documentation/blob/8babca6ac1a9d513d3167301d74964201fb9103d/whitepapers/Pangea%20-%20LEOS%20Tokenomics%20Whitepaper%20v1.2.1.pdf?raw=true
  Checksum (sha256):
  b24efcd4fbd39ea88c00461dc17beb2443d570240325755fff813f06f46bec99

Pangea Technology - Technical Paper

Focused on the technological infrastructure of Pangea, this technical paper delves into the advanced features of the technology that powers Pangea, which is called Tonomy Gov OS. It covers the security architecture, decentralised identity management, and the integration of

blockchain technology to facilitate seamless, secure, and efficient digital interactions and governance within the Pangea virtual nation.

- **Tonomy Gov OS - Paper v1.1** (1 hour 15 minute read)
- Appendix Document: Appendix 3: Pangea Technology
- GitHub Link: https://github.com/Tonomy-Foundation/documentation/blob/2a77606e68d4d8cff2d36adaea5d3d203a06149f/whitepapers/Tonomy%20Gov%20OS%20-%20Whitepaper%20v1.1.pdf?raw=true
  Checksum (sha256):
  7d138436b3e1133db81e0588622c3f471c18643ea58748394f9bcdea19921c00

Risk Factors

Before investing in the LEOS, prospective investors should consider carefully the risks described below, together with the other information contained in this Whitepaper. The occurrence of any of the events or circumstances described in these risk factors, individually or together with other circumstances, may have a significant negative impact on business, financial condition, results of operations and prospects. The price of the LEOS could decline and an investor might lose part or all of its investment upon the occurrence of any such event.

All of these risk factors and events are contingencies which may or may not occur. Some risks described below may be interdependent. Although the most material risk factors have been presented first within each category, the order in which the remaining risks are presented is not necessarily an indication of the likelihood of the risks actually materialising, of the potential significance of the risks or of the scope of any potential negative impact.
Although the executive board (bestuur) of the Foundation (the Executive Board) and the Foundation believe that the risks described below are the material risks concerning the LEOS, they are not the only risks. Other risks, events, facts or circumstances not presently known to the Foundation or that the Foundation deems to be immaterial could, individually or cumulatively, prove to be important and may have a significant negative impact.

Prospective investors should carefully read and review the entire Whitepaper and should form their own views before making an investment decision with respect to any LEOS. Furthermore, before making an investment decision with respect to any Offer Shares, prospective investors should consult their own professional adviser and carefully review the risks associated with an investment in the LEOS and consider such an investment decision in light of their personal circumstances.

Risks associated with the offer of LEOS (and their admission to trading):

Risk	Mitigation
Risks associated with the offeror/ the Foundation	
Financial Stability Risk: Potential for	Establishing financial reserves, securing

financial instability impacting the project's continuation.	diverse funding sources, and careful financial planning.
Risks associated with LEOS	
Market Volatility Risk: High volatility in token price due to market dynamics.	Implementing token stabilisation tools and educating investors about potential volatility.
Liquidity Risk: Challenges in buying/selling tokens without affecting price.	Forming partnerships with multiple exchanges to ensure sufficient liquidity.
Risks associated with project implementation	
Adoption Risk: Difficulty in achieving widespread adoption of the platform.	Extensive marketing campaigns, stakeholder engagement, and demonstrating clear use cases.
Operational Risk: Inefficiencies in project rollout or delays.	Strong project management practices and contingency planning for delays or setbacks.
Risks associated with the technology used as well as mitigation measures	
Technology Failure Risk: Possibility of technical failures or security breaches.	Continuous technology upgrades, rigorous security protocols, and regular system audits.
Scalability Risk: Issues with scaling the platform as user base grows.	Designing scalable architecture from the outset and periodic scalability testing.

Important Information

General

The validity of this Whitepaper shall expire on 1 August 2026. The obligation to supplement this Whitepaper in the event of significant new factors, material mistakes or material inaccuracies shall cease to apply upon the expiry of the validity period of this Whitepaper.

Prospective investors are expressly advised that an investment in LEOS entails certain risks and that they should therefore carefully read and review the entire contents of this Whitepaper. Prospective investors should ensure that they read the whole of this Whitepaper and not just rely on key information or information summarised within it. Prospective investors should, in particular, read the section "Risk Factors" when considering an investment in LEOS. Prospective investors should also consult their own tax advisors as to the tax consequences of the purchase, ownership and disposal of the LEOS.

a. the crypto-asset (LEOS) may lose its value in part or in full;
b. the crypto-asset (LEOS) may not always be transferable;
c. the crypto-asset (LEOS) may not be liquid;
d. the crypto-asset (LEOS) intended as a utility token may not be exchangeable against the good or service promised in the crypto-asset white paper, especially in the case

of a failure or discontinuation of the crypto-asset project (as described in the chapter of this Whitepaper “The Offering and reasons for the Offering and Use of Proceeds”;

e. the crypto-asset (LEOS) is not covered by the investor compensation schemes under Directive 97/9/EC of the European Parliament and of the Council;
f. the crypto-asset (LEOS) is not covered by the deposit guarantee schemes under Directive 2014/49/EU

The contents of this Whitepaper should not be construed as business, legal or tax advice. It is not intended to provide a recommendation by any of the Foundation, the Executive Directors, the Supervisory Directors, the Underwriter, the Subscription, Listing and Paying Agent or any of their respective representatives that any recipient of this Whitepaper should subscribe for or purchase any LEOS tokens.

Prospective investors should only rely on the information contained in this Whitepaper and any supplement to this Whitepaper. The Foundation does not undertake to update this Whitepaper, unless required by law, and therefore prospective investors should not assume that the information in this Whitepaper is accurate as at any date other than the date of this Whitepaper. No person is or has been authorised to give any information or to make any representation in connection with the Offering, other than as contained in this Whitepaper. If any information or representation not contained in this Whitepaper is given or made, the information or representation must not be relied upon as having been authorised by the Foundation, the Executive Directors[, the Supervisory Directors, the Underwriter, the Subscription, Listing and Paying Agent or any of their respective affiliates or representatives].

Neither the delivery of this Whitepaper nor any sale made hereunder at any time after the date hereof shall, under any circumstances, create any implication that there has been no change in the business or affairs of the Foundation since the date of this Whitepaper or that the information contained herein is correct as at any time since its date.

The Offering and the distribution of this Whitepaper, any related materials and the offer, acceptance, delivery, transfer, exercise, purchase of, subscription for, or trade in LEOS may be restricted by law in certain jurisdictions other than the Netherlands and therefore persons in to whose possession this Whitepaper comes should inform themselves and observe any restrictions.

This Whitepaper may not be used for, or in connection with, and does not constitute, any offer to sell, or an invitation to purchase, of the Offer Securities offered hereby in any jurisdiction in which such offer or invitation would be unlawful or would result in the Foundation becoming subject to public reporting obligations outside the Netherlands. Persons in possession of this Whitepaper are required to inform themselves about and to observe any such restrictions. See the section "Selling and Transfer Restrictions".

Each person receiving this Whitepaper acknowledges that such person has relied only on the information contained in this Whitepaper, and no person has been authorised to give any information or to make any representation concerning the Foundation or the LEOS.

LEOS Classification

Taylor Wessing has classified LEOS as “crypto-assets other than asset-referenced tokens and e-money tokens” within the upcoming EU MiCAR regulation and further sub-classifies it as a “utility token”. Due to the progressive and comprehensive nature of MiCAR, the Tonomy Foundation expects this classification to pave the way for future classifications.

Selling and Transfer Restrictions

The Offering to persons resident in, or who are citizens of, a particular jurisdiction may be affected by the laws and regulations of that jurisdiction. Investors should consult their professional advisers as to whether the investor requires any governmental or any other consent or needs to observe any other formalities to enable the investor to accept, sell, exercise or purchase LEOS.

Receipt of the Whitepaper will not constitute an offer in those jurisdictions in which it would be illegal to make an offer and, in those circumstances, the Whitepaper will be sent for information purposes only and should not be copied or redistributed. If an investor receives a copy of the Whitepaper, the investor may not treat the Whitepaper as constituting an invitation or offer to the investor of LEOS, unless, in the relevant jurisdiction, such an offer could lawfully be made to the investor, or LEOS could lawfully be dealt in without contravention of any unfulfilled registration or other legal requirements. Accordingly, if an investor receives a copy of the Whitepaper or any other offering materials or advertisements, the investor should not distribute or send it to any person in or into any jurisdiction where to do so would or may contravene local regulatory laws or regulations. If an investor forwards the Whitepaper or any other offering materials or advertisements into any such territories (whether under a contractual or legal obligation or otherwise) the investor should draw the recipient's attention to the contents of this section.

LEOS Holder Rights and Obligations

Holder Rights

Access and Utility: LEOS holders can utilise the currency within the Pangea ecosystem to access and engage with various services, from DAO participation to digital identity verification for Web 3 Apps. LEOS serves as a transaction medium, incentivising participation and reinforcing societal protocols within Pangea.

Global Transactions: LEOS can be used to settle payments globally, facilitate transactions both within the Pangea platform and externally, and enhance economic opportunities and financial inclusivity for all participants.

Transfer and Vesting: LEOS is transferable and can be exchanged on secondary markets, adhering to the platform's guidelines and regulatory compliance. LEOS obtained during initial distribution phases may be subject to a vesting schedule, gradually releasing tokens to holders over time.

Holder Obligations

Legal Compliance: Holders of LEOS must ensure compliance with all relevant laws and regulations in their respective jurisdictions concerning the possession and use of cryptocurrencies, including tax laws and any financial regulations.

Adherence to Pangea's Policies: Utilising LEOS within Pangea requires adherence to the platform's democratically established constitution, policies and guidelines. These policies aim to maintain a secure, respectful, and law-abiding environment, prohibiting using LEOS for unauthorised activities and ensuring the platform's integrity and safety for all members.

Amendments to the Rights and Obligations

Amendments to the rights and obligations of LEOS holders will be made amendments to the Whitepaper. Once the Pangea governance system has been in place, policies will be set regarding the rights and obligations of LEOS holders.

KYC/AML Compliance

All purchasers of LEOS must comply with Know Your Customer (KYC) and Anti-Money Laundering (AML) requirements as mandated by the Foundation’s banking partners. This is essential for using regulated payment systems and the successful launch of Pangea.

Sale Details and Pricing

The Tonomy Foundation retains the right to modify details of ongoing currency sale rounds, such as dates, prices or sales mechanisms and platforms. The flexibility is necessary to ensure LEOS sales can be adapted to market conditions and give LEOS the best opportunity for economic growth.

Sale Funds Custody

Crypto assets received as part of the LEOS sale will have the custody of funds received managed by Coinbase using their trusted Coinbase Custody service. Coinbase was chosen as a well-recognised sales partner to give investors further confidence that we can get through Coinbase’s rigorous onboarding and due diligence checks.

Right of Withdrawal

Retail holders who purchase LEOS have a right of withdrawal in conformity with section 13 MiCAR. They have a period of 14 calendar days within which to withdraw from their agreement to purchase LEOS without incurring any fees or costs and without being required to give reasons. The period of withdrawal shall begin from the date of the agreement of the retail holder to purchase those crypto-assets.

The Foundation will reimburse the funds via the same payment channels and mechanisms through which LEOS was purchased, or through mutual agreement.

Issuer Corporate Information

General

This section gives an overview of the material information concerning the corporate structure, Executive Board, the Supervisory Board, the Group's employees and its corporate governance. It is based on, and discusses, relevant provisions of Dutch law in effect as at the date of this Whitepaper and the Articles of Association. The Articles of Association in the governing Dutch language and in an unofficial English translation are available on the Foundation's website.

This overview does not purport to give a complete overview and should be read in conjunction with, and is qualified in its entirety by reference to, the relevant provisions of Dutch law as in effect as at the date of this Whitepaper and the Articles of Association.

Domicile, Legal Form and Establishment

The Tonomy Foundation (Stichting Tonomy) is a Dutch nonprofit foundation based in Amsterdam, Netherlands. It was incorporated on 31 May 2022 by Jack Tanner and Christian Verhoef.

The Foundation's Deed of Incorporation states that its purpose is:
The development, control, release of softwar in the field of decision systems, as well as the creation of transparent solutions for software systems to stimulate the functioning of society and further all that which is related to one another directly or indirectly or may be conducive thereto, all in the broadest sense of the word.

Other important details and identifiers include:

Chamber of Commerce "Kamer van Koophandel" number	86537288
D-U-N-S number	494274811
LEI number	724500NEH6AVYV4INR79
Registered address	Nadia Ecurystraat 31D 1087 VV, Amsterdam
Email	contact@tonomy.foundation
Phone	+31 294 799 023

Management Structure

Board Members

The Foundation's is responsible for its operations. It is primarily responsible for:

- Representing the Foundation
- Protecting the vision and mission of the foundation, including the open source software It builds
- Choosing the management team

As part of the Foundation's official Deed of Incorporation, the board is must be guided by the interests of the foundation and its business or organisation.

During a startup period, it is also customary for the board (the founding team) to to be more involved in the startup's operations.

1. **Jack Tanner**

Masters of Computer Science from Imperial College London and BEng from University of Queensland. 8 years experience as blockchain engineer including working with Atos and MN in finTech, social, govTech and other sectors. Taught blockchain in London with Ethereum Foundation members in early 2016, and major contributor to Ethereum upgradeability standards. Self-Sovereign identity engineer for 4 years with major contributions to DIF and W3C standards. Pioneered 3 startups.
https://www.linkedin.com/in/jack-tanner
https://twitter.com/theblockstalk

2. **Christian Verhoef**

A dynamic leader renowned for his logistics and financial management expertise, coupled with a strong understanding of FinTech. With a Bachelor's in Business IT and Management from Amsterdam University, he brings diverse expertise from roles at The New Fork and as a startup advisor, technology incubator manager and angle investor.
https://www.linkedin.com/in/christiaanverhoef
https://twitter.com/ChrisVerhoef

3. **Chetana Bhardwaj**

Brings over 6 years of experience in leading software projects. As a Scrum Master at KoinWorx BV for 5+ years, she ensures success with innovative solutions. Previously, she spent 6+ years as Inflight Team Lead/Trainer at Airindia Limited. Holding a Bachelor in Political Science from Delhi University, she excels in managing complex tasks and delivering top-notch results within tight deadlines.
https://www.linkedin.com/in/chetana-bhardwaj-21a26398

Board of Advisors

1. **Chris Tanner**

https://www.linkedin.com/in/chris-tanner-ba797431/

2. **John Van Meer**

https://www.linkedin.com/in/johnvanmeer

3. **Dr Jane Thompson**

https://www.linkedin.com/in/drjanethomason/

Management Team

- **Jack Tanner**

Chief Executive Officer and Chief Technology Officer

- **Christiaan Verhoef**

Chief Commercial Officer

- **Chetana Bhardwaj**

Chief Operating Officer

Employees and Contributors

The Tommy Foundation has 17 full and part-time contributors, including the management team above. Explore the team here:
https://pangea.web4.world/team

Corporate Authorisations

The Deed of Incorporation outlines the responsibilities and authorities of the board as follows:

- **Direction of the Foundation:** The board is responsible for directing the foundation and must act in the best interests of the foundation and its associated business or organization.
- **Real Estate Transactions:** The board has the authority to make decisions regarding the purchase, alienation, or encumbrance of registered property.
- **Financial Guarantees and Debts:** The board is authorized to enter into agreements where the foundation acts as a guarantor, a primary debtor, or assumes responsibility for a third party's debt.

In summary, the board plays a central role in managing both the strategic and significant financial decisions of the foundation, ensuring that its actions align with the foundation's interests.

Conflict of Interest

A board member does not take part in deliberations and decision-making if he has a direct or indirect personal interest which conflicts with the interest of the foundation and its business or organisation. If, as a result of this, no board resolution can be taken, the board is authorised to take the board resolution after all with a written record of the considerations underlying the decision.

Issuer Financial Information

The financial information included in this Whitepaper reflects the situation as at the date of this Whitepaper, unless specified otherwise. Neither the issue nor the distribution of this Whitepaper shall under any circumstances imply that the information contained herein is accurate and complete as of any time subsequent to the date of this Whitepaper or that there has been no change in the information set out in this Whitepaper or in the affairs of the Foundation since the date of this Whitepaper.

All figures are in Euros.

Balance Sheet

BALANCE SHEET AT 15 APRIL 2024

CURRENT RATIO	**1.43**	**CASH RATIO**	**1.43**
QUICK RATIO	**1.43**	**WORKING CAPITAL**	**€10,702**

ASSETS		**LIABILITIES**	
CURRENT ASSETS		**CURRENT LIABILITIES**	
Cash	€32,894	Accounts Payable	€6,655
Crypto	€2,617	Short-term Loans	
Accounts Receivable		Accrued Liabilities	€18,154
Prepaid Expenses		Prepaid Expenses	
Inventory		**Total Current Liabilities**	**€24,809**
Total Current Assets	**€35,511**		
		OTHER LIABILITIES	
NON-CURRENT ASSETS		Long-term Debt	
Property, Plant and Equipment (PPE)		Contributed Capital	€47,028
Intangible Assets		**Total Other Liabilities**	**€47,028**
Long-term Investments			
Total Non-Current Assets	**€0**	**TOTAL LIABILITIES**	**€71,837**
TOTAL ASSETS	**€35,511**		

Monthly Cash Flow

The following cash flow is approximate, giving you a rough idea of the foundation's current cash flow (monthly). This has been our approximate monthly cashflow for all the months of 2024.

MONTHLY CASH FLOW
For period of 1-31 March 2024

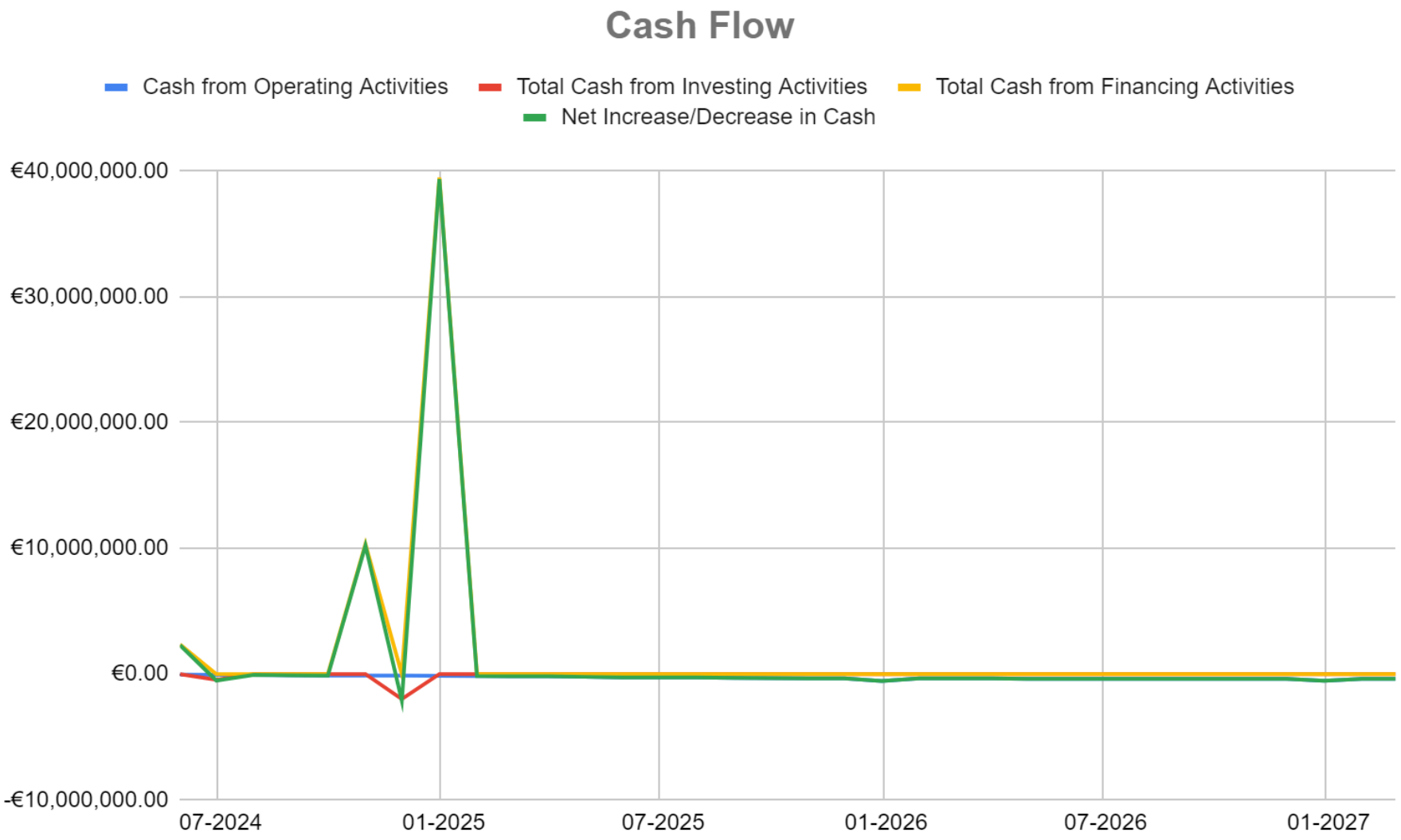
OPERATING ACTIVITIES	
CASH INFLOW	
Software Product Sales	
Service Revenue	€4,977
Receivables	
CASH OUTFLOW	
Supplier Payments	-€6,690
Digital Infrastucture	-€150
Platform Services	-€500
Rent, Utilities and Overhead	
Research and Development	
Taxes Paid	€10
Net Cash from Operating Activities	**-€2,353**
INVESTING ACTIVITIES	
Sale of Capital Assets	
Purchase of Equipment	
Net Cash from Investing Activities	**€0**
FINANCING ACTIVITIES	
Repayment of Long-term Loans	
Net Cash from Financing Activities	**€0**
INCREASE IN CASH DURING PERIOD	**-€2,353**

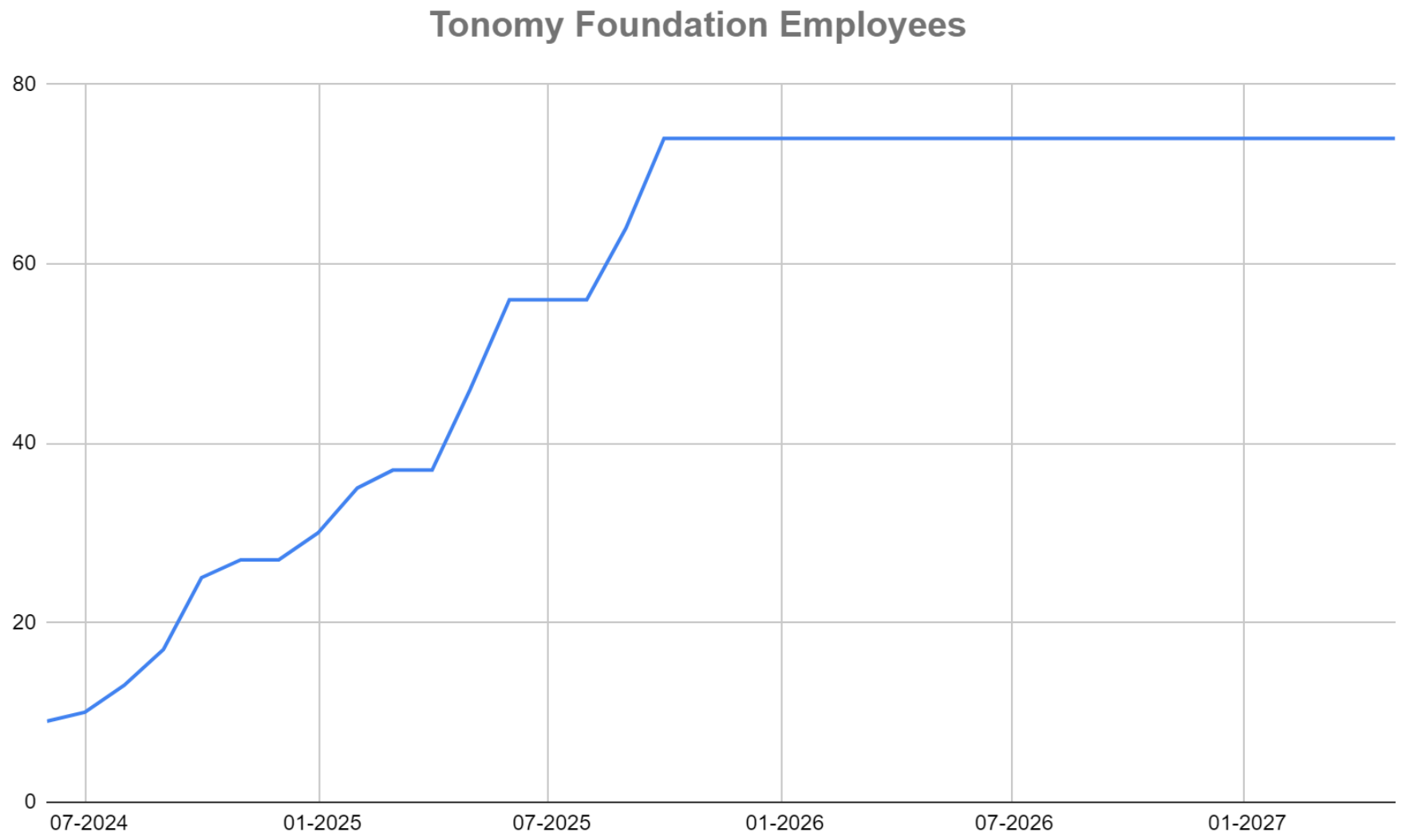
Financial Forecast

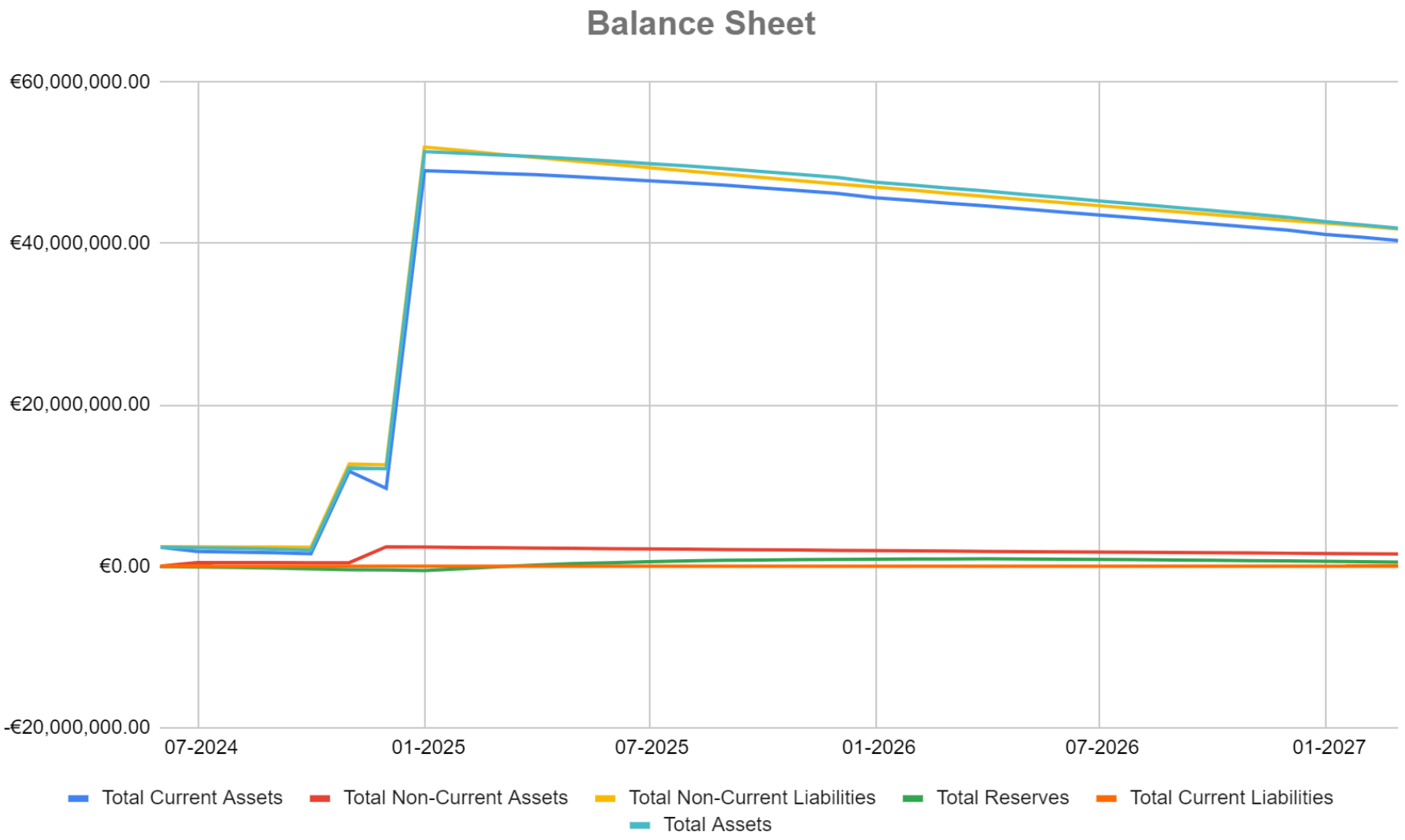
The following documents have been prepared to understand the token sale and the projected financial impact of the Tonomy Foundation.

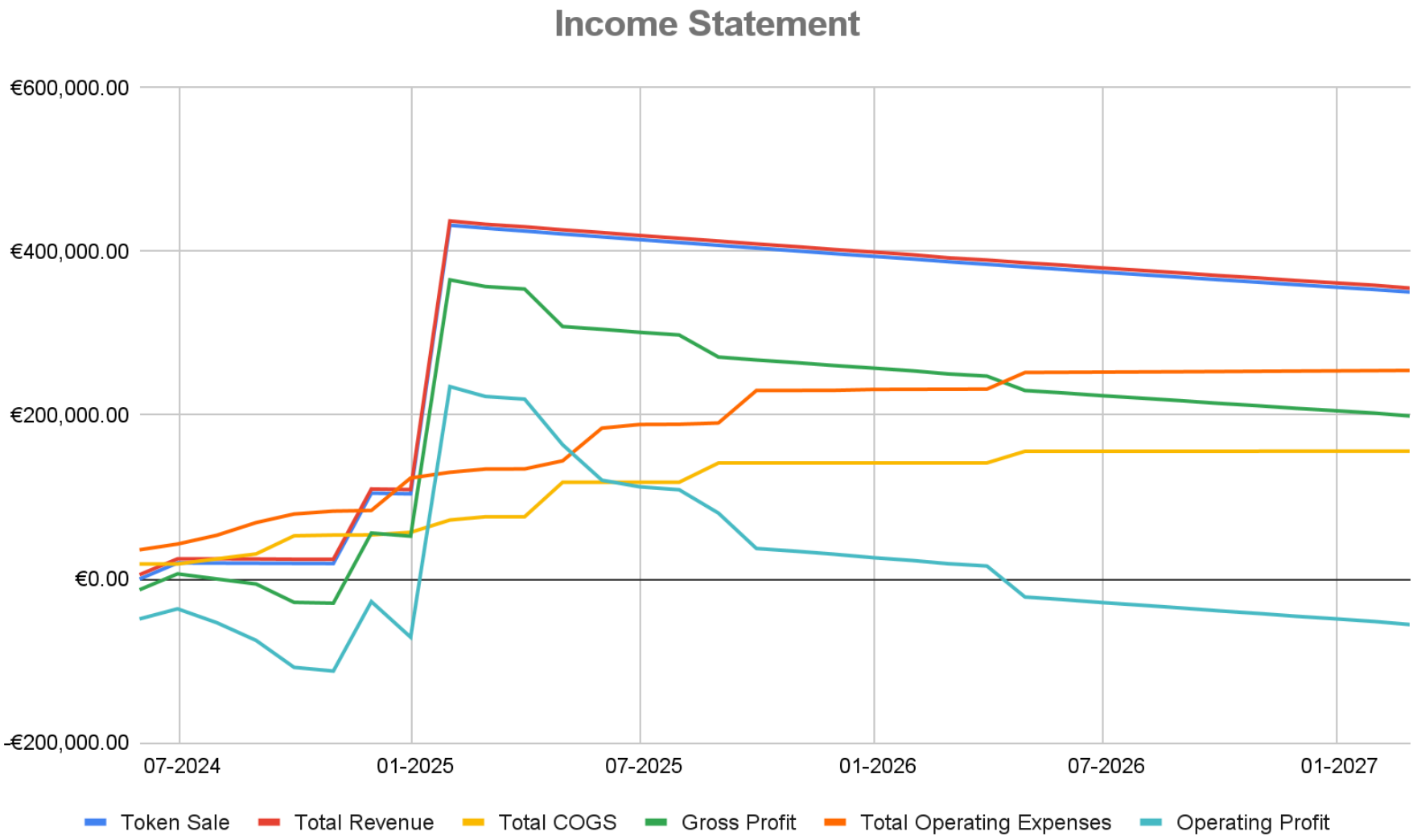
On the following pages, you will find:

- Cash Flow: Shows the assets and cash movement per month.
- Employees: The number of employees shows the plan hiring strategy, which is a crucial expense factor for the operation.
- Balance Sheet: Shows the current and non-current assets and liabilities of the Foundation
- Income Statement: This shows the official monthly income statement we expect to present. Amortisation is used on all expenses and income.


Cash Flow
Cash from Operating Activities
Total Cash from Investing Activities
Total Cash from Financing Activities
Net Increase/Decrease in Cash
€40,000,000.00
€30,000,000.00
€20,000,000.00
€10,000,000.00
€0.00
-€10,000,000.00
07-2024
01-2025
07-2025
01-2026
07-2026
01-2027


Tonomy Foundation Employees
80
60
40
20
0
07-2024
01-2025
07-2025
01-2026
07-2026
01-2027


Balance Sheet
€60,000,000.00
€40,000,000.00
€20,000,000.00
€0.00
-€20,000,000.00
07-2024
01-2025
07-2025
01-2026
07-2026
01-2027
Total Current Assets
Total Non-Current Assets
Total Non-Current Liabilities
Total Reserves
Total Current Liabilities
Total Assets


Income Statement
€600,000.00
€400,000.00
€200,000.00
€0.00
-€200,000.00
07-2024
01-2025
07-2025
01-2026
07-2026
01-2027
Token Sale
Total Revenue
Total COGS
Gross Profit
Total Operating Expenses
Operating Profit

Taxation

Taxation of the Tonomy Foundation is in the Netherlands.

Persons receiving or using the token are responsible for their own taxes.

Expenses of the Offering

Two important external bodies were consulted to assist with the LEOS token sale

1. Taylor Wessing was contracted to provide legal guidance for the sale of the LEOS token for regulatory compliance. Taylor Wessing is a reputable international law firm that has guided other successful token sales.
2. Brightnode was contracted to conduct a network and sale tokenomics audit of the LEOS token. Brightnode is a reputable Swiss tokenomics and web3 services company.

Related Party Transactions

Within the Foundation, several transactions have involved parties related to the organisation, typically termed "Related Party Transactions".

1. A loan provided by Jack Tanner, one of the founders, amounting to €45,028, used as founding capital for the foundation. Out of this, €21,813 has already been repaid.
2. A smaller loan of €8,095 from Christian Verhoef, which has been fully repaid, reflecting the foundation's commitment to fulfilling its financial obligations to involved parties.
3. Chetana Bhardwaj, also part of the founding team, contributed €2,000 as founding capital.

These transactions underline the financial involvement and support of the founding members in the initial phases of the foundation's development.

Appendix 1: Pangea Virtual Nation

Pangea Virtual Nation Whitepaper

The Global Sovereign Virtual Nation
With Radically Transparent Governance
And
Universally Recognized Citizenship

Overview, Strategy & Governance v1.3.1

By the Tonomy Foundation

Pangea: An Overview

Pangea is a virtual nation built on Web 4 technologies designed to enhance interactions and transactions across digital infrastructure and beyond. It is a unique upgrade to Web 3 with an innovative digital platform for collaborative governance at multiple scales. This will enable enhanced discussion, cooperation and action to deal with challenges that cross traditional sovereign and corporate boundaries, for example, climate change. Leveraging the robust Tonomy Gov OS the Pangea platform is transparent, facilitating business practice, legal entity creation, and equitable financial systems. Security is paramount and managed by the digital sovereign identity app – the Pangea Passport.

Capabilities

The tried and tested Pangea Passport is a digital sovereign security (or digital ID) that is already in operation, and ready for multiple market sectors. It provides a passwordless, decentralised, privacy compliant and easy, highly secure digital environment. The Passport is powered by advanced cryptography, using zero knowledge architecture ensuring there is no centralised database containing private, personal data. This enables the secure management of personal and institutional data, in a way that has not previously been practical at scale.

Pangea enables a democratic digital community or liquid democracy at multiple scales – from a cooperative to a global nation. A liquid democracy is a form of delegative democracy, whereby a community engages in collective decision-making through direct participation and dynamic representation, powered by a digital platform. Central to this is the digital ID.

The platform provides for the efficient management of legal entities like decentralised autonomous organisations (DAO), or more traditional organisations, enabling fast, efficient and economic management of human resources, access authorizations and agreements. It provides out-of-the-box Tooling to enable highly secure advantage management and governance of apps, their users, algorithms and smart contracts.

Taken together, Pangea provides a platform for a global sovereign/autonomous zone - a new self-regulating global legal zone – with seamless international business operation, management of internet applications and digital commons for businesses and entrepreneurs.

Performance

Pangea's performance sets a new benchmark for Web 3 applications. It is:

- Very fast (0.5 second latency and 15,000+ transactions per second);
- Energy efficient (comparable or better than competitors, and 100's of times better than Ethereum);
- The only fully decentralized, passwordless & serverless IAM and DAO solution with optional MFA;
- Provides fully anonymity and privacy of citizen data while simultaneously enabling social accountability of citizens to prevent hacks and fraud; and,

- Provides a seamless platform for always accessible and secure digital identities for citizens and institutions such as businesses, enterprise, communities and governments.
- The user experience far exceeds other platforms solutions.

Economy and LEOS (Ł) Currency

The LEOS (Ł) token within the Pangea ecosystem signifies a pivotal development in the realm of digital governance and decentralized economies. As the native currency of Pangea, LEOS underpins a novel and inclusive economic model designed to facilitate transactions, incentivize participation, and re-enforce the nation's society protocols. With the backdrop of a burgeoning decentralized digital identity market, projected to grow significantly in the coming years, LEOS is positioned as a critical asset. It not only serves as the primary medium of exchange for services like reusable identity verification and DAO participation but also embodies the potential for much needed economically viable utility, reflective of Pangea's market exposure and innovative approach to data security and participatory governance.

The economic framework of Pangea, with LEOS at its core, is designed to balance network participants security, sustainable incentives and fees and allow seamless global payments for goods and services within and external to Pangea. Through a variety of roles ranging from individual citizens to collective DAOs, the ecosystem fosters a vibrant economy where LEOS circulates as the backbone currency. This circulation is governed by strategic mechanisms to counteract dishonesty and cybersecurity threats, thereby ensuring the integrity and resilience of the network. Moreover, the governance system of Pangea, underpinned by LEOS, facilitates a transparent and equitable economic environment. This environment rewards contributions, manages blockchain resources efficiently, and dynamically adapts to internal and external economic conditions, securing Pangea's position as a leading figure in the evolution of global digital governance and economic systems.

Pangea - LEOS (Ł) Tokenomics contains more information about the Economic design and LEOS currency.

Why? In a 'Nutshell'

Pangea offers out-of-the-box, mainstream-ready building blocks of identity, institutions, governance and accounting in one seamless platform. It provides breakthrough technology for data security, the backbone of a digital community or nation using the ideas of liquid democracy and management of new legal entities. It is faster and better than its competitors. The technology is powered by Tonomy Gov OS which has a proven track record. Pangea puts people and communities first, it will be good for the planet, and for economies at multiple scales.
Pangea is now seeking venture capital to underpin managed growth and will realise significant capital gains with ongoing participation in various revenue streams.

Founder Jack Tanner
Master Computer Science - Imperial College
Bachelor Engineering - 1st Class Honours University Queensland

Contents

Introduction

Pangea: a twist on the original term of a super-continent combining all landmass, now envisaged as a digital sovereign nation open to all citizens.

In an era defined by rapid technological advancement and interconnectedness, the concept of nation-states is being reimagined. Enter the age of 'Digital Nations' - virtual ecosystems where governance, community, and economic interactions are defined not by physical borders, but by digital connectivity and shared ideologies. These nations are more than just digital spaces; they represent a transformative approach to how societies organise, interact, and govern themselves in an increasingly digital world.

Digital Nations leverage advanced technology to facilitate direct democracy, transparent governance, and decentralised administration, all while prioritising digital identity, security, and privacy. They provide the means to ‘sidestep’ the lottery of where you are born. They stand at the forefront of using blockchain technology for maintaining immutable records, executing smart contracts, and upholding the integrity of digital interactions.

Purpose and Vision

Pangea is at the vanguard of this digital revolution, conceptualised as a comprehensive Digital Nation. It's a visionary platform where innovative technology aligns with humanity's aspirations for justice, autonomy, and cooperative living. Pangea's vision extends beyond global governance, delving into state, provincial, and community-level project and market management, fostering open and fair opportunities for participation and governance in various societal layers.

This vision is grounded in creating an ecosystem that is not only globally inclusive but also resonates with local and communal identities, offering a balanced approach to managing commons, markets, and governance structures at multiple societal levels.

Pangea will provide the opportunity to participate in a ‘digital world’ with enhanced digital security, seamless institutional and business to business incorporation, management and interactions, and low cost financial transactions.

Figure 1: Pangea ecosystem

Scope

The scope of this document is to outline the *launch* vision for Pangea, the governance model, and the key technical capabilities of Tonomy Gov OS which are being utilized. Other important documents can be found here:

https://pangea.web4.world: A highly visual graphical summary of Pangea's value propositions, LEOS and technology building blocks

Pangea - LEOS (Ł) Tokenomics: A description of the economics and LEOS currency used in Pangea

Tonomy Gov OS White Paper: The technical white paper describing the technology that powers Pangea

Pangea - Vision 2030: The long-term vision for Pangea

Journey to Pangea

Need

The creation of Pangea is driven by critical needs identified within traditional nation states nations, the centralized architectures of Web 2.0, and the emerging challenges of Web 3.0, each presenting unique obstacles that hinder the advancement and equitable governance of digital and physical communities.

Traditional State Nations:

- **Bureaucratic Inefficiencies:** Traditional governance structures are often mired in inefficiencies, with studies indicating that bureaucratic red tape costs economies billions annually. For example, the World Bank highlights that businesses globally spend an average of 240 hours a year on tax compliance alone[1], underscoring the need for more streamlined governance systems.
- **Transparency and Trust Issues:** Transparency International's Corruption Perceptions Index reveals that more than two-thirds of countries score below 50[2], on a scale where 100 is very clean and 0 is highly corrupt, indicating a pervasive issue of trust in state governance.
- **Limited Public Engagement:** The OECD “How’s Life” has found that 1 in 3 people in OECD countries (which represent the more optimistic list of countries that engage with their citizens) feel they have a say in what the government does[3], actual public participation in policy-making remains low, highlighting a gap in inclusive governance.

Web 2.0 Centralization:

- **Data Privacy Concerns:** According to a report by the Pew Research Center, 8 in 10 adult Americans are concerned about the way companies use their data[4], emphasizing widespread privacy concerns in centralized Web 2.0 platforms.
- **Platform Dependency and Monopolies:** Hardvard Business Review found that more than 50% of global spending went through Meta (Facebook) or Alphabet (Google)[5], leading to monopolistic practices and reduced innovation diversity.
- **Security Risks:** Cybersecurity Ventures reports that there is a hacker attack every 44 seconds, with the average cost of a hack being $150 million[6], largely due to vulnerabilities in centralized Web 2.0 infrastructures.

Web 3.0 Fragmentation and Accessibility:

- **Complexity and Usability:** Cointelegraph revealse that complexity and technical jargon stands as one of the major obstacles to blockchain and web3 adoption[7]. This emphasizes that user interfaces often fail to meet the needs of non-technical users, hindering widespread adoption.
- **Data Privacy and Compliance:** Despite blockchain's promise of enhanced security, current protocols struggle to offer practical privacy solutions that align with data protection regulations like GDPR. The European Parliamentary Research Service has recognized the large discussions and contradictions of blockchains core feature to deny erasure and GDPR’s right for data to be erased[8], underscoring a critical gap in compliance and user trust.
- **Governance and Regulation:** The decentralized nature of blockchains presents significant challenges in self-regulation, contributing to vulnerabilities that hackers exploit that go without adequate justice. According to a report by DE.FI, the blockchain sector saw losses of $2 billion in 2023 due to thefts, hacks, and fraud[9], illustrating the urgent need for effective governance and regulatory frameworks within Web 3.0 ecosystems.

These statistics underline the pressing needs across the three areas, revealing systemic issues that demand innovative solutions for a more efficient, transparent, and inclusive global ecosystem. Pangea has been envisaged to respond to these issues, and the Goals below set this out.

Goals

Pangea's goals are ambitious and multifaceted, reflecting the broad aim to provide an essential building block enabling a holistic Digital Nation:

Delivering Private yet Open Technical Systems: Pangea is committed to enhanced digital security – the Pangea Passport – powered by the proven the Pangea blockchain, with a functional easy to use, 'open' and human centric interface.

Creating Inclusive and Efficient Markets: A key goal is to establish cheaper, more efficient, and trustworthy markets. Pangea aims to facilitate seamless collaboration and the exchange of goods and services, enhancing economic opportunities for all. Low cost, highly secure micro and B2B transactions are enabled.

Fostering Participatory Governance: At its core, Pangea will implement a governance model that is transparent, inclusive, and participatory. Using blockchain technology, it will ensure integrity and fairness in decision-making, covering global, local and community governance spheres.

Pangea is a unique platform in the emerging Web 4.0 space, providing various services such as digital sovereign identity and data security (Tonomy ID), personal and institutional data management, a democratic digital community using liquid democracy, efficient management of legal entities like DAOs, and a global sovereign/autonomous zone for seamless international business.

Core Technology – Tonomy Gov OS

At the core of the Pangea ecosystem lies the Tonomy Gov OS, a robust and modular software backbone designed to revolutionize digital governance and identity management. Central to this system is the Tonomy ID, rebranded as the Pangea Passport, which epitomizes digital sovereignty with its advanced, user-friendly, and privacy-compliant features. This comprehensive framework supports a wide array of functionalities including:

Decentralized Identity: Through Tonomy ID, offering a secure, passwordless, and privacy-oriented digital environment.

Inclusive Governance: A holistic platform accommodating various governance models for transparent and broad participation.

Dynamic Institution Management: Facilitating the creation and management of DAOs with its flexible infrastructure.

Integrated Financial Solutions: Embedding transparent monetary and accounting mechanisms within the ecosystem.

The development and credibility of Tonomy Gov OS are underpinned by the Tonomy Foundation's extensive research, collaboration, and practical implementations over the past eighteen months. Noteworthy achievements include:

- Significant advancements in decentralized identity standards in partnership with the W3C and the Decentralized Identity Foundation.
- The launch of Tonomy ID and its positive market reception and strategic partnerships, alongside contributions to the Telos Network and the successful Tonomy Participate project.

These efforts underscore the Foundation's commitment to and capability in delivering cutting-edge, scalable solutions for the digital age, positioning Pangea as a leader in the next generation of digital governance and community building.

Trends in Digital Democracy and Virtual Nations

In the dynamic landscape of digital democracy, a revolutionary transformation is unfolding, one that sees the **decentralization of power from traditional, centralized institutions to a more dispersed, democratic network**. This evolution is significantly propelled by blockchain technology, which serves as the backbone for a new era of autonomous governance. This transition isn't merely a technological upgrade; it encapsulates a profound societal shift towards governance systems that are **more transparent, accountable, and inclusive**.

The incorporation of Artificial Intelligence (AI) alongside blockchain technology in governance frameworks marks a pivotal trend. This combination promises to revolutionize decision-making processes, offering **efficiency and insights driven by data** like never before. It's a testament to the growing recognition of technology's role in fostering democratic values and efficient governance.

As we navigate through the digital age, the concept of identity extends beyond the physical realm, making digital identity and security paramount. The quest for a **secure, verifiable digital identity is no longer optional but essential**. This need is vividly illustrated by initiatives like Estonia's pioneering e-Residency program, which offers a sneak peek into the potential of digital citizenship. Pangea's Passport, built using Tonomy ID, builds upon and exceeds these initiatives, providing a more comprehensive, decentralized solution for digital identity, ensuring accessibility and security for all.

Estonia stands as a beacon of what digital governance can achieve, offering a suite of digital public goods unmatched by any. Pangea draws inspiration from Estonia but transcends its model by employing a **decentralized, zero-knowledge technology stack** that is permissionless, global, and universally accessible, embodying the true essence of a global sovereign virtual nation.

The concept of "virtual nations" has seen various iterations, often manifesting as online communities. Yet, these attempts often stumbled upon the centralization hurdle, eventually succumbing to the jurisdictions they operated within. The notion of the "network state" has sparked considerable discourse[24], yet tangible success has been elusive due to inherent structural limitations.

Cryptocurrencies, however, have offered a glimpse into the potential for virtual nations, creating sovereign financial jurisdictions with decentralized governance, as seen in Bitcoin and Ethereum.

These platforms demonstrated the feasibility of autonomy but also highlighted the challenges, particularly in governance and security.

Previous ventures into virtual nationhood using decentralized infrastucture, such as Bitnation and Nation3, encountered significant obstacles, primarily due to the nascent state of underlying technologies. Pangea distinguishes itself by leveraging mature, proven technologies, backed by extensive research and development, ensuring technical feasibility without compromising on decentralization or security.

However, the **micronation** of Liberland has emerged as a notable example, adopting a technology-progressive approach by embracing web3 governance norms. Despite its innovative governance model, Liberland's political scope remains limited, illustrating the challenges of achieving comprehensive virtual nationhood within the constraints of existing technologies and political frameworks.

Liberland's journey underscores the intricate balance between technological innovation and political viability, serving as a pivotal case study for Pangea's strategic development. As outlined in the Pangea Vision 2030 document, Liberland is identified as a primary use case for the Pangea platform during its secondary phases. This strategic inclusion not only acknowledges Liberland's pioneering efforts in web3 governance but also positions **Pangea as a scalable, inclusive solution capable of accommodating and enhancing such innovative governance models**.

The journey towards virtual nations has been paved with extensive research and development, particularly in decentralized identity and governance systems. Recent advancements, propelled by W3C Decentralized Identiters[25] standards and innovations in DAO technologies, have laid the groundwork for what Pangea envisions as its "core public services," analogous to the public services provided by traditional nations.

Pangea stands at the forefront of this new era, not as just another project, but as a holistic, **human-centric approach** that integrates the lessons learned and technologies developed from past endeavors. The Tonomy Foundation, with its deep institutional knowledge and **expertise in web3, decentralized identity, and governance**, is uniquely positioned to bring the vision of Pangea to life. This initiative is more than plausible; it is a tangible reality, drawing on the rich tapestry of digital democracy's evolution to create a virtual nation that is **inclusive, secure, and sovereign**. Pangea is not just the next step in digital governance; it is the leap into a future where virtual nationhood is **not only achievable but inevitable**.

Table 1 in Comparison with Existing Governance Infrastructure shows a more granular comparison of Pangea to existing governance structures.

Initial Target Audience Identification

At the heart of Pangea's initial citizen audience are the **tech-savvy individuals** who embrace digital innovation daily. These are people for whom technology is not just a tool but a lifestyle, and they are constantly seeking new ways to integrate digital solutions into their personal and community

endeavours. Alongside them stand the **advocates of decentralisation**, who see decentralised systems as the cornerstone for fair and equitable governance. These individuals are the pioneers, advocating for a world where power and decision-making are distributed and transparent.

In parallel, in a world where large amounts of the population are struggling to interact with new technology, Pangea brings the power of emerging technology to all users. It does away with centralised security solutions (like existing single sign on with Google). It is the only fully decentralized, passwordless & serverless IAM and DAO solution with optional MFA providing full anonymity and privacy of citizen data to prevent hacks and frauds.

Pangea also resonates deeply with **global citizens and expatriates**—those who live beyond the confines of traditional nation-states and seek a platform that reflects their global identity. Additionally, we see immense potential in **communities seeking autonomy**, such as Catalonia or small island nations. These groups represent not just market opportunities but also partners in shaping a new paradigm of self-governance. Lastly, the **environmentally and socially conscious** are integral to our community. They bring passion and purpose to our platform, driving change on climate action and social equity.

Demand and Opportunities

The demand for platforms like Pangea is underscored by the emerging challenges and opportunities in the digital world, supported by statistics and real-world examples:

Need for Secure Digital Identity Systems: A study by McKinsey Global Institute suggests that implementing digital IDs can unlock economic value equivalent to 3-13% of the 2030 GDP in emerging economies. The Pangea Passport, as a sovereign identity model, can play a pivotal role in this transformation by providing secure and universally recognised digital identities, especially in areas with low trust in traditional systems.

Opportunities in E-Governance Services: The United Nations E-Government Survey 2020 highlights a global trend towards digital government services, while also noting that most participatory discussions are still facilitated through social media at the city level. Pangea's platform aligns with this trend, offering enhanced e-governance solutions that are more transparent and participatory.

Collectively Owned, Autonomous Currencies: The increasing interest in decentralised currencies is evident from the rapid growth of the cryptocurrency market, which reached a valuation of over $2 trillion in 2021[10]. Pangea's vision of creating collectively owned, autonomous currencies aligns with this trend. These user-friendly mediums of exchange can empower communities by facilitating equitable financial participation and offering an alternative to traditional financial systems. This approach not only fosters economic inclusivity but also aligns with the growing global interest in financial autonomy and community-driven economic models.

Creating Decentralised Marketplaces: The rise of decentralised finance (DeFi) has shown the potential for blockchain-based systems to transform markets. As per a report by DeFi Pulse, the total value locked in DeFi projects grew from under $1 billion in 2019 to over $40 billion in 2021[11],

indicating a significant market opportunity for decentralised marketplaces like those Pangea can facilitate.

Autonomous Governance Systems for Communities: Instances like Catalonia's push for independence or the self-governance efforts of small island nations demonstrate a real-world need for autonomous governance models.[12] Pangea can offer these communities the tools and infrastructure to establish their governance systems effectively.

Global Governance and Participation Platforms: According to the Pew Research Center, there is growing public interest in global participation platforms, with 70% of surveyed individuals expressing a desire for more direct involvement in political decision-making.[13] Pangea meets this demand by enabling global citizens to actively participate in governance processes.

Addressing Trust Issues with Web 4 Technologies: The World Economic Forum reports that trust in internet-based services is declining due to concerns over data privacy and security.[14] Pangea's use of Web 4.0 technologies can address these trust issues by providing a more secure and transparent digital environment.

Contributing to Social and Environmental Causes: The Global Impact Investing Network estimates the current market size of impact investing at $1.164 trillion,[15] reflecting a growing investor interest in projects that generate social and environmental impact. Pangea's commitment to addressing global challenges like climate change positions it to capture a share of this market.

The sections on Governance and Economics, further on in this paper, describes the options available and operation of Pangea governance and economic systems.

Governance

Pangea introduces an innovative model of digital governance, setting a new standard in how digital communities are managed and how decisions are made. At the Pangea ecosystem governance level, this is done through a Liquid Democracy. Within the ecosystem, DAOs can choose their own governance mechanisms as set out in the Tonomy Gov OS White Paper such as direct democracy, share-based or representative.

Liquid Democracy

At the core of Pangea's governance model lies Liquid Democracy, a form of delegative democracy that represents a significant evolution in collective decision-making. This model marries the direct involvement of Direct Democracy with the representative aspect of Representative Democracy, creating a system that is both participatory and practical for large communities.[16]

Liquid Democracy in Pangea allows voters the flexibility to **directly participate** in the voting process **or delegate their voting power** to a trusted party. This unique system is adaptable, letting individuals **delegate their voting rights on a category, or issue-by-issue basis**. Such delegation is not merely a

transfer of power; it is a strategic choice to empower individuals with domain-specific knowledge to influence decision outcomes, leading to **more informed governance**.

This approach naturally cultivates a Meritocracy within Pangea. Decisions tend to be made by those who possess the requisite expertise and experience, ensuring **well-rounded and knowledgeable governance**. Additionally, Liquid Democracy in Pangea emphasises the concept of vote recommendation over vote proxying, allowing individuals to retain ultimate control over their decisions while being guided by expert advice.

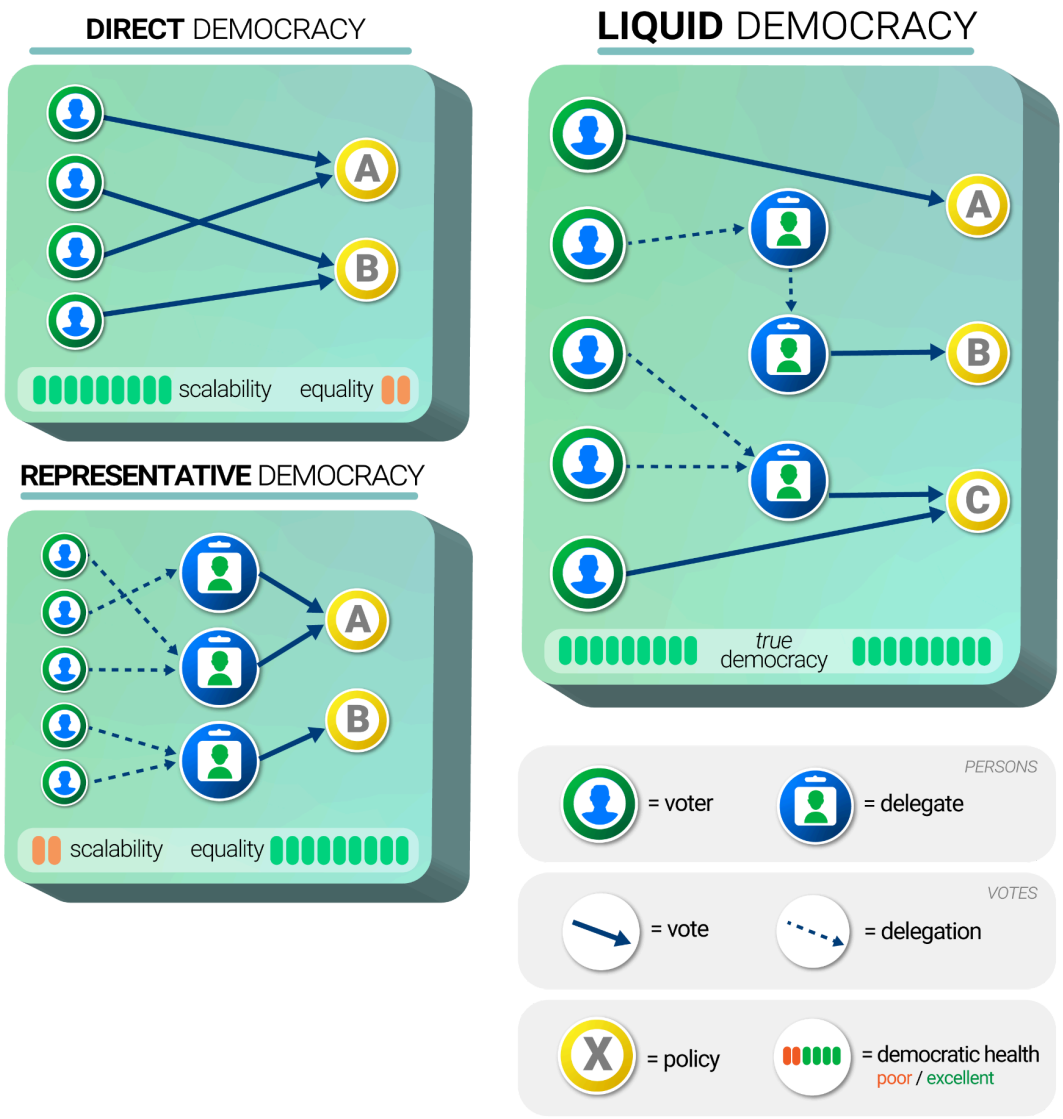


Figure 1: Direct, Representative and Liquid Democracy

Addressing Current Democratic Challenges

In traditional Direct Democracies, scalability becomes an issue as the complexity and volume of decisions grow with the community.[17] Liquid Democracy addresses this by enabling efficient delegation, reducing the burden of continuous direct involvement for each individual.

On the other hand, Representative Democracies often leave citizens feeling disconnected from actual decision-making, restricted to choosing from a limited pool of representatives. Pangea's Liquid Democracy model overcomes this limitation by providing granular control over representation. It ensures that even minority voices can find representation, enhancing the inclusivity and diversity of viewpoints in governance.

Furthermore, Liquid Democracy introduces an unprecedented level of flexibility and engagement in the democratic process. This adaptability encourages higher participation, allowing individuals to tailor their involvement to their own expertise and interest levels.

Democratic Principles and Inclusivity

Pangea's governance model is built on core democratic principles, ensuring fairness, transparency, and inclusivity. The platform is designed to be accessible to all, regardless of geographic location, socio-economic background, or technical expertise. Key features include:

Equal Representation: Ensuring that every member of Pangea, regardless of their status or contribution, has an equal say in the governance process.

Transparency and Accountability: All decisions and transactions within Pangea are recorded on a blockchain, providing a transparent and immutable record of governance activities.

Inclusivity in Decision-Making: Pangea is committed to representing a diverse range of voices and perspectives, ensuring that minority groups and underrepresented communities have a platform to be heard.

Self-Regulating Legal Framework

Pangea introduces its unique, self-regulating legal system tailored for its citizens and the encompassing ecosystem of DAOs. This innovative approach is designed to establish Pangea as a distinct and more effective jurisdiction, particularly in the digital commons arena.

Policies governing the ecosystem are created, maintained, and evolved through this democratic process, ensuring they are reflective of the community's collective will and adaptable to its changing needs. This approach allows Pangea to swiftly respond to unique challenges and opportunities presented within the digital realm, setting a standard for responsive and community-driven legal systems.

Arbitration and Cryptographic Enforcement

Enforcement within Pangea is managed through a sophisticated arbitration platform, utilizing advanced cryptographic techniques to enhance proof recognition and verification. This system ensures that disputes are resolved fairly and efficiently, with a high degree of transparency and security. The arbitration platform is integral to maintaining order and trust within Pangea, providing a reliable mechanism for upholding the ecosystem's legal standards.

Compliance With Existing Digital Frameworks

While Pangea charts its course, it draws significant inspiration from current digital ecosystem frameworks, such as the General Data Protection Regulation (GDPR). These inspirations serve as a foundation for Pangea's legal framework, ensuring it incorporates globally recognised principles of privacy and data protection.

Recognizing the need for compatibility with external legal systems, Pangea engages in strategic efforts to align its unique legal framework within the broader context of international law. This endeavor involves ongoing dialogue and collaboration with legal experts and international bodies to find synergies and ensure that Pangea's citizens can operate confidently both within and outside the platform.

Short-Term Focus and Long-Term Vision

In the short term, Pangea's legal framework is particularly focused on digital commons, providing a robust structure for managing digital assets, intellectual property, and online interactions. As Pangea evolves, the vision is to expand this framework, adapting and scaling it to encompass broader aspects of digital and physical interactions, ultimately offering an alternative governance model to influence global politics and legal systems.

Economics

Pangea's economy is shaped by a variety of economic roles, each integral to its functioning. These roles, encompassing service operators, contributors, and more, exist as human identities equipped with the Pangea Passport or as collectives in the form of Pangea DAOs, all functioning within the ecosystem as accounts.

The circulation of LEOS, Pangea's native token, through transactions between these accounts, creates an economy designed to incentivise network participation, counter dishonest behaviour, and prevent cybersecurity threats. Pangea's governance system is tasked with fostering a sustainable economy, rewarding network participants for their contributions to its development.

The Pangea governance system is charged with maintaining the economic health of the ecosystem. This includes monitoring internal dynamics and the impacts of external market conditions. As the Pangea economy grows to encompass more complex transactions, the governance system will adapt to nurture its evolution.

The core roles within the Pangea economy, as outlined in the Tonomy Gov OS White Paper, include:

- **Citizens:** Human members of Pangea.
- **DAOs:** Teams formed by citizens to create legal entities such as businesses, foundations, and communities.
- **Apps:** Software applications used by citizens or DAOs for various purposes, including governance, commercial, or non-profit activities.
- **Services:** Servers (nodes) that operate system services foundational to Pangea's digital infrastructure, such as blockchain nodes or identity verification services.
- **Gov:** A special DAO or group of DAOs responsible for Pangea ecosystem governance.

Each role contributes uniquely to Pangea's economic system.

The ownership of LEOS tokens does not give any more or less rights or responsibilities regarding the governance system. Governance is democratic, and weighted only by the amount of identity verification a citizen has.

For further detail on the LEOS token operation refer to Pangea - LEOS (Ł) Tokenomics paper.

Development Strategy

Short-Term Phase: Building Technical Credibility and Adoption

In its initial phase, Pangea is dedicated to establishing a solid foundation in **technical credibility** and fostering **widespread adoption** of both its platform and the underlying Tonomy framework. This stage is pivotal in positioning Pangea as a premier platform for "great governance" in the realm of digital commons, such as internet identity and internet exchange value. The emphasis is not on establishing a global nation per se, due to the absence of physical land, but rather on creating a **global jurisdiction** that governs **digital commons** and various industry and community initiatives.

Technical Excellence and Security

Central to this phase is the development and refinement of Pangea's technical infrastructure, which aims to achieve **unparalleled security, privacy, and user experience**. The **Pangea Passport** stands out as a digital identity solution, offering enhanced security and seamless integration with various SaaS platforms. In addition to focusing on industry adoption in traditional sectors, Pangea aims to utilise the Passport and DAO along with underlying services to **address real-world business challenges**. These include legal frictions, privacy concerns, data portability, and mitigating cybersecurity risks and compliance issues. Small-scale **civic participation platforms** for local and municipal participatory systems are also emphasised, along with the potential to address existing **gaps in Web3**. This includes offering a user-friendly system without compromising on decentralization and sovereignty, which could be utilised within Pangea to create CBDCs for governments or UBI/ration systems for communities.

With the economic addition of the LEOS (Ł) currency of Pangea, this stage will likely see the rise of autonomous communities that have previously been locked into forced economic reliance by more powerful nations. The validity of Pangea, along with new internal mechanisms for more complex governance and sustainability, will further solidify its capacity. The use of the LEOS currency, validated through its integration with the Pangea Passport into internet applications, aims to become a standard payment method, thereby increasing its utility and stability.

Market Strategy

Pangea's market strategy in this phase is **deliberately non-political**, aiming to attract tech-savvy citizens, developers, and organizations interested in secure digital identity solutions and efficient DAO creation tools. The focus shifts towards **citizen adoption through application adoption**, on-boarding applications that **utilise the security and privacy benefits of Pangea Passport** and Pangea DAO, and subsequently on-boarding their users.

Community engagement and partnerships will still focus on the **human enthusiasm** for the moral reasons behind the project, creating hype and dialogue around Pangea, especially in preparation for the next phase. This phase will concentrate on positive use cases and building reputable credibility with large institutions and governments to **foster trust**. Another crucial part of this strategy is to gain **acceptance** of the underlying technology, Tonomy, by utilizing its white-label feature to deploy ecosystems.

Community Engagement and Partnerships

The engagement with tech communities, blockchain enthusiasts, and early adopters is fundamental in receiving feedback and fostering a robust user base. **Collaborations** with existing digital platforms and services will be instrumental in showcasing Pangea's utility and integration capabilities. The rise of new types of **autonomous communities** inside well-governed jurisdictions, leveraging digital infrastructure and low trust technologies for cybersecurity and privacy reasons, is also anticipated.

Showcasing Use Cases

Demonstrating real-world applications of Pangea is key in this phase. Examples include enhancing online transaction security and streamlining DAO governance. Other notable applications include the healthcare sector, where privacy and portability can be enhanced with the Pangea Passport, supply chain management through track and trace systems using Tonomy blockchain infrastructure and Pangea DAO, and finance, where cross-border transactions can be secured and identity onboarding made more private.

Mid and Long Term Phase: Wider Horizons

As Pangea solidifies its technical credibility and scale, it is anticipated that users will embrace the capability for working at larger scales – micronations, sovereign states and the globe - with confidence in the democratic principles and decision making methods that are at the nucleus of Pangea. Partnerships with global initiative catalyst groups will be a strategic move in this phase, and

over time could become the new 'home' for NGO's and other world organisational initiatives. The Pangea Vision 2030 document provides more detail about this.

Adoption Strategy and Roadmap

Figure 3: Roadmap

Implementation Plan

Completed: Pangea Passport Launch

Focus: Develop and launch the core features of Pangea Passport, LEOS token and decentralized network.

Goals: Establish technical validation of the project's feasibility.

Actions:

- Market the Pangea Passport as a robust cybersecurity and privacy identity solution, adopting a freemium SaaS business model that offers free Single Sign-On with the ability to upsell on advanced signature, identity verification and other features branded as "web4".
- Develop case studies and whitepapers demonstrating the effectiveness and versatility of Pangea Passport and underlying infrastucture.
- Engage with cybersecurity forums and conferences to showcase the product's capabilities.

Phase 1: Public Services and Onboarding

Focus: Deployment of Pangea's core infrastructure, including Pangea Passport, DAO, and Developer Console.
Goals: Establish a foundational citizen base of early adopters and tech-savvy individuals.
Actions:

- Conduct targeted marketing campaigns focusing on the unique value proposition of Pangea.
- Host webinars and workshops to educate potential citizens about the platform's benefits and functionalities.
- Provide incentives for early adopters, such as discounted access or exclusive features.
- Broaden the sales strategy to emphasise Pangea's SaaS offering, streamlining onboarding processes.
- Monitoring of Pangea uptake and performance
- Support

Phase 2: Expansion and Integration

Focus: Expand the citizen base by integrating with existing digital platforms and communities; begin development of the Pangea Gov+ platform.
Goals: Wider adoption in targeted sectors and communities; integrate modular governance models.
Actions:

- Establish partnerships with industry leaders and digital platforms for integration opportunities.
- Ongoing research to refine and adapt Pangea, responding to phase 1 monitoring and to enable platform module development
- Develop and refine citizen-friendly interfaces based on continuous citizen feedback.
- Initiate governance forums and discussions to introduce and refine Pangea Gov+.
- Start developing modular governance features, including direct and representative voting systems.
- Monitoring
- Support

Phase 3: Consolidation and Growth

Focus: Solidify Pangea's market position and scale the platform; launch Pangea Gov+ with liquid democracy.
Goals: Establish Pangea as a leader in digital governance across various sectors, from industry to government (national to local).
Actions:

- Intensify community-building initiatives to create a sustainable and engaged citizen base.
- Refine and perfect governance models based on real-world application and feedback.
- Actively participate in and facilitate discussions in political and governance circles, ranging from academic and activist communities to political entities.
- Explore new markets and sectors for Pangea's application, emphasising its adaptability and scalability.

Potential Use Cases and Opportunities

In the realm of **Digital Identity Management**, Pangea's secure and decentralized approach has far-reaching implications. The platform can revolutionize how individuals and organizations manage privacy and data security across various sectors. For instance, in the financial sector, Pangea could simplify onboarding processes, ensuring secure transactions and identity verification. In healthcare, the portability of medical records becomes a reality, allowing seamless, secure access across different healthcare providers, enhancing patient care and data privacy.

The potential for a secure global sovereign single sign-on system is immense, particularly for e-commerce and SaaS platforms. This would streamline user experience and enhance security, reducing the risk of data breaches.[21] In enterprise and government workforce management, Pangea's identity solutions can manage employee access and authentication, ensuring data integrity and confidentiality. For Web3 gaming platforms and DeFi applications, Pangea provides a backbone for secure, decentralized identity management, critical in environments where trust and verification are paramount. In sharing economies and real estate, Pangea can facilitate trustful interactions and transactions, enhancing citizen confidence and platform reliability.

For **DAOs**, Pangea offers an effective governance framework, crucial for multifaceted ecosystems like supply chains, banking networks, and airport traffic control. These systems require a robust and transparent governance mechanism, which Pangea can provide. The platform's capabilities extend to facilitating multi-party contracts, such as employment agreements and corporate mergers, ensuring transparency and accountability. It also supports the governance of international digital commons like web standards and decentralized assets. This includes managing compliance with international privacy regulations, an increasingly important aspect in the global digital landscape.

The **Cross-Border Transactions and Trade** aspect is particularly transformative. Pangea could streamline remittances and bank settlements, enhancing efficiency in global financial operations. It offers potential for major global e-commerce and SaaS platforms, like Amazon or those similar to ChatGPT, to manage transactions securely and efficiently. Supply chain payments, often complicated by international trade regulations and currency exchange issues, could be significantly simplified and secured through Pangea's platform.

In **Community Governance**, Pangea's potential is vast. It can enable local communities to autonomously manage digital commons governance, including the governance of AI or cryptocurrencies. The platform can also play a crucial role in managing international environmental commons like oceans or the atmosphere, areas where global cooperation and secure, transparent governance are crucial. Pangea's tools for voting, decision-making, and resource allocation can empower communities to manage these resources effectively, aligning with global sustainability goals.

Overall, Pangea's adoption strategy opens doors to numerous opportunities across various sectors, fostering a more connected, secure, and efficiently governed digital world.

Strategic Partnerships and Collaborations

Pangea's strategic partnerships and collaborations are pivotal in realizing its vision of a decentralized and secure digital ecosystem. The first strategic partnership focus is on **technology giants** and **blockchain companies**. This collaboration aims to enhance Pangea's technological capabilities and ensure seamless integration with existing systems. By partnering with established tech firms, Pangea gains access to advanced technological resources and expertise, enabling the platform to maintain a cutting-edge stance in digital identity and governance solutions. These partnerships also offer an opportunity to integrate Pangea's framework into **existing digital platforms**, expanding its citizen base and applicability.

Another critical area of collaboration is with **governments and regulatory bodies**. These partnerships are essential for navigating the complex regulatory landscape of digital currencies and governance systems. By working closely with these entities, Pangea can ensure cooperation with global regulations while advocating for regulatory frameworks that support innovation in digital governance. This collaboration is also crucial in exploring the adoption of Pangea's solutions in public sector **e-governance initiatives**, potentially revolutionizing how citizens interact with government services.

In addition, Pangea plans to forge partnerships with **educational institutions** and **non-profit organizations**. Collaborating with academic institutions will support research and development initiatives, driving innovation within the Pangea ecosystem. These partnerships can also play a significant role in **educating** the next generation about the importance and potential of digital democracy and decentralized governance. Collaborating with non-profits aligns with Pangea's mission to have a positive social impact, particularly in projects that focus on community-driven initiatives and social change. These collaborations not only enhance Pangea's societal impact but also bring diverse perspectives and expertise into its ecosystem, enriching its development and outreach.

The platform's commitment to innovation, compliance, education, and social impact, bolstered by these collaborations, sets the stage for Pangea to become a frontrunner in digital governance and identity management.

Sustainability and Social Impact

Environmental Considerations

Pangea is deeply committed to environmental sustainability, recognising the vital role digital platforms play in reducing ecological footprints. The core of Pangea's environmental strategy lies in its digital-first approach, which inherently reduces the need for physical resources and minimises waste. By facilitating digital governance and transactions, Pangea significantly reduces paper usage and the carbon footprint associated with traditional bureaucratic processes.[22]

Moreover, Pangea's infrastructure is designed to be energy-efficient, utilising advanced technologies that require less power compared to traditional data centres. The platform also supports using

renewable energy sources in its operations and among its partners. Pangea is exploring implementing blockchain solutions that are more energy-efficient than traditional models, recognising the environmental concerns associated with some blockchain technologies.[23]

The platform's infrastructure annual energy usage has been modelled and estimated using this formula:

$$Energy_{Annual}(kWh) = 8.7 \times w \times (a \times U^{b} + c)$$

$$U = number\ of\ citizens$$
$$8.7 = Annual\ kWh\ per\ server$$
$$w = 50\ watts\ (average\ server)$$
$$a = 0.03\ (server\ efficiency)$$
$$b = 0.5\ (economies\ of\ scale\ factor)$$
$$c = 30\ (minimum\ servers)$$

Image 1 compares Pangea's energy consumption per citizen with that of Bitcoin, Ethereum, and Google, highlighting Pangea's efficiency. Furthermore, Pangea plans to offset its environmental impact by investing in carbon credits, contributing to a net negative carbon footprint.

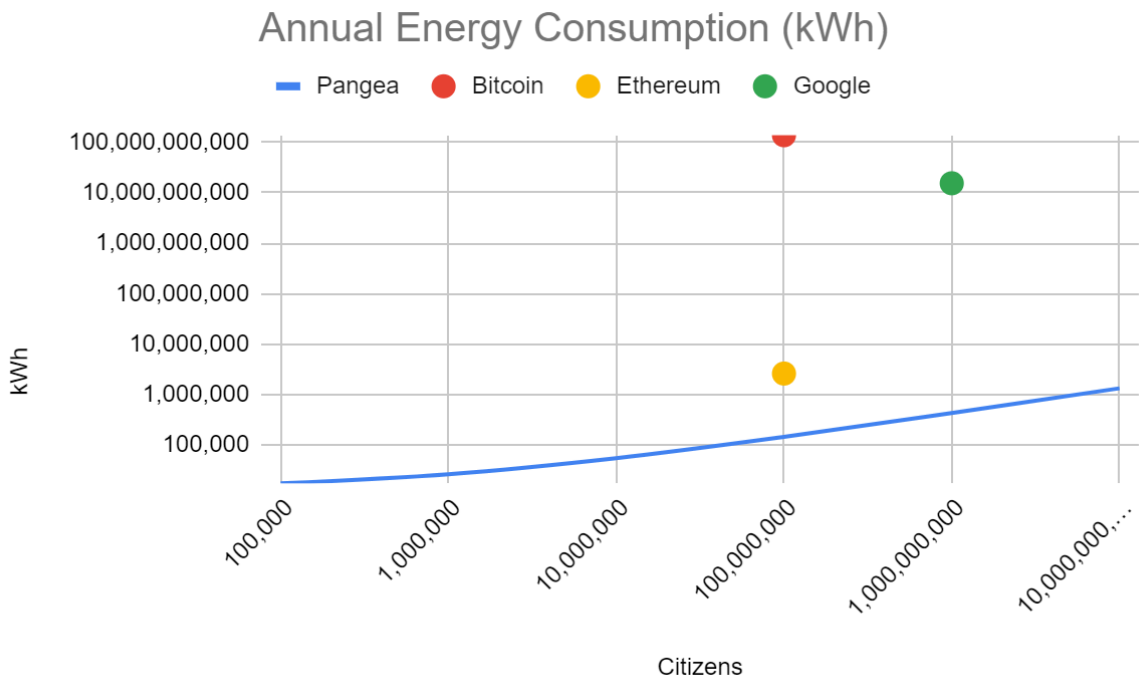


Image 1: Energy Consumption Comparison

Social Impact Goals

Pangea's social impact goals are aligned with several of the United Nations Sustainable Development Goals (SDGs). Key among these are:

- **Quality Education (SDG 4):** Promoting digital literacy and providing educational resources through the platform.
- **Gender Equality (SDG 5):** Ensuring equal access and participation for all genders in digital governance and economic activities.
- **Decent Work and Economic Growth (SDG 8):** Creating economic opportunities through decentralised marketplaces and fostering innovation in digital workspaces.
- **Industry, Innovation, and Infrastructure (SDG 9):** Building resilient infrastructure and fostering innovation in digital governance solutions.
- **Reduced Inequalities (SDG 10):** Offering equal digital identity and governance access to marginalised and underrepresented communities.
- **Sustainable Cities and Communities (SDG 11):** Empowering local communities to leverage digital tools for sustainable development.
- **Peace, Justice, and Strong Institutions (SDG 16):** Promoting peace and justice through transparent and secure digital governance solutions.
- Read more in Pangea Vision 2030.

Through these goals, Pangea aims to foster an inclusive, equitable, and sustainable digital ecosystem.

Contribution to Global Goals

Pangea's contribution to global goals extends beyond the digital realm, influencing broader societal and economic domains. The platform is designed to enable more efficient governance models, reduce inequalities, and promote social justice through its decentralised and transparent framework.

Pangea's mission extends to advocating for establishing a **new Sustainable Development Goal focused on good democratic governance**. This proposed SDG would emphasise the importance of transparent, inclusive, and accountable governance systems. Pangea, with its decentralised governance model, demonstrates a commitment to these principles, offering a template for digital democracy that can be emulated globally. The platform's efforts in promoting democratic engagement, safeguarding data privacy, and ensuring equitable participation in governance processes resonate with the ethos of this proposed SDG. Pangea's contribution to this new goal reflects a broader vision of a digitally empowered society where governance is not only a function of state institutions but a collective responsibility of all citizens.

Technology and Infrastructure

Technical Infrastructure of Pangea

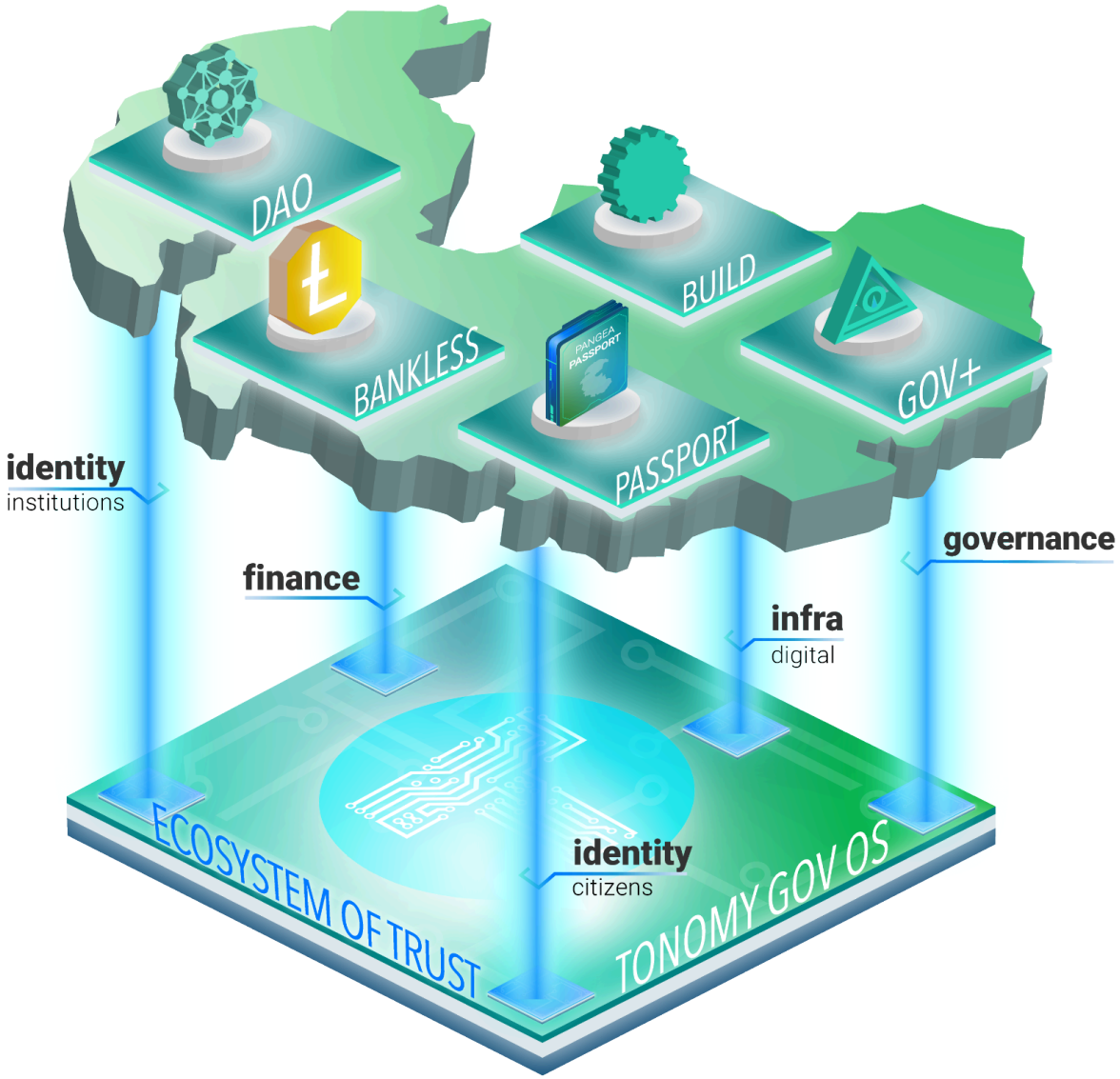


Figure 4: Pangea platform technologies

Pangea's technical infrastructure is a sophisticated amalgamation of Tonomy's adaptable modules, rebranded and fine-tuned to create a unique global ecosystem. The core underlying technical capacity and architecture of this is outlined in detail in the Tonomy Gov OS White Paper. Key components of the Pangea infrastructure include

Pangea Passport, Pangea DAO, Pangea Gov+, Pangea Bankless, and Pangea Build: These core applications, derived from Tonomy's versatile modules (e.g. Pangea Passport is a whitelabeled instance of Tonomy ID), form the backbone of Pangea's digital landscape. They facilitate the seamless integration of various functionalities, from governance to economic transactions, within the Pangea network.

Pangea Governance Modules: At the forefront of Pangea's governance structure are multiple DAOs, each responsible for distinct aspects of governance: legislative, executive, and jurisdictional functions. These DAOs function through a liquid governance model for policy-making, allowing for flexible delegation and direct voting. The legislative DAO facilitates the creation and amendment of policies, while the executive DAO, often referred to as the Treasury, manages financial aspects and resource allocation. Additionally, the Pangea Arbitration Platform is critical in interpreting and enacting policies, providing a fair and transparent dispute resolution mechanism.

Guaranteed Global Digital Passport System: This system ensures that every human on Earth is entitled to a unique, lifetime digital identity, symbolised by a global digital passport. It plays a pivotal role in maintaining the integrity and uniqueness of each citizen within the network.

Multi-Level Identity Verification: Pangea's identity verification process incorporates a gamified approach, engaging and incentivising citizens to level up their verification status. The initial level offers basic protection against Sybil attacks. Higher levels, which may involve document verification, social proofs, or endorsements from other network entities, unlock additional features and privileges. This system not only enhances network security but also ensures that verified identities remain anonymous, fostering a socially accountable ecosystem where citizens can self-regulate their interactions.

DAO Registry: Pangea enables citizens to form DAOs representing a diverse range of entities. Depending on their verification level, citizens can establish organisations, fostering collaborative and autonomous communities within the Pangea ecosystem.

Pangea App Store: This high-trust digital marketplace allows DAOs to develop and manage applications. It leverages privacy and security technologies to foster trust between citizens and technical operators. The store is integral to Pangea's vision of a secure, interoperable app ecosystem.

Security and Privacy Features

In the realm of Pangea's expansive digital nation, security and privacy are not mere features but foundational elements woven into the fabric of its infrastructure. Recognizing the paramount importance of these aspects, Pangea has developed a comprehensive approach to safeguard its ecosystem and its citizens.

At the heart of Pangea's security strategy is its **decentralised** nature. Unlike traditional centralised systems, which often suffer from vulnerabilities related to central points of control and failure[18], Pangea's decentralised network architecture ensures that control is distributed across its entire landscape. This decentralization plays a crucial role in enhancing the network's resilience, making it robust against both internal and external threats and ensuring that there is no singular entity with overarching control over the system.[19]

Advanced cryptography is a cornerstone of Pangea's security framework. Far beyond just a shield against external threats, this advanced cryptography introduces a new level of low-friction data

verifiability and integrity. By leveraging cryptographic algorithms, Pangea achieves a dual goal: it ensures the highest standards of security while simultaneously boosting efficiencies within the network. This innovative approach significantly reduces operational costs, particularly those associated with data verification and maintenance, making the network more efficient and sustainable.

A standout feature of Pangea's privacy measures is its **zero-knowledge architecture**. This pioneering approach ensures is no centralised database containing citizens' personal data. Unlike traditional systems where citizen data is stored in a central repository – often creating a vulnerable target for data breaches – Pangea's architecture fundamentally eliminates this risk. Personal data is not centrally stored or managed, thereby drastically reducing the potential for large-scale data exploitation or loss.

Complementing the zero-knowledge architecture is the use of **zero-knowledge proofs** in data interactions. This cryptographic technique allows one party to prove to another that a statement is true without revealing any information beyond the validity of the statement itself.[20] In Pangea's context, this means that data transactions and interactions can be verified for their authenticity and integrity without exposing any underlying private or sensitive information. This dual application of zero-knowledge concepts – both at the architectural level and in cryptographic proofs – sets a new standard in privacy preservation, ensuring that citizens can interact and transact with confidence and security.

Through this multi-faceted approach to security and privacy, encompassing decentralisation, advanced cryptography, and zero-knowledge principles, Pangea establishes itself not only as a secure digital nation but also as a trailblazer in protecting digital identities and fostering a **trustworthy digital community**.

Comparison with Existing Governance Infrastructure

Table 1 provides a comparison reference for understanding Pangea versus other digital and nondigital governance and collaboration systems. This has been highly simplified and put in the context of a governance analysis framework to help understand Pangea's strengths weaknesses and opportunities.

Risk Assessment and Mitigation

Category	**Risk**	**Mitigation**
Technology	Dependency on Web3 and advanced technologies may lead to challenges in tooling and expertise availability.	Pangea will leverage a range of proven, secure, and modern Internet standards and tooling, as detailed in the Tonomy Gov OS White Paper. These tools are well-audited in security and privacy, supported by extensive tooling availability. The Tonomy Foundation brings substantial experience in utilising these major

Category	Risk	Mitigation
		toolsets.
Cybersecurity	The decentralised network architecture and political aspirations might attract targeted security threats.	Pangea will utilise cutting-edge Tonomy technologies like zero-knowledge architecture and advanced cryptography. This is coupled with multi-layered security protocols, regular system audits, and ongoing updates to align with industry standards.
Regulatory Compliance	The evolving landscape of digital currency and governance regulation presents compliance challenges.	Engaging with legal experts and regulatory bodies, Pangea aims to navigate and influence compliance frameworks using its digital commons governance strategy. Its governance portal allows adaptive and participatory policy modifications to respond to regulatory, social, or financial changes quickly.
Adoption and User Engagement:	Achieving and maintaining high levels of citizen adoption and engagement.	The Tonomy Foundation employs an agile, citizen-centric design process with lean feedback cycles for continuous improvement. In case of declining engagement, Pangea will reevaluate its strategies based on market research. Application onboarding and Tonomy's trust-enhancing technologies like provable democratic voting and autonomous identity control are key strategies for citizen growth and engagement.
Financial Sustainability	Maintaining long-term financial health and viability.	Pangea will diversify revenue streams and practice prudent financial management. The Tonomy software suite's dual-benefit sales strategy will aid in income generation and ecosystem credibility. Commercial collaborations within Pangea will stimulate an internal market. A reserve fund and flexible Treasury funds will manage financial shortfalls.
Scaleability	Potential challenges in scaling to accommodate a growing citizen base.	Pangea leverages proven technologies that support large citizen numbers and plans for further scalability advancements. Regarding scalability challenges, the focus will be on integrating more efficient technologies and enhancing server capacities.
Backup Systems and Data Recovery	Large-scale system failures or attacks causing data loss and downtime.	Pangea employs Tonomy technologies with built-in redundancy to handle system failures, ensuring system availability. Robust backup systems and data recovery protocols are in place to minimise the impacts of such failures.

Criteria	Pangea	United Nations	World Trade Organization	Ethereum	Google Workspaces	Estonia
Governance Structure	Decentralised,blockchain-based governance with flexibility	Centralised, intergovernmental governance	Centralised, intergovernmental governance	Decentralised, off-chain governance	Centralised, corporate governance	Centralised, e-governance with digital advancements
Participation and Inclusivity	High, with digital citizenship and global access	Low, varies by country participation, no direct participation	Medium, limited to member states participation, no direct participation	Medium, open globally to all technically educated citizens	Low, within corporate or educational organizations that have no governance rights of the platform	Medium, for Estonian citizens and residents only
Transparency and Accountability	High, with blockchain transparency and anonymous social accountability	Medium, formal processes but limited transparency	Medium, formal dispute resolution processes	Medium, with public ledger transparency and open-source development but little to no social accountability	Medium, depends on governance and usage policies	High, with transparent digital processes
Efficiency and Scalability	High, scalable with digital technologies	Medium, challenges with large membership and bureaucracy	Medium, scalability depends on member collaboration	Low, limited by network performance	High, scalable cloud-based infrastucture	High, efficient digital services
Security and Privacy	High, with decentralised architecture advanced cryptography	Medium, depends on member state compliance	Medium, depends on member state compliance	Medium security, but with concerns about smart contract vulnerabilities. Low personal privacy architecture	High, with robust security and privacy standards	Medium, with a focus on e-identity and data protection but centralised data
Economic and Financial Management	High, with integrated transparent blockchain transactions	Medium, subject to member state contributions	Medium, financial management reliant on member contributions	High, transparent transaction records	Low, no integrated currency controls	High, digital financial management systems
Policy Creation and Enforcement	High, self-regulating policies and decentralised enforcement	Medium, policies created by member consensus	Medium, policies formed by member consensus	Medium, through smart contracts but only using financial incentives	Medium, corporate policies and regulations	High, effective digital policy enforcement
Technological Innovation	High, innovative Web3 technologies	Low to Medium, traditional systems with some digital	Low to Medium, traditional systems with some digital	High, leading in blockchain innovations	High, innovative cloud-based technologies	High, pioneer in e-governance technologies
Global Impact and Outreach	Low, currently, with potential for global digital governance	High, significant global impact and outreach	High, significant global trade impact and outreach	High, significant impact on digital economices	High, widespread corporate use and collaboration	Medium, model for digital governance restricted to Estonia

Table 1: Comparison of Governance solutions

Conclusion

Pangea stands at the **forefront of digital sovereignty and transparent governance**. Pangea is technically unique and is testament to the power of collaborative innovation and the potential of a connected global society. It interweaves **cutting-edge technology with steadfast commitments** to inclusivity, sustainability, and democratic governance, setting a new paradigm in the digital world.

An invitation is extended to all potential stakeholders, including visionary investors, who are keen to be part of a transformative journey. Engagement, whether as a citizen, partner, community member, or investor, is crucial in shaping the trajectory of Pangea. Pangea values the diverse perspectives and contributions that each stakeholder brings to the platform. Investment, be it time, resources, or capital, is an **investment in a future** where digital democracy flourishes, and governance transcends traditional boundaries.

Early Pangea investors are poised to participate in **significant economically advantageous opportunities** by buying the LEOS currency in the pre-launch sales.

The horizon for Pangea is replete with **opportunities and growth**. Pangea's commitment to evolving the platform, expanding its reach, and enriching the global community remains unwavering. A future is envisioned where **Pangea is synonymous with innovative governance and a sustainable digital ecosystem**. This vision is more than aspirational; it is achievable with the collective effort and support of our dedicated community and forward-thinking investors.

Join this ground breaking endeavour to redefine digital citizenship and governance. Pangea will enable a more equitable, transparent, and connected world where every individual's voice is empowered, and collective actions shape a sustainable and inclusive digital civilisation.

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Appendix 2: LEOS Tokenomics

LEOS (Ł) Tokenomics Whitepaper

Global Trusted Currency
And Pangea Utility Payments

v1.2.1

By the Tonomy Foundation

Contents

Introduction

In the evolving landscape of digital economies, the Pangea Virtual Nation emerges as a pioneering entity, introducing LEOS (Ł) as its native currency. This currency is at the heart of Pangea's ecosystem and is designed to facilitate transactions, global payments, and access to core public services. The introduction of LEOS represents a strategic move towards establishing a more inclusive, secure, and efficient economic system within the digital realm.

Read the Pangea - Overview, Strategy and Governance whitepaper to learn more about Pangea.

LEOS acts as a global payments solution, backed by the permissionless global democratic governance framework within Pangea

Due to the importance of the LEOS currency, a full audit of the tokenomics was conducted by experts at the Swiss company Brightnode(https://brightnode.io), a reputable global tokenomics service provider.

Significance of LEOS within the Pangea Ecosystem

LEOS is more than just a digital currency; it is the lifeblood of the Pangea ecosystem, enabling seamless transactions and interactions among its citizens and entities. As the primary legal tender, LEOS is utilised for purchasing essential products and services, such as seats in Decentralized Autonomous Organizations (DAOs) and identity KYC verifications, necessary for maintaining the integrity and security of the virtual nation. This integration of LEOS into the core functionalities of Pangea underpins its crucial role in the ecosystem's economic and social fabric.

Need for a Better Currency System for Pangea

Traditional and central bank currencies often fall short in addressing the unique needs of virtual nations, primarily due to their centralised nature, susceptibility to geopolitical influences, and lack of flexibility.

Decentralised payment solutions already exist; however, they fail to meet Pangea's requirements for being mainstream-ready. This is due to the need for mainstream-ready usability of existing cryptocurrencies, low transaction fees and predictability, lack of social accountability which results in hacks, and poor wallet control features such as recovery and funds security management.

With its global citizenship and decentralised governance model, Pangea requires a currency system that transcends these limitations. LEOS is meticulously designed to meet these needs, offering a decentralised, secure, safe and scalable solution.

Terms

Contributor	A Citizen who contributes their time to the government or operations of the Pangea virtual nation. E.g. a delegate or core developer
Feature	One of the features that users can access using the Pangea platform. E.g. Citizens can incorporate a DAO in the Pangea DAO app
Service	A computer server that runs infrastructure for the network. Owned and controlled by a DAO. e.g. Blockchain Block Producer node
Staker	A Citizen or DAO decides to lock their LEOS coins to a Service

LEOS (Ł) Tokenomics

The Pangea ecosystem is a dynamic assembly of participants, each playing a vital role in its decentralized economy. The LEOS tokenomics framework (powered by the Tonomy Gov OS) is designed to support this intricate network, ensuring fluidity, security, and equitable participation for all involved.

Actors

- **Citizens:** Individuals who engage with the ecosystem, leveraging LEOS for transactions, services access, and governance participation, embodying Pangea's democratic ethos.
- **DAOs:** Collective entities undertaking various functions within Pangea, using LEOS for operations like incorporation, membership verification, and project execution.
- **Governance :** The central governance entity orchestrating the ecosystem's regulatory framework, economic policies, and automated resource allocation to maintain balance and adherence to founding principles.
- **Apps:** Software applications facilitating daily operations, from governance to communication, essential for the seamless functioning of the ecosystem.
- **Services:** Infrastructure services, including blockchain nodes and identity verification systems, form the technological backbone, ensuring Pangea's operational efficiency and security.

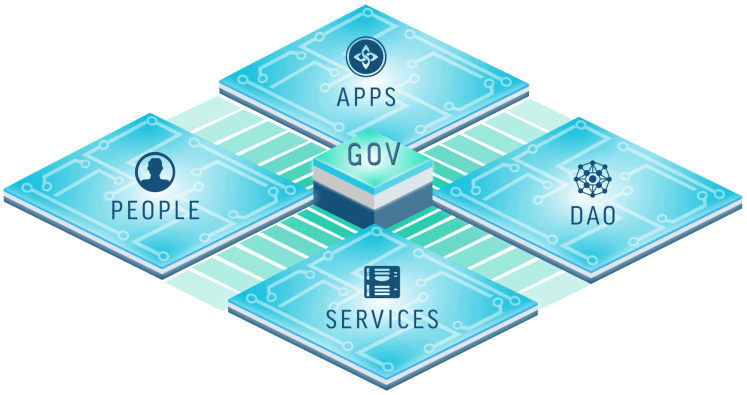


Figure 1: Actors in LEOS currency

LEOS Currency Model

Citizens and **DAOs** pay for Pangea Features through **Apps** using the LEOS currency, paid into a treasury fund governed by **Gov**. These features are equivalent to Pangea's public services when considered from a traditional state-nation perspective.

Gov manages the monetary policy of the ecosystem, which uses a smart contract to automatically pay for **Services** provided by **DAOs** that run the network infrastructure.

This flow can be seen in Figure 2 as a circular system in which all money circulates around the ecosystem. If the fees paid for public services through **Apps** "income" is equal to (or greater) than the costs to run the **Services** "expenses", then the ecosystem is said to be in equilibrium (or growth).

Figure 2: Circular Economic Model of Pangea

LEOS Uses

Figure 3: Different uses for LEOS

LEOS for Payments for Pangea's Features

Each core Pangea **App** allows **Citizens** and **DAOs** to purchase its features through a flexible Software as a Service (SaaS) model. This model has been designed to facilitate a familiar experience while adequately covering the underlying infrastructure costs for the services from mainstream users. Two examples of features are DAO seats available in Pangea DAO, and Citizen identity verification in Web 4.0 Apps available in Pangea Build.

Pangea features are all paid for in LEOS, though the amount of LEOS is determined using a $ USD price to provide predictability for **Citizens** and **DAOs** using the platform. The underlying currency, LEOS, remains a free market currency. The LEOS prices of the services are updated to facilitate predictable pricing models and services on a semi-regular basis, based on the volatility of the underlying LEOS price - aka, if the LEOS price changes significantly, then the service prices will be changed.

Using a pegged product or transaction price has been shown on prominent networks like Hedera to **attract significant institutional use of network features due to its predictability**. This drives the coin's utility, a leading long-term strategy for bringing LEOS currency stability as outlined in Pangea Vision 2030.

The most accessible place to see and understand these pricing models is on the Pangea website:

- Pangea Passport (always FREE)
- Pangea DAO
- Pangea Gov+
- Pangea Bankless
- Pangea Build

LEOS for Infrastructure Incentivization

Each of Pangea's features is powered by infrastructure provided by **Services** (server nodes in the network). The Tonomy Gov OS White Paper describes these infrastructure services in detail. Each type of **Service** requires a different number of nodes and has other trust properties. Such requirements have been used to design the three mechanisms used in Pangea to incentivise **Service** providers.

The Pangea Build **App** facilitates the infrastructure management of the network (goverened by **Gov**). The Pangea Build website shows the different **Services** and their incentives.

Services are all paid for in LEOS, though the amount of LEOS is determined using a $ USD price to provide predictability for **DAOs** running the **Services**. The underlying currency, LEOS, remains a free market currency, and the LEOS prices of the services are updated regularly to facilitate predictable utility.

Base Rewards

Each **Service** provider gets paid a base reward monthly. These rewards are designed to cover the minimum running infrastructure costs and are based on server node requirements.

Staking Rewards and Penalties

A staking reward pool is also provided for each **Service** requiring trust. **Services** that require more trust have a higher reward pool. This reward pool is distributed monthly based on the distribution of **Citizens** and **DAOs** that stake LEOS on the **Services**. Staking is done by locking LEOS coins in a fund attributed to a specific Service provider.

If the **Service** makes a mistake, they can also be fined. There are two parts to each fine. The base fine is charged to the **DAO** that runs the **Service**, while the stake fine is covered by all those that have staked in the **Service**.

This model incentivises Service providers to provision correctly running software while providing a shared risk and reward exposure for **Citizens** and **DAOs** that want to back the **Service** based on their trust in the **DAO** that runs it.

This is similar to staking pools on Ethereum but is more explicit, predictable for node operators, transparent, and fairly governed.

Incentives and Penalties Formular

Equation 1 shows the different components of how Services are rewarded. The **Service** provider takes the base reward and covers expenses (discussed in Service Resource Management). Stakers, also expected to include the **Service** provider (who knows they are trustworthy), share a fraction of the stake reward based on how much they have staked.

$$MonthlyRewards_{Service} = BaseReward_{Service} + Expenses_{Service}$$
$$MonthlyRewards_{Staker} = \frac{Stake_{Staker}}{TotalStaked_{Service}} \times StakeReward_{Service}$$

Equation 1: Rewards for Services

Equation 2 shows The different components of how Services are penalised. The **Service** provider takes a base fine, and stakers lose a fraction of their staked funds.

$$Fine_{Service} = BaseFine_{Service}$$
$$Fine_{Staker} = Fine\%_{Service} \times Stake_{Staker}$$

Equation 2: Fines for Services

The most accessible place to see and understand these fines is on the Pangea Build website.

LEOS for Governance and Operations Contributors

Actively contributing to the governance and operation of the Pangea virtual nation takes time and skill. From creating, reviewing, deliberating and voting on Pangea policies, such as monetary policies, to writing platform software and monitoring deployments, there are many important roles.

During the early stages of the network, while higher priority aspects of the network are tested and stabilised, contributors to the network are rewarded from the ecosystem fund. The Tonomy Foundation will be present and a primary active contributor in these early phases and a contributor, using funds from the LEOS currency sale to pay its contributors to support Pangea. In the long term, this is expected to transition to be balanced with higher feature prices or other income streams. More information on this translation can be found in the Pangea 2030 Vision document.

LEOS for Global Payments

LEOS extends its utility beyond the Pangea features by enabling bankless, peer-to-peer payments. This feature allows participants to engage in transactions with greater freedom and flexibility, free from the constraints of traditional banking systems. LEOS enhances its value proposition to users within and outside Pangea by fostering a more inclusive and self-regulating sovereign economic environment. Citizens and DAOs are expected to offer goods and services within and outside Pangea to each other using LEOS as a convenient, easy and global payment tender.

International payments are facilitated for Citizens and DAOs through the Pangea Bankless platform and its APIs.

Service Resource Management

The Pangea Build platform's features are structured to provide developers with the control and flexibility to utilise various underlying resources, optimising the performance and efficiency of their Web 4.0 **Apps** within the Pangea environment.

Service Resources Incentivation

Figure 4: Resource Payments

Apps within Pangea can be engineered to leverage different resources provided by **Services**, which are essential for these applications' diverse functionalities. Developers buy and control these through Pangea Build as Web 4.0 **Apps** are built and upgraded.

The critical service resources in the Pangea ecosystem are described in detail in the Tonomy Gov OS White Paper and are briefly described here:

- **Blockchain Node RAM:** This resource is crucial for storing stateful data related to smart contracts, including the contracts themselves. It ensures the persistence and accessibility of critical data across the network.

$$Expenses_{BlockchainNode} = Total\_RAM \times Price_{RAM}$$

- **DIDcomm Server Messages:** This service facilitates secure messaging between identities within the system, with charges applied per million messages sent. It is vital for maintaining communication integrity and privacy.

$$Expenses_{DIDComm} = \frac{Messages}{1{,}000{,}000} \times Price_{Messages}$$

- **Private Data Storage:** Apps can leverage sovereign storage vaults for storing user data, offering significant privacy and security advantages. The service includes backup capabilities, charged per gigabyte, to safeguard against data loss due to account access issues.

$$Expenses_{PrivateData} = Data \times Price_{Data}$$

- **Public Data Storage:** This resource allows apps to store data on a public decentralised cloud, essential for features like public profiles and accessible by the broader Pangea community, with fees applied per gigabyte of data stored.

$$Expenses_{PublicData} = Data \times Price_{Data}$$

- **Identity Verification Bridge:** Apps requiring user identity verification for compliance or anti-Sybil attack measures utilise this service, with charges per verification performed.

$$Expenses_{IdentityVerification} = Verifications \times Price_{Verification}$$

- **eIDAS QES:** Provides a mechanism for identity-verified users to sign documents with EU-recognized digital signatures, charged per signature, integrating high trust and compliance into digital transactions.

$$Expenses_{EidasSignatures} = EidasSignatures \times Price_{Signature}$$

Prices for the above services consider the base resource costs (e.g. RAM hardware running costs per month) to provide such services and the market supply and demand dynamics and competitors to provide a high-value service at a reasonable price. These prices can and are expected to be tweaked through Pangea's governance system.
Unsustainable

Economic Considerations and Security Measures

The pricing model for these services is meticulously designed to deter the overutilisation of network resources, thereby preventing potential denial of service attacks and ensuring the network remains accessible to all Pangea citizens. Attack prevention is further enhanced through anonymised verified identities in the network, as explained in Pangea - Governance and Strategy. This economic strategy is integral to maintaining the network's resilience and availability.

Furthermore, the fees collected for these underlying resources are directed to the **Service** providers through an automated **Gov** treasury pool, aligning the economic incentives of the ecosystem with the provision of high-quality, reliable services.

Citizen Blockchain Resource Accounting

Besides the resources mentioned above, the Pangea ecosystem also significantly emphasises the management of core blockchain resources, namely CPU (computation time for smart contracts) and NET (network bandwidth and transaction history storage). These resources are allocated exclusively to **Citizens** based on the identity verification level of the accounts, ensuring a fair and democratic distribution of network capacity.

This unique approach to resource allocation, where anonymised **Citizen** accounts exclusively initiate transactions, simplifies the blockchain resource model. It enhances the system's efficiency and upholds the principles of fairness and inclusivity central to the Pangea democracy.

Financial Safety, Sustainability, and Transparency

Democratic Governance

Pangea's economy and LEOS currency are governed by the Pangea liquid democratic governance system, which plays a crucial role in guiding its monetary policy decisions. This governance model allows for a more fluid and dynamic participation of citizens in decision-making, ensuring that policies remain adaptive and representative of the community's needs. The Pangea - Governance and Strategy documentation provides a deeper insight into this governance framework, illustrating its effectiveness in maintaining the financial health and sustainability of the ecosystem.

Financial Sustainability

Through this democratic process, governance is empowered to balance income and expenditures, as mentioned in the LEOS Currency Model and as seen in Equation 3, ensuring the ecosystem's long-term viability. The flexibility inherent in this approach allows Pangea to adapt over time and adjust to varying economic environments, ensuring its resilience and sustainability.

$$Income \geq Expenses$$

$$Fees_{Features} + Fines_{Services} \geq Rewards_{Services} + Rewards_{Contributors}$$

Equation 3: Core economic balance of Pangea

The Pangea Governance process is also used to select the infrastructure providers for the network. This will be based on their technical merit, and the amount staked to them will be used as an indicator but not a deterministic metric.

Pangea Economics Simulator

The Pangea Economics Simulator has been introduced to aid stakeholders in navigating the complexities of the ecosystem's economy. This tool enables users to simulate various economic scenarios, providing a tangible understanding of the ecosystem's financial dynamics. By adjusting specific variables, stakeholders can visualise the impact of different policies and conditions on the ecosystem's economy, fostering informed decision-making and strategic planning.

Pangea Economics Simulator

Safety, Fraud, and Hack Prevention Features

Figure 5: Safety features of LEOS

Anonymised Identity Verification

In security, Pangea places a significant emphasis on anonymised identity verification standards. This system not only ensures accountability within the ecosystem but also maintains the privacy and security of its citizens. By adhering to stringent verification standards, Pangea establishes a secure environment that deters fraudulent activities hackers and enhances the overall trustworthiness of the ecosystem.

Arbitration Features

Pangea has implemented an arbitration system capable of addressing disputes and misconduct within the ecosystem to safeguard LEOS holders further. This platform allows for

the trial and justice of accounts involved in fraudulent or malicious activities, leveraging the anonymised verification system to hold offenders accountable.

For more detailed information on these mechanisms, refer to the Pangea - Governance and Strategy documentation, which outlines the procedures and principles guiding the arbitration system.

Recovery Features

Understanding the risks associated with digital assets and identity, Pangea incorporates robust account recovery mechanisms. These features are designed to protect citizens' funds and access without placing them under the custody of network operators or governance contributors. This approach significantly reduces the risk of accidental or malicious loss, ensuring **Citizens**' assets remain secure even in device loss or compromised access.

LEOS Currency Utility and Benefits

Global Utilities of LEOS

LEOS, the native currency of the Pangea ecosystem, offers a broad spectrum of utilities both within and beyond the virtual nation's boundaries. Its design caters to a multifaceted approach, ensuring trust in internet services at an economical price while delivering high value.

Using Pangea's features, LEOS facilitates a range of core functionalities:

- **Pangea Passport:** LEOS enables reusable identity verification and access to Web 2.0, 3.0 and 4.0 Apps across the internet, providing better than banking security, natural compliance and seamless UX, all at a cost-competitive rate to existing internet identity and Web3 Dapps.
- **Pangea DAO:** In the realm of Decentralized Autonomous Organizations, LEOS serves as the currency for transactions, governance participation, and human resource and authorisation management and enabler of collaborative teams, enabling low-friction and always-accessible institutional management and agreements services in one seamless low-friction platform.
- **Pangea Bankless:** LEOS supports the Bankless platform, offering a decentralised financial infrastructure that allows for global peer-to-peer transactions without traditional banking systems, enhancing financial inclusivity and freedom. The ease of use and wealth management features set this apart from other Web3 Dapps.
- **Pangea Gov+:** LEOS is used for payments for auxiliary features such as arbitration cases and more within the governance model. Many Gov+ features are available for free to Citizens. Gov+ is the enabler for the trust of the currency, stemming from inclusive and participatory monetary policy management.
- **Pangea Build:** For developers and creators, LEOS enables access to essential resources and services in Pangea Build, supporting innovation and development of next-generation Web 4.0 Apps across the internet. It is also used as the incentive mechanism for Service providers that provide core network resources.

The website provides an easy and visual portal to understand better how much value the Pangea platform containing these tools can provide to existing markets.
https://pangea.web4.world

Benefits

User Experience and Accessibility: LEOS is designed to provide an exceptional user experience characterised by its global accessibility, ease of use, and scalability. Its integration capabilities allow for seamless interactions with various services and platforms within Pangea, enhancing the overall user experience.

Safety and Self-Regulation: The safety features embedded in LEOS, including mechanisms for self-regulation and social accountability, ensure a secure environment for transactions and interactions. These features protect users from fraudulent activities and foster a trustworthy ecosystem.

Transparent Monetary Policy: A clear and transparent monetary policy governs LEOS, which is crucial for maintaining its long-term stability and building trust among citizens and institutions. This policy is carefully crafted to ensure the sustainability of the Pangea ecosystem, balancing supply and demand while accommodating growth and innovation.

LEOS Currency Sale

The launch and distribution of LEOS coins are meticulously planned to ensure a fair, transparent, and strategic introduction into the economy. This section outlines the key components of the LEOS currency sale, including the initial distribution strategy, the structure of the currency sale rounds, and the vesting terms designed to align the interests of early adopters, team members, and partners with the long-term vision of the Pangea ecosystem.

The LEOS currency sale is offered by the Tonomy Foundation (Chamber of Commerce # 86537288), a Dutch non-profit organisation. While the Tonomy Foundation controls the LEOS token during the sale, it will not control LEOS when Pangea transitions to a democratically governed system, a planned and essential milestone in the roadmap. For more information on Pangea governance, please read the whitepaper.

It is important to understand what LEOS is not:

- An equity, or a stake in the Tonomy Foundation; and
- An equity, or a stake, that buys controlling rights and special privileges (compared to other Citizens) of the Pangea governance system

LEOS is a fraction of the currency from the Pangea economy. Buying LEOS in the currency sale is like prepurchasing some of the $ Dollars or € Euros at a discounted price before the launch of the USA or European Union. What owners of LEOS can do is outlined in LEOS Uses and further explored in LEOS Currency Utility and Benefits.

Recognising the foundation on which LEOS is built is also essential. That is a long-term stable governance system built using a modern democracy hybrid. The ecosystem is global and permissionless, maintaining the vision of many existing Layer 1 crypto protocols. Unlike most of these protocols, however, Pangea contains the facilities to autonomously self-regulating within the Pangea self-sovereign economic zone and protect its citizens from various forms of economic damage such as loss of private keys or hacks and theft commonly found in crypto, as described in Pangea - Governance and Strategy.

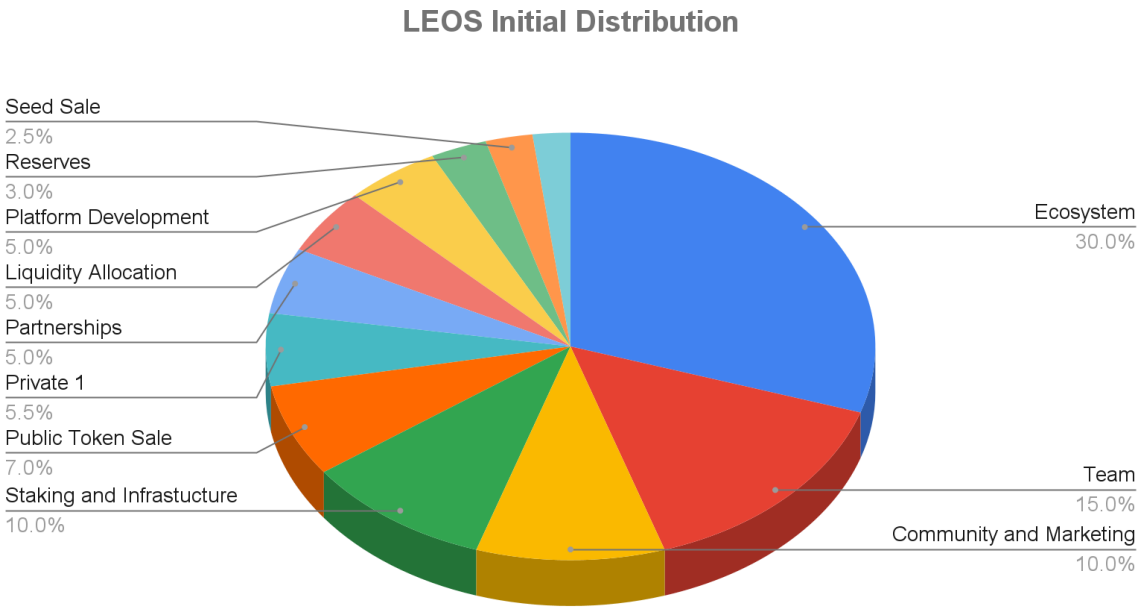
To ensure the highest levels of compliance in the still unclear regulatory environment of Web 3, cryptocurrency specialists at Taylor Wessing (https://www.taylorwessing.com) were consulted to advise the LEOS currency sale. Their expert globally recognised advice has also led the LEOS currency sale to comply with the upcoming EU regulation Markets in Crypto Assets (MiCA) regulations. LEOS will be one of the first MICA-compliant coins on the European market.

More information about the LEOS currency sale can be found at
https://pangea.web4.world/leos-currency

Initial Coin Distribution Strategy

LEOS has a capped total supply of 50 billion coins. There is no inflation or burning of LEOS tokens.

A comprehensive strategy to foster a robust and balanced ecosystem guides the currency's initial distribution. This strategy encompasses several key allocations:



LEOS Sale Rounds

The LEOS currency sale is structured in several rounds to facilitate orderly participation and LEOS adopters.

	Start date	FDV	Price	Raise Amount	Maximum Allocation
Seed	April 2024	$100,000,000	$0.002	$2,500,000	2.5%
Strategic Partnerships	October 2024	$200,000,000	$0.004	$11,000,000	5.5%
Public (TGE)	December 2024	$600,000,000	$0.012	$42,000,000	7.0%

Table 2: LEOS Sale Rounds

The seed and strategic partnerships sales will go through selected Tonomy Foundation contacts and partnerships. The public sale is expected to be facilitated through a mix of self-hosted purchasing platforms and selected coin sale platforms on centralised and decentralised exchanges. LEOS can be purchased in exchange for USD, EUR, BTC, ETH or USDT.

Our valuation is based on significant research into recent and similar protocol launches. This has included a comprehensive analysis framework that looked at fundamentals, technology and innovation, tokenomics and distribution, regulatory landscape, market performance, and sentiment pre- and post-launch. We were guided by the advice provided by the Brightnode tokenomics team while conducting this analysis. This analysis identified and analysed Several successful and unsuccessful projects, to understand the best valuation and pricing strategy, including 5IRE, Humanode, Crypto Tex, Astra Protocol, Zetachain and Celestia. As Pangea positions itself as a web4 virtual nation, we recognised that our analysis has significant overlap with these projects while also extending or having different areas of focus.

Vesting Schedule

Vesting schedules are an integral part of the currency distribution strategy, ensuring that the interests of LEOS adopters, team members, and Pangea treasury funds are aligned with the long-term objectives of the Pangea ecosystem, as seen in Table 3.

Allocation	TGE Unlocked	0 months	6 months	12 months	18 months	24 months	30 months
Seed 1.25M LEOS 2.50%	0.00%		25% unlocked, 4.17% monthly for 1.5 years				
Strategic Partners 2.75M LEOS 5.50%	0.00%			25% unlocked, 4.17% monthly for 1.5 years			
Public 3.50M LEOS 7.00%	100.00%	100% unlocked					
Team 7.50M LEOS 15.00%	0.00%			1.67% monthly for 5 years			
Legal and compliance 1.00M LEOS 2.00%	8.33%	8.33% monthly for 1 year					
Reserves 1.50M LEOS 3.00%	4.17%	4.17% monthly for 2 years					
Partnerships 2.50M LEOS 5.00%	4.17%	4.17% monthly for 2 years					
Liquidity Allocation 2.50M LEOS 5.00%	4.17%	100% unlocked					
Community and Marketing 5.00M LEOS 10.00%	1.67%	1.67% monthly for 5 years					
Platform Development 2.50M LEOS 5.00%	1.67%	1.67% monthly for 5 years					
Staking and Infrastructure Rewards 5.00M LEOS 10.00%	1.67%	1.67% monthly for 5 years					
Ecosystem 15.00M LEOS 30.00%	0.00%			1.67% monthly for 5 years			

Table 3: Vesting Schedule

All dates are relative to the TGE (public sale), when all token vesting starts.

Use of LEOS Currency Sales Proceeds

The proceeds from the LEOS currency sale are crucial for the foundational and operational development of the Pangea ecosystem, done by the Dutch non-profit Tonomy Foundation. The strategic allocation of these funds aims to ensure the ecosystem's long-term sustainability, growth, and success. The following outlines the proposed percentage breakdown of how the funds from the LEOS currency sale will be utilised.

- **Product Development and Innovation (30%)**: To fuel the research, development, and continuous improvement of Pangea's technology, including the Tonomy Gov OS framework, Pangea Passport, DAO structures, and other essential digital infrastructure components.
- **Ecosystem Growth and Partnerships (18%):** To support the expansion of the Pangea ecosystem through strategic partnerships, collaborations, and integration with other platforms and technologies, enhancing the ecosystem's capabilities and reach.
- **Marketing and Community Engagement (15%):** For comprehensive marketing strategies, community building, and engagement initiatives to increase awareness, adoption, and active participation within the Pangea ecosystem.
- **Fundraising Growth and Development (14%):** To ensure the best success of raising the necessary funds to build and develop Pangea.
- **Operational Expenses (10%):** To cover the day-to-day operational costs of running the Tonomy Foundation, including administrative expenses, legal compliance, and other overheads.
- **Security and Compliance (8%):** To ensure the highest standards of security, privacy, and regulatory compliance across the Pangea ecosystem, safeguarding against risks and maintaining trust.
- **Reserve Fund (5%):** A contingency fund to address unforeseen challenges, capitalise on new opportunities, and provide financial flexibility and resilience to the ecosystem.

This allocation strategy is designed to balance immediate operational needs with long-term strategic objectives, ensuring that the LEOS currency sale proceeds are used effectively by the Tonomy Foundation to build a robust, secure, and thriving Pangea ecosystem. It reflects a commitment to transparency, accountability, and responsible financial management,

aligning with Pangea's vision of creating a sovereign, decentralised virtual nation powered by its community.

Conclusion

The LEOS Tokenomics document presents a comprehensive framework for the economic and operational foundation of the Pangea ecosystem and the utility of the LEOS currency as a means for global payments. At its core, LEOS serves as the native currency, facilitating various transactions within Pangea, from governance and identity verification to incentivising infrastructure and enabling global payments. The tokenomics model emphasises democratic governance, ensuring that monetary policy decisions are made inclusively and adaptively. The introduction of the Pangea Economics Simulator further underscores the commitment to transparency and stakeholder engagement, enabling participants to understand and navigate the ecosystem's economy.

The strategic allocation and distribution of LEOS currency, detailed in the LEOS Currency Salee section, highlights a balanced approach to supporting the ecosystem's growth while aligning the interests of early LEOS adopters, team members, and partners with Pangea's long-term success. The phased currency sale rounds and carefully structured vesting schedules reinforce this alignment, ensuring a steady and sustainable introduction of LEOS into the market.

Looking ahead, the role and evolution of LEOS within Pangea are poised for significant growth and expansion, in line with the vision outlined in the forthcoming Pangea Vision 2030 document. As Pangea develops and matures, LEOS will play a pivotal role in enabling the ecosystem to achieve its ambitious goals of creating a sovereign, decentralised virtual nation. The tokenomics framework laid out in this document sets the stage for a future where LEOS powers the Pangea ecosystem and contributes to reshaping the global digital economy, offering a model for financial trust, inclusivity, and participation.

Appendix 3: Pangea Technology

Pangea Technical Whitepaper

Governance Operating System for Ecosystems of Trust

Pangea is powered by Tonomy Gov OS

v1.1

By the Tonomy Foundation

Executive Summary

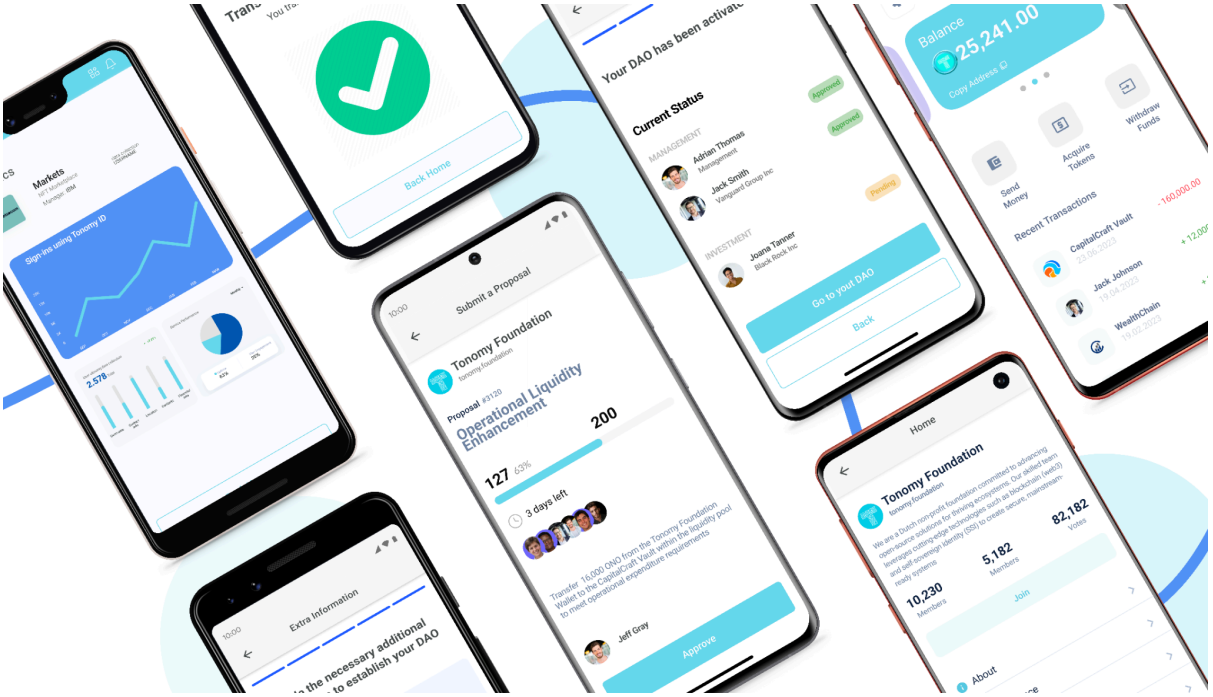
Tonomy Gov OS is a groundbreaking governance operating system, meticulously crafted to establish trust in various ecosystems, including governmental, enterprise, and public commons governance. This innovative platform adeptly handles the governance of complex multi-party ecosystems such as social welfare, healthcare, large enterprises, infrastructure, state nations, land territories, AI systems, cryptocurrencies, and global environmental commons management. Key features include:

- **Modular, Configurable Governance:** The network features a highly customisable system for governance, identity, and economics. Its modular design allows for tailored solutions to meet diverse requirements, ensuring adaptable and effective governance in various environments.
- **High-Performance Consensus Algorithm:** Tonomy utilises a scalable aBFT consensus algorithm with a 0.5s latency, capable of handling 10,000 transactions per second. This high performance is crucial for supporting large-scale, efficient, and secure transactions within the network. This can be further increased to support an infinite number of transactions per second with the implementation of sharding in the future.
- **Artificial Intelligence Enhancement:** AI is ethically integrated into the network to streamline governance, developer and administrative tasks. This reduces operational friction and improves usability, making governance more efficient and user-friendly.
- **Zero Knowledge, Privacy and Compliance-Centric:** The network's identity management system prioritises privacy and compliance, employing a zero-knowledge architecture and advanced cryptography. This architecture eliminates the need for databases to store personal information, thereby enhancing cybersecurity and ensuring compliance with privacy regulations. It also embodies the first true implementation of fully self-sovereign Identity adhering to and exceeding industry standards.
- **No-Code Platform:** The network's no-code features significantly enhance its scalability and mainstream usability. These no-code applications empower developers to launch blockchain-ready apps in minutes rather than weeks, making the platform accessible to a broad audience and streamlining the development process. For the first time, dApp developers are also able to manage users & their privileges, enabling a regulation-ready infrastructure & the elimination of bad actors.

In essence, Tonomy represents a significant advancement in digital governance. Integrating state-of-the-art technologies offers a robust, scalable, and user-friendly governance operating system, ready to transform how digital ecosystems operate and interact on a global scale. While offering all of the benefits of traditional blockchain networks, a Tonomy network introduces a set of advancements that enable the mainstream adoption of distributed ledger technology while exceeding the capabilities of predecessor networks.

The Tonomy Foundation will use this the Tonomy Gov OS software suite to launch Pangea, the first global decentralised governance network. This network aims to provide a trusted global governance system to power Internet users with better autonomy and privacy while providing Internet application providers with better facilities for user security, team management and cooperation. Pangea will introduce the global currency LEOS (Ł), which is

a payment system between individuals and DAOs. The strategy, governance and economic system for this network are outlined in the [Pangea Virtual Nation Whitepaper](#).



Contents

Impact Statement

Before the initiation of this project, the Tonomy Foundation deemed it imperative to establish both internally and externally the feasibility and sufficiency of its expertise in developing the technologies delineated in this White Paper. This objective has constituted a principal focus of the Foundation over the past eighteen months.

One of the most important and intricate components of Tonomy is its identity system. The Foundation has successfully developed Tonomy ID, a comprehensive and production operational system. This system encompasses a fully non-custodial wallet capable of signing data, including smart contract transactions and W3C Verifiable Credentials and DIDComm messages. It facilitates the storage and sharing of private data. Remarkably, the Tonomy ID maintains stringent security measures while offering an experience akin to mainstream Web2 interfaces. This product, having recently been introduced to the market, is garnering favourable responses from our clientele. Try using Tonomy ID here.

In this venture, the Tonomy Foundation has significantly contributed to the World Wide Web Consortium (W3C) decentralised Identity ecosystem. Through collaboration with the W3C Credentials Community Group and the decentralised Identity Foundation, the Foundation has substantially developed the did-jwt and did-jwt-vc, facilitating multi-party and delegated signatures. These technologies, the most utilised libraries in DID technologies with an upward trend of 40,000 weekly downloads, are poised for widespread adoption within the EU digital identity wallet framework and various national identity programs. These developments utilise the W3C CCG standard, co-authored by Tonomy founder Jack Tanner, which introduces the "Conditional Proofs" which extends the Decentralised Identifier standard enabling multi-party and delegated signatures. Further details can be found at W3C CCG Conditional Proofs standard.

Additionally, the Tonomy Foundation has been instrumental in establishing the Telos Network, serving as one of its launching nodes. This engagement has provided critical insights into the core consensus model, which will be substantially modified to forge a democratic-enabled blockchain. Our research and development in governance have demonstrated the adaptability of the core protocol in supporting diverse governance models, including democratic, proof of share, proof of stake, and direct or representative frameworks. More information can be found at EOSIO Governance Contracts.

The Tonomy Participate project, a proof of concept delivered for the city of The Hague as a participatory budgeting tool, has been another significant achievement. This project secured the second prize at the Odyssee hackathon, followed by engagement from the Hague government.

In conclusion, our team possesses the requisite technical expertise and the operational capability to implement and develop the technologies specified in this White Paper.

Overview

Tonomy is a software suite that can deploy digital governance on any ecosystem. Tonomy does this by including critical out-of-the-box components necessary for digital governance. These enable the management of identity, organisations and institutions including governance systems and software applications. The modular approach can create various and upgradeable models for the governance of ecosystems of trust, such as democratic, proof of stake, representative, direct or hybrid models.

Tonomy heralds a paradigm shift in **digital governance architectures**, meticulously engineered to instil trust across a spectrum of ecosystems, inclusive of governmental, enterprise, industry, and communal governance domains. This pioneering system adeptly orchestrates governance processes within intricate multi-stakeholder ecosystems, addressing sectors ranging from social welfare and healthcare to large-scale corporate entities, infrastructural initiatives, national territories, artificial intelligence frameworks, cryptocurrency mechanisms, and comprehensive global environmental stewardship.

Central to Tonomy is a digital ecosystem, distinct in its ability to foster autonomous user engagement, team collaboration, and the development of revolutionary applications **devoid of reliance on centralised third-party services or data repositories**.

At the core of its operational model, Tonomy encompasses five pivotal actors: individuals with unique identities, decentralised autonomous organisations (DAOs) constituting multiparty entities, a specialised DAO for ecosystem governance, applications providing standard functionalities, and network infrastructure services, including blockchain nodes.

The network employs a diverse array of scalable, low/no trust technologies to construct a decentralised service network, powering a comprehensive application ecosystem. This infrastructure facilitates a suite of standardized, user-centric applications, encapsulating:

- **Tonomy ID:** A self-sovereign identity, data and web3 wallet facilitating single sign-on across Web2 & Web3 applications, whilst also enabling digital eiDAS compliant signatures, sharing of W3C Verifiable Credentials & sovereign data storage.
- **Tonomy DAO:** A platform enabling collaborative formation & democratic administration of new legal entities for joint management of apps, data, funds, policies and much more.
- **Tonomy GOV:** A platform for sustainable ecosystem governance encompassing policy management, network infrastructure, operations, arbitration, funds management.
- **Tonomy PAY:** A tool for seamless financial management, micropayments & connection of different Web2 & Web3 payment rails, incorporating advanced features such as subscription models, AML adherence and threshold settings.
- **Tonomy DEV:** A no-code platform for managing network infrastructure, including applications, validator nodes, and servers, smart contract creation, user management & much more powered by Artificial Intelligence

Tonomy's architecture is underpinned by a **modular software approach**, offering high configurability to meet diverse requirements of complex ecosystems, whilst avoiding the

need for L2 networks and rollups which constitute a series of usability and security risks. This is achieved through:

- A **flexible identity management** system employing multi-key technologies and Self-Sovereign Identity principles for private, secure, and interoperable identities.
- A **modular governance** system integrating various consensus algorithms and governance models, including traditional direct and representative democracy, alongside innovative stake-based and liquid democracy systems.
- A **versatile economic system** enabling advanced resource allocation configurations, denial of service security methods, and currency token management tools.

Beneath its interface, the network integrates a multitude of system services to deliver a unique user experience in a decentralised and secure manner. This is facilitated by a multilayer system comprising:

- A **scalable blockchain network** acting as the core execution layer for critical ecosystem components such as identity, governance, and economics, utilising an advanced aBFT consensus algorithm capable of handling substantial transaction volumes.
- Support services enabling peer-to-peer communication, identity verification, secure data and identity recovery, all leveraging decentralised Identifiers (DIDs).

Tonomy's **zero-knowledge architecture** for identities and DAOs obviates the need for trust or storage of personal information, addressing significant cybersecurity risks and data compliance challenges inherent in current internet architectures. The system's identity and key management framework and a design-driven approach enhance user accessibility and usability.

Advanced cryptographic techniques, such as **zero-knowledge proofs**, are employed for selective data disclosure and on-chain proofs, fostering provable and private systems and facilitating enterprise adoption by ensuring compliance with data privacy regulations such as GDPR.

Integrating **artificial intelligence** within DAO and ecosystem governance processes provides concise summaries of technical proposals and discussions, aiding in managing new proposals from diverse perspectives in an opt-in ethical way.

User safety within the ecosystem is enhanced through features like DAO and identity anonymised accountability, transparent governance, and an arbitration system that allows for the issuance of warrants under specific conditions for governance and administrative functions.

Tonomy offers developers an engaging experience through the **no-code network infrastructure** developer console, enabling easy onboarding, user retention, and efficient management of applications and network infrastructure.

Cryptocurrency comparison:
Tonomy facilitates the creation of decentralised, public currencies. Unlike Ethereum and

most cryptocurrencies, Tonomy provides out-of-the-box no-code tools for autonomous governance and administration of cryptocurrency operations, such as developer grants, improvement proposals, and policy and standard updates. Its mainstream-ready application suite provides an immediate web2-like experience for using currencies as well as governance and operation without compromising on web3 fundamentals like autonomy and decentralisation.

State-nation comparison:
When applied to state-nation governance, Tonomy enables the digital foundation for sovereign-state institutions, including ministries and sub-departments, to manage legislative, judicial, and executive functions. This approach contrasts with existing state-nation systems by providing a digital platform that allows for the rapid adaptation and expansion of policies and governance structures, responding more effectively to citizens' needs. The advanced cryptography and distributed network systems enable state nations to manage their cyber security needs without worries of citizen fraud, data breaches or foreign digital attacks.

Pangea and LEOS (Ł) Currency

This white paper outlines the software suite in which Tonomy creates a modular Governance Operating System for Ecosystems of Trust. These can be adapted and configured for various use cases requiring complex governance and multi-party interactions.

The community including Tonomy Foundation and partners will use this framework to launch the first global decentralised governance network called Pangea. This network aims to provide a trusted global governance system to power internet users with better autonomy and privacy while providing application providers with better facilities for user security, team management and cooperation. Pangea will introduce the global currency LEOS, which is used as a payment system between individuals and DAOs. The network has a long-term vision of fostering better global political and environmental governance.

Read the Pangea - Governance & Strategy document for details of this Tonomy powered network.

Features

For Users

Self-Sovereign Identity Management

Tonomy ID empowers users with full autonomy over their digital identities, enabling seamless interaction with various entities within the network, including people, DAOs, and applications. This system eschews third-party identity providers, offering a democratised approach that caters to all technical skill levels.

Zero Knowledge Privacy-Preserving Autonomous Control

The design paradigm of Tonomy prioritises user privacy. By vesting data control in the hands of users and employing advanced cryptographic techniques such as zero-knowledge proofs, the network guarantees privacy and consent without reliance on third-party custodians.

Decentralised Identity Verification

The network facilitates private and anonymous identity verification processes. Personal verification proofs are stored locally on users' devices, not on central servers, enhancing privacy and trustworthiness across the network. KYC costs for businesses integrating with Tonomy ID are reduced 100-fold as users verify their identity once and can prove their status anywhere, as many times as needed.

Seamless UX with Advanced Web 4.0 Security Features

Tonomy enables users to execute digital eiDAS compliant qualified electronic signatures (QES) and smart contract transactions within the app environment, leveraging multi-factor authentication, multi-party approvals, hardware signature proofs to bolster security. This enables a military and banking-grade infrastructure that adheres to the highest industry standards.

Simplified Financial Transactions and Account Management

Tonomy PAY offers a user-friendly financial interface akin to modern neo-banking systems. It allows for simplified payments, receipt management, and advanced account management, blending hot and cold wallet features while hiding cryptographic complexities. The network's low transaction fees also make it an ideal rail for micropayments and small-value transactions.

Robust Governance and Identity Access Management (IAM) for DAOs

Tonomy DAO offers flexible and comprehensive governance templates and IAM structures, supporting diverse organisational models. It enables efficient management of permissions and roles, enhancing operational security and efficiency whilst paving the road for entities that aim for high levels of compliance.

Arbitration System for Privacy-Preserving Safety and Conflict Resolution

The network features a comprehensive arbitration system that ensures privacy while providing safety and conflict resolution mechanisms. This system is crucial for maintaining a secure and compliant environment, enabling the resolution of disputes and the protection of user data. Justice should be delivered digitally in the 21st century and an environment of accountability is established through a mix of privacy-preserving identity, arbitration and governance features.

Transparent and Participatory Ecosystem Governance

The network's governance and administration system is open and accessible, fostering democratic participation in policy and rule-making. This transparency ensures

accountability and sustainable evolution of the ecosystem. Tonomy is the first blockchain suite with an inbuilt network governance platform.

AI-Assisted Decision-Making and Policy Formulation

The network leverages artificial intelligence to aid in creating clear and comprehensive governance proposals and policies, enhancing decision-making quality and regulatory compliance. AI is also used to intelligently analyse the network & social sentiment to create improvement proposals for the network.

Streamlined Network Infrastructure Management

Tonomy offers a no-code application development and management platform, facilitating rapid deployment and integration of decentralised applications for anyone, regardless of their technical skill set.

For Infrastructure Operators

High-Performance On-Chain Consensus and Scalability

The network achieves significant throughput (15,000 transactions per second) with low latency (0.5 seconds), utilising advanced consensus algorithms like aBFT and HotStuff, enabling efficient on-chain application performance.

Modular and Adaptive Transaction Fee System

The network employs a flexible and modular approach to transaction fees, allowing for customisable models that cater to diverse needs within the ecosystem. The core network employs fixed-dollar fees, enabling predictable expenses for businesses that deploy applications on Tonomy-powered networks.

On-Chain Consensus Model for Modular Governance

Tonomy implements an on-chain consensus model, facilitating a dynamic and adaptive governance structure of the technical infrastructure. This model allows the network to evolve its governance policies in response to its participants' changing needs and consensus.

Eco-Friendly and Upgradeable Cryptographic Framework

The network's use of optimised server technologies and efficient consensus algorithms minimises its environmental footprint. Its cryptographic infrastructure is designed to be upgradeable, ensuring readiness for future advancements. The Tonomy Foundation also commits to purchasing carbon credits in the future to make the network carbon-negative.

Enhanced Data Privacy and Interoperability

Employing decentralised identifiers (DIDs), the network ensures private and verifiable off-chain data, enhancing interoperability across the internet and other blockchain systems.

Multi-Language Smart Contract Support Including EVM

The network supports the creation of on-chain smart contracts in multiple programming languages and execution in WASM smart contracts or through the Ethereum Virtual Machine

(EVM), offering developers flexibility and choice based on use-case requirements and team expertise.

EVM and DeFi Compatibility

Ensuring compatibility with Ethereum Virtual Machine (EVM) and decentralised finance (DeFi) protocols, Tonomy is poised to integrate with existing DeFi ecosystems. This compatibility facilitates liquidity and interoperability, broadening the network's appeal and utility within the broader blockchain landscape.

Data Privacy Compliance

The network's architecture ensures compliance with global personal data privacy regulations such as GDPR, CCPA, and CCRA to facilitate enterprise and government adoption. This compliance is intrinsic to the system's design, making it a viable and trustworthy option for enterprise and government applications, ensuring cybersecurity and privacy.

For Ecosystem Operators

User-Centric Design for Mainstream Adoption

Tonomy adopts a human-centric approach, prioritising intuitive user experiences and seamless integration of cryptographic technologies, mirroring familiar Web2 standards while leveraging advanced Web3 innovations.

Integrated Suite of Standardized Tools

Contrasting with the fragmented nature of many cryptocurrency ecosystems, Tonomy provides an integrated, user-friendly suite of standardised out-of-the-box tools. This cohesive ecosystem enhances the user experience, reducing complexity and confusion for novice and experienced users.

Self-Regulation and Enhanced User Safety

Tonomy’s self-regulation mechanism, underpinned by its robust identity and governance systems, allows applications and the ecosystem to enforce policies and network rules autonomously. This approach diverges from traditional, unregulated cryptocurrencies, establishing a secure and politically resilient environment.

Modular Governance System for Ecosystem and DAOs

Tonomy introduces a flexible governance framework, enabling customisable governance models for both the ecosystem at large and individual DAOs. This modular system accommodates a range of governance styles, from democratic to share-based, supporting diverse organisational needs and facilitating effective self-governance.

Modular System Architecture with White Label Capabilities

The network's architecture is modular, allowing for tailored configurations in various sectors. Its white-labelling capability makes it adaptable to diverse ecosystems, enhancing trust and adoption rates.

Open Source Development Ecosystem

All software within Tonomy adheres to the Apache 2.0 license, encouraging community collaboration and bolstering security and privacy. This also assists in government adoption to prevent vendor lock-in.

Solution

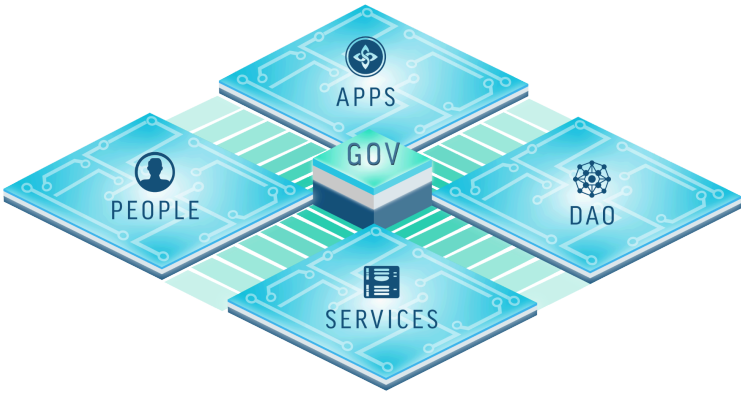


Figure 1: Network Actors

Actors

Tonomy ecosystems comprise diverse actors, each playing a crucial role in the network's functionality and governance. These actors include individuals, decentralised Autonomous Organizations (DAOs), the Governance unit (GOV), applications (Apps), and services. Below is a detailed exposition of each actor within the network.

Individuals

Individuals are the primary users of a Tonomy network. Each person engages with the system through a unique digital identity, which serves as a gateway to access the broader ecosystem. This digital identity is a critical component, ensuring secure and personalised interaction within the network.

Decentralised Autonomous Organizations (DAOs)

DAOs represent collectives of individuals, varying from companies and NGOs to government departments and state governments. These entities collaborate towards shared objectives within agreed governance frameworks. DAOs may be structured as open or closed teams. Furthermore, they are pivotal in managing the network's infrastructure, including blockchain nodes and communication services. Tonomy is the first network that enables democratic voting within DAOs due to its advanced identity capabilities.

Governance (GOV)

The Gov acts as the administrative body for the network's ecosystem. It is a specialised DAO with additional explicit responsibilities for overseeing network rules, security, and operational management. The Gov sets network fees, and incentives and ensures that DAOs managing the network infrastructure adhere to set expectations. The Gov DAO manages a pool of the native currency which may be present in the network (such as an ecosystem fund), and it’s distribution within the governance system or to contributors or other DAOs.

Applications (Apps)

Apps are software programs that facilitate interaction for users, DAOs, and the Gov DAO. The network features five core Apps — Tonomy ID, DAO, GOV, PAY, and Developer Console — which form the foundation for enabling ecosystem features. DAOs also have the

autonomy to develop their Apps, ranging from existing Web2 SaaS applications to fully decentralised applications utilising the network's unique architecture and smart contracts.

Services
Services in Tonomy refer to specific server operations run by DAOs that support the network infrastructure. The operational policies and management of these services are determined by the Gov DAO.

Architecture Overview

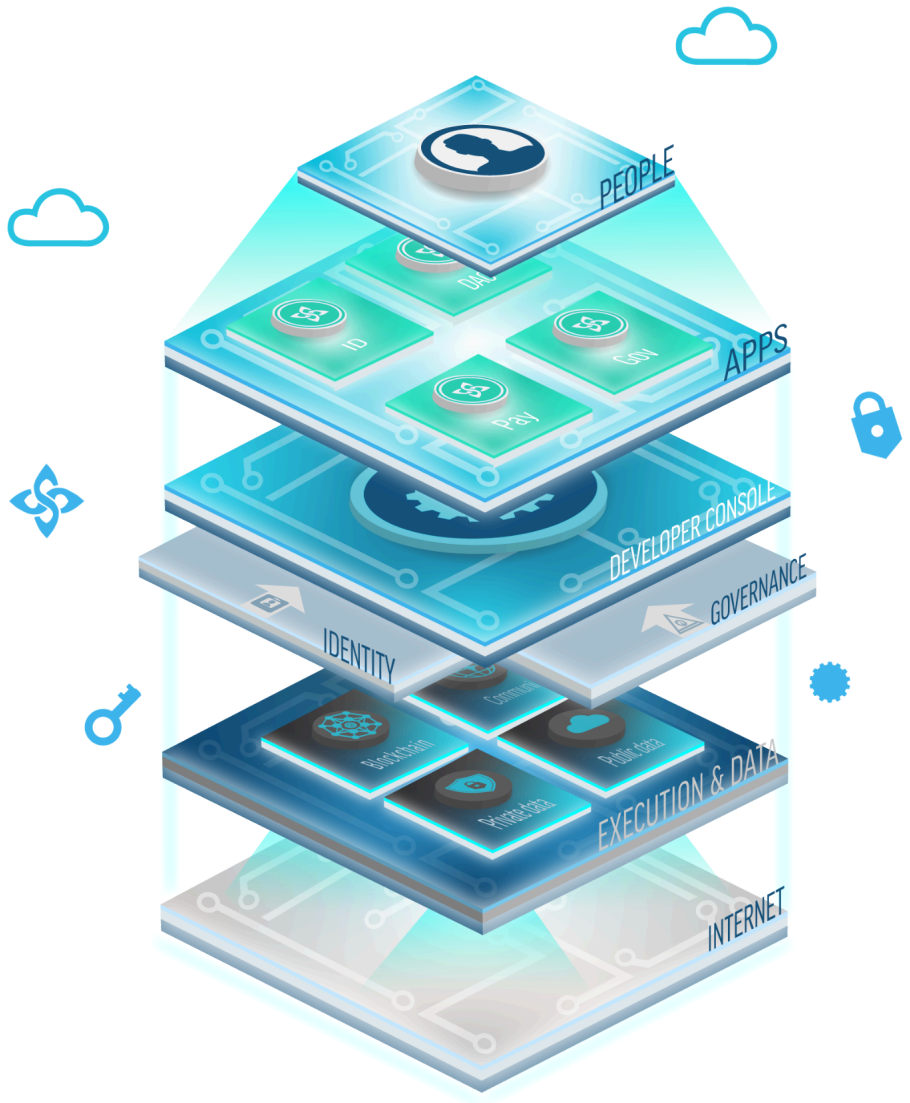


Figure 2: Architecture Layers

Execution and Data Layer
At the foundational level, the network is built upon the Internet protocol, encompassing an execution and data layer. This layer is responsible for storing both private (secured via zero-knowledge architecture) and public data. The network's infrastructure operators cannot access private data, ensuring confidentiality for individuals and DAOs. The consensus engine within this layer acts as a unifying source of truth in the peer-to-peer network, facilitating data consistency and integral services such as peer-to-peer communication, identity verification, and recovery.

Identity Layer
The identity layer operates as an intermediary between the execution applications and the core services. It is pivotal in representing the identities of individuals and DAOs within the system.

Governance Layer
The governance layer provides mechanisms for policy and ecosystem configuration decision-making. It is a versatile platform where various economic, governance, and system tools can be configured and upgraded. This adaptability makes Tonomy suitable for diverse applications in government, enterprise, public communities, and large-scale community environments.

Core Applications
The ecosystem provides standardised core applications to facilitate the formation and operation of citizen and DAO interactions. These applications include Tonomy ID, DAO, Gov, Pay, and Developer Console. They offer a mainstream-ready interface, enabling no-code, Web2-like interactions within the ecosystem and other applications.

DAO-Managed Applications
DAOs can create and manage their applications within the marketplace. This feature caters to Web2 and Web3 applications, encompassing various domains like decentralised finance, gaming, social networking, and e-commerce.

Application Layer
Individuals interact within the ecosystem primarily through applications. These applications provide a user interface that allows safe and trustless interaction, shielding users from the technical complexities of the underlying layers.

Applications Layer

The Application Layer of Tonomy networks comprises both the Tonomy Core Applications and those developed by DAOs. This document elucidates the quintet of Tonomy Core Applications, delineating their objectives and functionalities. Collectively, these foundational applications empower entrepreneurs and developers to expedite the creation of innovative use cases with unprecedented efficiency.

This facilitation is primarily attributed to the diminution of developmental intricacy and the mitigation of associated risks. This is actualised through several strategies:

- Provision of comprehensive solutions for identity, team Identity and Access Management (IAM), governance, and payment systems. These solutions are designed to accommodate 99.9% of potential use cases.
- Offering these solutions in formats amenable to developers, notably through enabling access to blockchain functionalities via application interfaces. This obviates the necessity for developers to engage directly in smart contract creation or blockchain interactions.
- Endowing developers with a "no-code" experience, permitting facile customization of identity, IAM, and governance aspects within their systems. This flexibility allows for adaptations in response to evolving requirements.
- Ensuring a streamlined and intuitive onboarding process for users. This approach ensures the security inherent in web3 technologies while maintaining a user experience akin to web2 standards. Additionally, it offers users an ongoing, straightforward interface to navigate and manage the diverse applications within a Tonomy ecosystem.

Web3 comparison:
Currently, web3 developers are compelled to undertake the complex process of navigating identity, multi-party management and governance in the new web3 paradigm, often requiring learning new programming languages and paradigms. Users faced a technically daunting and complex experience, struggling with novel technical paradigms and a disjointed onboarding and application ecosystem. Tonomy eradicates the time-intensive and high-risk tasks inherent in initiating new projects for developers and users by offering a clean no-code application system anyone can use to create well managed apps, and onboard users and in a simple familiar, albeit significantly more secure manner.

Tonomy now enables application developers to conceive and execute a plethora of use cases that were previously unfeasible. These use cases can be categorized broadly into two segments:

- Web2 applications that can leverage the substantial cybersecurity advantages of web3 technology and make data breaches a thing of a past with passwordless identity.
- Web3 applications that were previously too arduous or cumbersome to develop and use become both consumer and developer friendly.

These categories span multiple industries, with examples including:

- Governance: Tools for policy creation and budgetary participation.
- Supply Chain and Logistics: Systems benefiting from transparent tracking and tracing, alongside flexible governance mechanisms.
- decentralised Finance (DeFi): Transparent operations and governance in financial systems.
- Healthcare: Enhanced privacy and portability of data facilitated by Tonomy ID.
- Gaming: Advanced web3 asset proofs and control mechanisms for in-game collectibles.
- eCommerce: Augmented security through the use of Tonomy ID's sovereign storage vault.

- Software as a Service (SaaS) Platforms: Improved public and inaccessible sovereign single sign-on capabilities.

Tonomy, thus, presents a paradigm shift in application development, significantly enhancing the feasibility and scope of various use cases across diverse sectors.

Tonomy ID

 *Pangea Passport is powered by Tonomy ID*

Identity serves as the foundational and terminal interface for individuals within digital ecosystems.

The Tonomy ID is an advanced wallet compatible with both Web2 and Web3 frameworks, encompassing all requisite identity functionalities for user engagement with digital systems. This system facilitates user access to both Tonomy Core Applications and broader market applications, enabling secure and sovereign digital signatures and data exchange.

Users are granted full technical autonomy, maintaining complete control over their data and authorizations. This concept is commonly referred to as self-sovereign identity or a non-custodial wallet. Unique authorisation secrets, such as private keys derived from phrases, PIN codes, and biometric data, are stored solely on the user's device, eschewing database storage. Likewise, personal data is exclusively retained on the user's personal device. This architecture significantly enhances security by mitigating the risk of centralised hacking attempts, a paramount concern for users and corporations when selecting identity service providers.

In contrast to Web2 identity services like those offered by Microsoft or Okta, the Tonomy architecture eschews the storage of any user authorisation secrets or data in databases, thereby offering substantial cybersecurity advantages. Unlike existing Web3 wallets and self-sovereign identity (SSI) wallets, the Tonomy ID combines the merits of being fully non-custodial with a user interface sufficiently intuitive for individuals accustomed to mainstream platforms such as Google.[1]

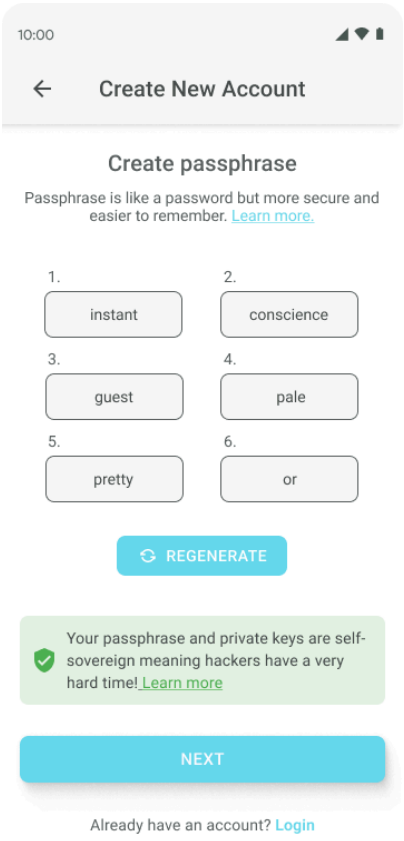


Figure 3: Siz-word mnemonic passphrase

Accounts and Onboarding

Account creation within the Tonomy ecosystem is primarily facilitated through the cross-platform mobile application via Tonomy ID. Users select a private username during this process and are assigned a random, unique, and publicly accessible anonymous user ID.

Users are provided with a cryptographically secure six-word mnemonic passphrase for account recovery and security. This passphrase is a randomly generated and easily memorable string and is passed through the secure argon2 key generation algorithm to create an ASIC-resistant, robust security. The algorithm would take every computer working together over 10,000 years to break a single key.

Resource Allocation and Transaction Fee Management

In the context of system security and protection against denial of service attacks, the identity administration portal of Tonomy incorporates a configurable resource allocation model. This model offers a selection of templates with diverse configurations to cater to various use cases, ranging from government entities to community groups, for efficient identity management.

The resource allocation model operates in the following exemplary manners:

- Central Allocation: The identity administration module possesses the discretion to allocate resources to users as deemed appropriate.
- decentralised and Equitable Allocation: All users receive equal resource allocations (e.g., 5 daily transactions) contingent upon complete verification.
- User-Directed Allocation: Users are initially provided equal allocations, with the option to acquire additional resource packages via the system's native currency.

This approach simplifies complex infrastructural aspects, enhancing accessibility for mainstream users. Requiring users to engage directly with blockchain or other intricate technical infrastructures on a per-transaction basis may result in user disengagement due to its complexity. The flexibility to revert to a cost-free account highlights the Tonomy's dedication to universal accessibility.

Social Login via Multi-Party Computation

For application processes not demanding elevated security measures, the system will support social login functionalities to streamline user onboarding for low-security applications.

The safeguarding of unique authentication secrets for this login mechanism is achieved through multi-party computation. In this framework, the user retains one key, while the social login service holds another, which is utilised to facilitate social login. Both keys are essential for the login process, ensuring the user maintains full control over their authorisation credentials[2].

Passwordless Single Sign-On

Tonomy enables users to access any affiliated Web2 or Web3 applications seamlessly. The sign-in process, analogous to Google Sign-In but employing QR codes, bridges desktop websites with mobile devices, establishing the mobile device as the primary authentication authority.

The passwordless single sign-on mechanism eliminates the need for users to input their passphrases for each website login. Instead, it utilises QR codes and URL redirections for swift and user-friendly authentication.

A distinctive aspect of the single sign-on process is the generation and authorisation of an application-specific private key. During the login procedure, a private key is randomly generated on the user's device within the currently used application. For instance, a unique key is created in the local storage of the user's browser tab on airbnb.com. Upon consenting to the login, this key is authorised to sign data on behalf of the user, with its scope limited to the application being accessed[3]. This key is subsequently employed for authorisation purposes from the application to Tonomy ID and in digital signature functionalities.

Google SSO comparison:
This feature resembles Google Sign-In, yet operates independently of Google's involvement, allowing users to authenticate directly from their phone to the application without intermediary involvement.

MetaMask comparison:
This method parallels the Web3 login experience via Metamask, focusing on user-friendliness by avoiding exposure to complex cryptographic details. It also facilitates in-app digital signatures, significantly enhancing user engagement and retention. Using scoped application keys within the multi-key account system elevates the usability of Tonomy ID, distinguishing it markedly from Metamask's single-account, single-key framework.

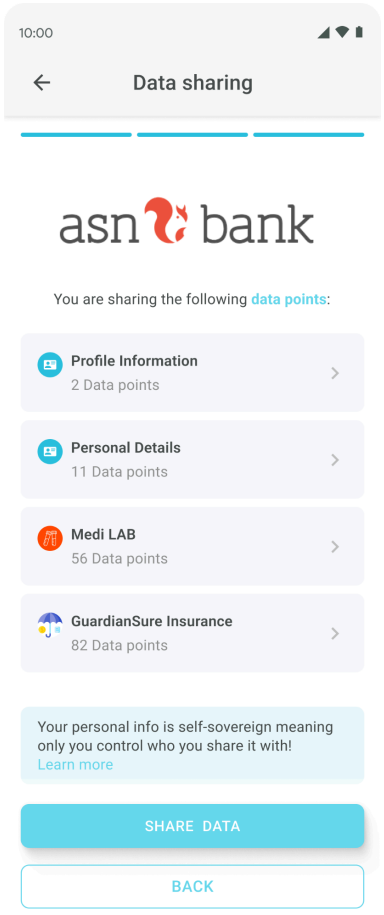


Figure 4: Data Sharing

Data Sharing and Consent:

Data stored in the sovereign storage vault can be utilised and downloaded by the applications in which it was originally created. Additionally, users can share data between applications. This is executed via a fully consensual process, allowing users to review the data being shared, its intended use, and the receiving parties. Since user data is stored on their device, there is a technical guarantee of their consent to any data sharing.

This functionality enables the transfer of portable and private data across the internet, facilitating a rich data experience across applications while preserving a seamless user experience. This capability addresses the current limitations of the internet due to technical data silos and the challenges posed by data privacy regulations. Tonomy ID heralds an era of Data Internet without compromising data privacy.

Sovereign Storage Vault

Application developers are empowered to store user-generated data within the confines of the user's device, as opposed to relying on a private database vulnerable to cyber-attacks or a public data system like IPFS, which compromises user privacy.

Healthcare example:
Consider the scenario in a healthcare application where a user's medical record, once generated, is transferred and stored in the user’s sovereign storage vault. This data is exclusively tied to the generating application, with read and write permissions limited to said application. Subsequently, other applications may access the data stored in the vault, subject to user consent for read privileges. For instance, an insurance application may request access to medical records, enabling the user to submit claims.

This paradigm of user-controlled, centralised yet fully autonomous data storage markedly enhances data security and portability across the internet. It results in diminished security risks for companies, elevated user trust, and a more enriched data interaction due to the facilitated, risk-reduced storage of personal information across diverse applications.

Conceptually, this feature is akin to having all personal certificates, diplomas, event tickets, employment contracts, and more stored digitally and verifiably within one's mobile device rather than in a remote database.

Private Identity Verification

During application sign-in procedures, users might encounter a request for identity verification to authenticate the congruence of their identity with the provided data. This is an elective part of the login process, determined by the application developer.
Various identity verification mechanism exists controled through the identity administration portal, which is in turn controlled through the governance system. Tonomy ID provides newer decentralised identity verification mechanisms utilising off-chain social graphs and ergonomics and backwards compatible identity document verification (KYC-like) flows with enhanced capabilities.

During an identity document verification flow, the verification proof is retained in the sovereign storage vault instead of being stored in a database, thereby preserving its confidentiality and reusability. This approach sustains user trust while reducing the long-term costs associated with identity verification.

For instance, numerous financial applications necessitate this process for regulatory compliance, whereas contemporary Web3 decentralised finance applications might forego this, permitting anonymous logins. These apps leverage the de-anonymization governance feature to ensure user accountability without necessitating personal information from each user.

Netverify comparison:
This feature could be compared to Netverify (utilised by Airbnb), with the distinction that post-verification, identity data, including the verification proof, resides solely on the user's device, enabling repeated use without additional verification costs.

Account Guarantee

The Tonomy ecosystem assures that users will maintain access to at least one account. This is facilitated through the private identity verification process. This guarantee is crucial, considering that certain governance features within the system allow for the partial or complete freezing/disabling of fake or compromised accounts. The identity verification protocol ensures that even individuals who violate the rules by creating fake accounts will always have one unfrozen account, thus ensuring uninterrupted network access. Such accounts may bear warnings to discourage such conduct, but access remains unfettered.

This feature ensures universal accessibility for every user while still maintaining the ability to self-regulate detrimental behavior.[4]

Digital Signature Mechanism

Tonomy ID integrates a sophisticated digital signature mechanism using fully non-custodial keys. This system accommodates diverse data formats, security protocols, and proof types to cater to a comprehensive spectrum of use cases.

DocuSign comparison:

The digital signature capability in Tonomy ID is analogous to a highly advanced and secure version of DocuSign but has considerably broader applicability. It facilitates the signing of a wide array of entities, from documents to transactions, employing customisable flows that can be adapted to various use cases and user preferences regarding security and usability.

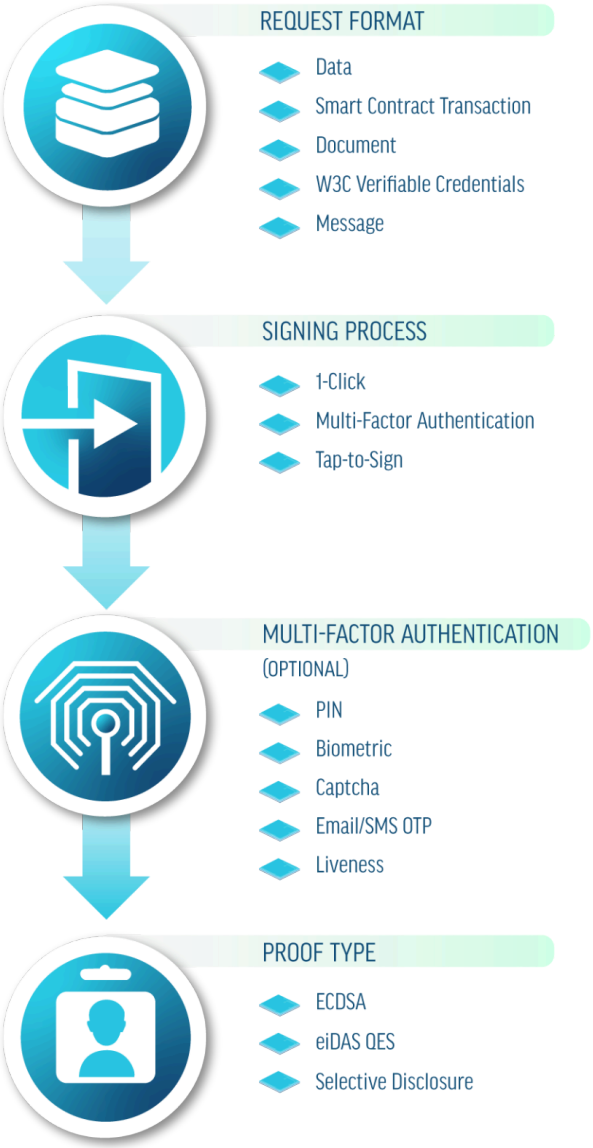


Figure 5: Digital Signature Process

The signature process is subject to the discretion of the application developer, who decides on the following parameters based on the application's specific needs:

- **Request Format:** This involves choosing the format of the data requiring a signature, ranging from raw data, W3C verifiable credentials, standard documents (e.g., PDFs), smart contract transactions, to simple messages.
- **Signing Process:** This determines the flow and security-usability balance of the signature. Options include in-app signing (generated during Single Sign-On, ideal for games or low-security transactions), multifactor authentication (for higher security, involving additional authentication like PINs or biometrics), and smart NFT technology (for offline or non-phone digital signatures using NFT-smart cards or hardware security wallets).
- **Multi-Factor Authentication:** If enabled, users undergo additional steps based on the requested challenges, each offering varying security guarantees. For instance, a PIN challenge provides a "proof of knowledge," whereas a biometric challenge offers a "proof of person."
- **Proof Type:** Developers can select from various digital signature proof types. The default is Elliptic Curve Digital Signatures (ECDSA), with options for an eiDAS Qualified Electronic Signature (QES) for EU-recognized signatures or Selective Disclosure Proofs for enhanced data privacy.

Crucially, the private keys used in these digital signatures remain under the user's control, ensuring maximal security and privacy for users and applications.

For further details, please refer to the Digital Signatures section of the Tonomy ID White Paper.

Peer-to-Peer Messaging

Leveraging the same private keys and digital signatures, Tonomy ID facilitates peer-to-peer messaging within and across various applications. This is achieved by implementing the new W3C standard DIDComm, a transport-agnostic, highly standardised, and interoperable private messaging protocol.

DIDComm Messaging represents a sophisticated method for individuals, institutions, and IoT entities to engage through machine-readable messages, underpinned by the security and privacy features of decentralised identifiers (DIDs). It is compatible across various transport mediums, including HTTP, Bluetooth, and websockets.

DIDComm also incorporates Onion routing for messages, significantly enhancing user privacy.

WhatsApp comparison:
This feature offers end-to-end encrypted messaging capabilities comparable to applications like WhatsApp, with the added flexibility of functioning across different applications and having enhanced security and governance.

Private Reputation System

Within the Tonomy ID ecosystem, identities can accumulate and be accountable for private ratings from other users, striking a balance between privacy and accountability. These private reputation systems can undergo audits via the governance's arbitration system through appropriate warrants.[5]

Account Recovery

Tonomy ID utilises a secure 6-word passphrase as the primary authentication method for its mobile app. To address situations where users forget or lose this passphrase, Tonomy ID offers several non-custodial recovery mechanisms, ensuring autonomous control over user accounts:

- Social Recovery: Users can designate trusted contacts to assist in account recovery collectively.
- Hardware Recovery: Pre-authorized devices like secure hardware wallets or NFC-enabled smartcards can be used for recovery.
- Security Questions: Utilizing advanced cryptographic techniques, users can recover accounts by correctly answering pre-selected personal questions.
- Partially-Custodial Identity Verification: An identity verification process through governance services allows temporary access to a user's sovereign storage vault for identity confirmation.

The recovery process includes a mandatory timeout period, varying based on the security level of the chosen recovery method.

Additionally, Tonomy ID offers optional plug-ins for various custodial recovery techniques, enhancing its suitability for enterprise use.

For more information, please see the relevant sections in the Tonomy ID White Paper.

Identity Administration Portal

The Identity Administration Portal facilitates the configuration of various features and settings integral to Tonomy ID. Key aspects that can be adjusted include:

- Identity Verification Methods: Establishing protocols for identity authentication.
- Resource Allocation Models: Defining parameters such as daily transaction limits per user.
- Security Policies: Implementing security measures for single sign-on and digital signatures, including considerations for mandatory multifactor authentication.
- Private Reputation Systems: Guidelines for activating and regulating private reputation mechanisms.
- Account Recovery Options: Selection of available mechanisms for account recovery.

This portal plays a crucial role in setting ecosystem-wide identity access policies. It enables administrators to:

- Specify policies governing user admission to the ecosystem.
- Administer account-related actions such as account freezing and issuance of access warrants.Establish identity systems ranging from closed systems (e.g., invite-only for enterprise employees) to open, public, permissionless networks.

Through the portal, individual identities within the ecosystem can be managed, including the ability to freeze accounts or de-anonymize identities under specific warrants.

The identity system's configuration is accessible via a user-friendly, no-code platform. Depending on the governance system in place, configurations may be determined by authorised entities (e.g., a department of identity employees) or through multi-party governance proposals.

Tonomy DAO

 *Pangea DAO is powered by Tonomy DAO*

Tonomy DAO represents a paradigm shift in organisational management, facilitating the formation and autonomous governance of various collective entities such as companies, foundations, communities, associations, and commons. This platform maintains autonomy and control over governance, data, funds, and operations, negating the requirement for external service providers.

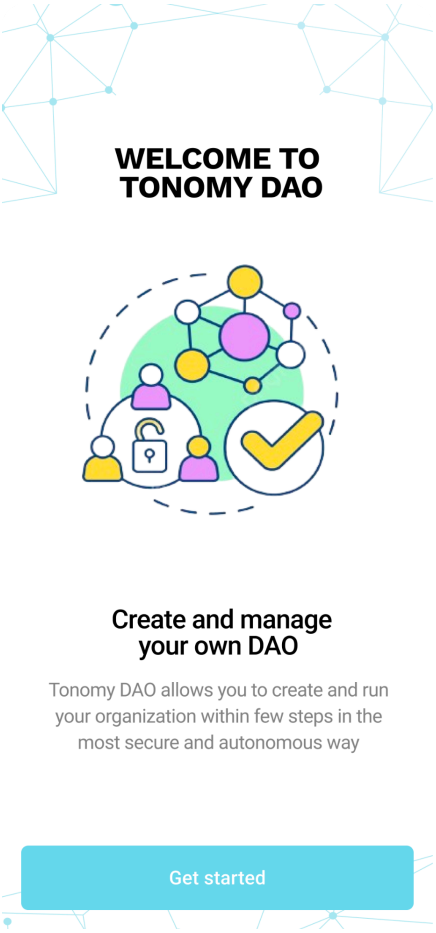


Figure 6: Create a DAO

Within Tonomy, governance is administered through the Tonomy DAO system, embodying a decentralised control model.

Tonomy DAO integrates advanced Identity and Access Management (IAM) mechanisms, supporting diverse member entities from individuals to other DAOs. Its architecture, characterised by low-latency transactions and versatile IAM configurations, enables a broad spectrum of governance structures. This makes Tonomy DAO a versatile platform for mainstream organisational management, straddling high-security Web2 and high-usability Web3 applications across various sectors.

DAOs, functioning as public entities, maintain visible profiles, yet member identities are safeguarded through anonymised account IDs. Membership entails automatic access to other members' information, aligned with the established privacy policy. This aspect of Tonomy DAO is critical, underpinning the decentralised control of multi-party sovereign entities on the Internet.[6]

Incorporation Process

Creating a DAO within a Tonomy network is a streamlined process. Prospective founders select key attributes such as name, description, liability model, categories, and governance structure. Post-creation, members are onboarded, and governance frameworks or DAO profiles are modifiable.

The chosen liability model, categories, and governance structure are integral in defining the regulatory framework of the entity, facilitated by the platform's self-regulating governance capabilities.

Governance Templates and Models

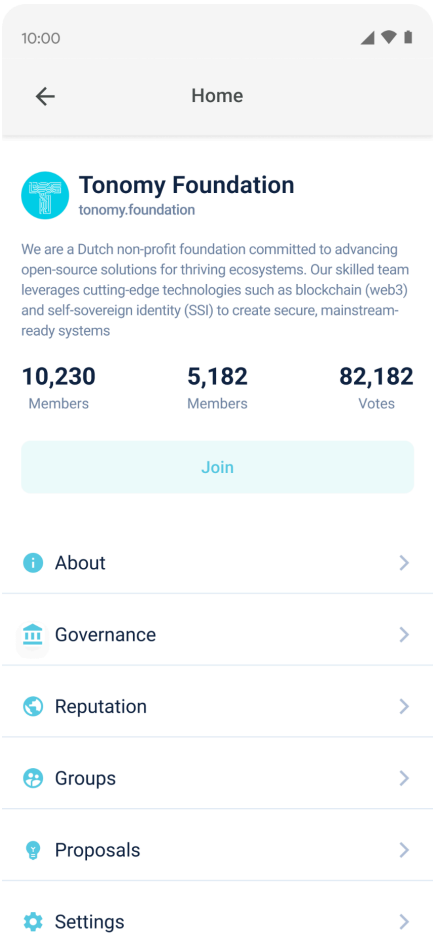


Figure 7: DAO Profile

Tonomy DAO offers an array of foundational governance templates, enabling diverse voting privileges:

- Democratic: Equitable voting rights for verified members.
- Share/Token-Based: Votes are weighted by token holdings, managed through Tonomy Pay.
- Sole-Proprietor: Tailored for individual enterprises with centralised decision-making.

Decision-making models within Tonomy DAO vary, including:

- Federated: Governance by a self-selected executive group.
- Representative: Indirect voting through trusted representatives.
- Direct: Direct voting on decisions by all members.
- Liquid: A nuanced approach combining direct and representative voting, allowing members to delegate voting power in specialised areas.

These models cater to a wide range of entities, from government departments, and profit-driven companies to self-managed communities, demonstrating Tonomy DAO's adaptability and innovation in organisational governance[7].

Identity Access Management (IAM)

IAM is crucial in managing DAO members and their authorisation levels. As DAOs expand, they can:

- Form multiple groups akin to departments, each with defined responsibilities, permissions, and security policies.
- Configure access rights which control the way members join and leave these groups. These can be configured to allow open access or invite only.
- Configure security policies for the group that control the requirements for digital signatures to authorise the documents or transactions for which the group is responsible.
- Assign members to these groups, granting them corresponding rights.

For example, a finance group might have specific responsibilities, permissions up to a certain transaction limit in Tonomy Pay, and security policies requiring multifactor authentication for authorisations.[8]

Sovereign Storage Vault

DAOs utilise sovereign storage vaults for private data storage, similar to Tonomy ID but adapted for multiparty use. These vaults are permissioned based on group assignment, with parent groups having access to child group data, supported by multiparty encryption.

Google Drive comparison:
The Sovereign Storage Vault for DAOs is like having a Google Drive available to employees, except that the data stored in the vault is not visible to any third parties. This is a significant privacy improvement for people and companies and a significant cyber security and compliance improvement for ecosystem operators.

Multi-party Proposals

Figure 7: DAO Profile

DAOs govern through multi-party proposals, encompassing:

- Documents - Creating or modifying the documents. For example, this can be used to create, sign and execute articles of association for a company. Or it could be used To sign an employee agreement between the employee and their new manager.
- Policy - Creating or modifying company policies and agreements. For example, this can create new security policies for groups or expectations for new employees regarding holidays.
- Funds - Sending money to suppliers or for other expenses. This is particularly useful for high-value transfers to have multiple-party authorisation. It can also create and configure new multi-party funds accounts and Tonomy Pay.
- Governance - The top-level owners and governance structure used within the DAO can also be upgraded. This leverages the upgradable accounts and governance features of the underlying structure. This allows DAOs to remain agile and flexible.

Proposals impact the proposing group and its subordinates, ensuring higher-level security integrity.

Voting Mechanisms

The network accommodates multiple voting mechanisms to meet distinct privacy and security requirements:

- **Public and decentralised On-Chain Voting:** Offers supreme security and transparency to users.

- **Private On-Chain Voting:** Employs advanced cryptography, balancing high security with user scalability and long-term cryptographic reliability.
- **Private Off-Chain Voting:** Utilizes cryptography with low-trust vote custodians, providing scalable private voting but with reduced security assurances.

Different voting strategies are also offered in modules. These can be configured at the policy proposal level or applied to all policies based on whether there is the option to vote on one policy at a time or between a selection of options:

Voting strategies for single policy voting:

- **Binary Choice:** Typically, voters are presented with a yes/no or approve/reject option for the proposal.
- **Quorum Requirements:** A minimum number of participants (quorum) may be required for the vote to be valid. This can be based on total membership or only active participants.
- **Counting Absences:** Depending on the rules, absentees may be counted as implicit approvals, rejections, or not counted at all.

Voting strategies for multi-option policies:

- **Multiple Candidates/Options:** Voters select from more than two options, which could be candidates, policies, or proposals.
- **Voting Systems:** Can use a variety of methods like first-past-the-post, preferential (ranked-choice) voting, proportional representation, etc.
- **Majority or Plurality:** Depending on the system, the winner may need a majority (more than 50%) or simply a plurality (the most votes).
- **Budget Based:** Users are allocated a budget which they can spend on proposals which each have been assigned a cost.
- **Sequential Elimination:** In some methods like instant-runoff voting, options with the fewest votes are eliminated in rounds until a winner emerges.

Artificial Inteligence Enhanced Proposal

During the creation of new policies and proposals, artificial intelligence creates suggestions For enhancements in the language and content, using the existing policies as well as its connection to the discussion and communication forums for context. Uses creating the proposals are always able to opt-in to suggestions, to ensure Verification and ethical use of AI generated content.

This feature helps proposal writers ensure they have captured the main perspectives including thinking about pros and cons. The artificial intelligence algorithms help summarise existing discussions and perspectives from them, and provides convenient links to these discussions for verification.

Public and Private Reputation

DAOs maintain both public reputations and private ratings, subject to audit through the governance's arbitration system under specific warrants.

Billing and Insights

DAOs, as entities, incur costs. The Billing and Insights portal offers insights into expenses and member analytics, aiding in efficient management.

DAO Administration Portal

This interface allows for the configuration of Tonomy DAO features, including:

- DAO incorporation requirements.
- Resource allocation models per DAO.
- Group-specific security policies.
- Reputation system management.

Like the identity system, DAO configurations are accessible through a no-code platform. They are subject to the prevailing governance system, potentially managed by authorised individuals or through multi-party governance proposals.

Tonomy PAY

Pangea Bankless is powered by Tonomy PAY

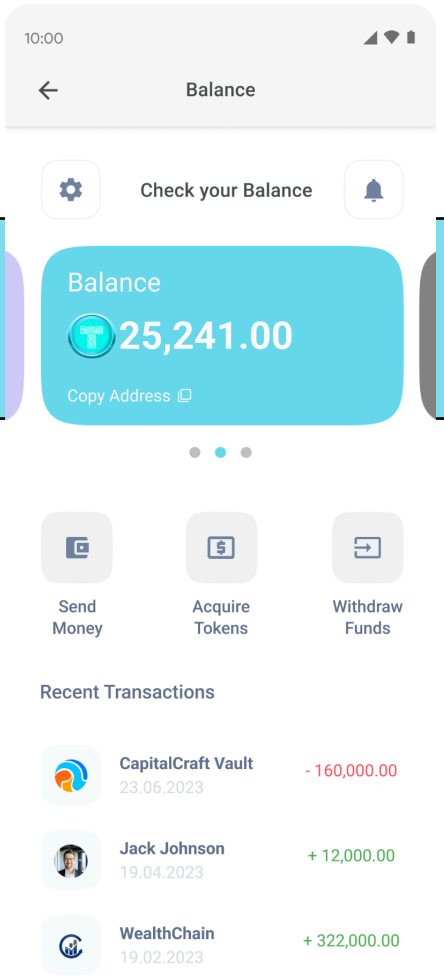


Figure 8: Tonomy Pay

Tonomy Pay represents a sophisticated, decentralised platform for payment processing and financial resource management. This platform facilitates secure and autonomous financial transactions and management for individual users and DAOs.

Neo-bank comparison:
The functionality is designed to simulate that of contemporary neo-banks like Revolut or N26; however are devoid of a centralised technical backend.

Primarily, Tonomy Pay is accessible to both individuals and DAOs, featuring an array of functionalities tailored for multiparty financial management. While individual users predominantly access the platform's services at no cost, DAOs engage with the platform on a paid basis, utilising its advanced banking infrastructure.

The platform's design emphasises user empowerment in terms of control and ownership, with a user experience mirroring that of Web2 applications. Integration with Web2 companies is streamlined through the use of simple JavaScript SDKs, bypassing the complexity of coding token contracts.

Payment Processing

Core to Tonomy Pay is its ability to process transactions using the system currency. Users execute payments via QR code scans by inputting usernames or selecting from pre-used contacts. Integrating with the Tonomy ID sovereign security vault enhances long-term transaction security, ensuring that contact information remains protected and is not centralised, in line with Tonomy's privacy principles.

Advanced Payment Options

Tonomy Pay supports diverse payment modalities including escrow payments, where the system currency is temporally secured, facilitating smart services and other Web3 applications. It also accommodates recurring subscription payments, a feature extensively employed by SaaS platforms and for billing DAOs for network services.

SWIFT/SEPA comparison:
In this way, Tonomy Pay matches and extends additional functionality while still retaining backwards compatibility with modern payment networks like SWIFT and SEPA.

Ethereum/Solana comparison:
Other cryptocurrencies often have features such as subscriptions or escrow built in as second-layer features, requiring users to use a second token or application creating a confusing experience. Tonomy Pay considers these features primary and is configurable in the native currency token.

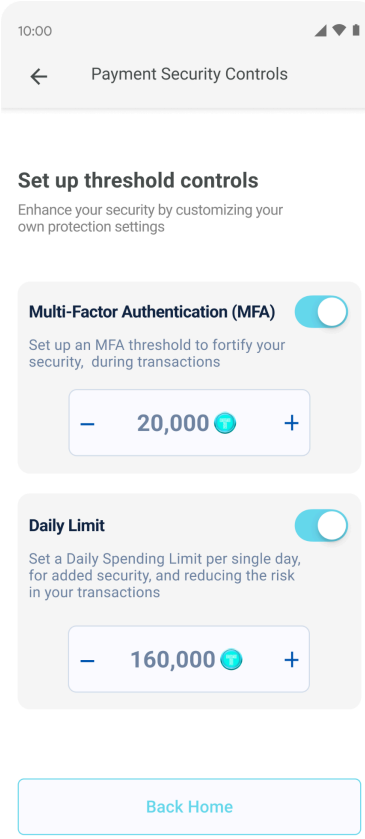


Figure 9: Payment Security

Account Management and Automated Budgeting

The platform allows users and DAOs to segment their funds into distinct accounts based on specific requirements. This feature includes creating tiered security systems within DAO's groups for effective funds management. Additionally, automated budgeting capabilities enable the strategic allocation of funds across accounts according to preset parameters.

Enhanced Payment Security

Tonomy Pay introduces granular security controls for transactions. These include threshold limits with attached security policies, enabling varying degrees of authentication based on transaction amounts. Such controls are customisable at the account level, with DAO groups controlling applicable security measures for their respective accounts. For example, users or DAOs can introduce a minimum threshold for payments after which multifactor authentication is required. DAOs may do the same but introduce a minimum threshold after which multi-party authentication is required.

Ethereum/Solana comparison:
Unlike other cryptocurrencies that work on a 1 key per account system, Tonomy Pay is easily able to allow users to flexibly manage large and small amounts of tokens in cold/hot wallet flows based on their needs while staying fully non-custodial

Transaction Receipts

The platform supports the generation of private, standardised receipts for each transaction, facilitating automatic insights reporting and, where applicable, transaction taxation. These receipts are cryptographically linked to their respective transactions, enhancing the integrity and traceability of financial records.

Asset Management

Beyond conventional currency, Tonomy Pay extends its management capabilities to other digital assets such as tokens, NFTs, and collectables. This feature caters to a diverse user base, including investors and gamers, while maintaining a user-friendly interface focused on primary system currency transactions.

Analytics and Insights

In line with neo-bank standards, Tonomy Pay offers comprehensive analytics and insights regarding account usage and payment activities. This is augmented by the platform's capability to process private receipts, providing detailed financial data.

Currency Management Panel

The platform encompasses advanced privacy management tools, including zero-knowledge proofs and ring signature privacy features, which users can configure according to their preferences. Furthermore, the currency administration panel facilitates the management and customisation of currency features, such as inflation rates and administrative controls. This is particularly pertinent for entities managing currencies like CBDCs, stablecoins, or decentralised cryptocurrencies, offering a modular, customisable approach to currency administration.

Tonomy GOV

 *Pangea Gov+ is powered by Tonomy GOV*

Tonomy Gov adopts a no-code paradigm, employing swift and adaptable foundational systems that ensure cryptographic integrity. This ensures that the governance framework is autonomous, accessible, and adept at fostering sound, well-integrated decisions within a self-regulatory ecosystem.

The foundational Tonomy technologies offer a modular toolkit, enabling a Tonomy network to select and modify its governance framework as needed. This adaptability is crucial for scaling the governance structure and features as the network expands. Additionally, it is vital for other networks to utilise the white label feature to create new networks, allowing them to harness and tailor this technology to their specific use cases.

The ecosystem governance institution within the networkIs a special DAO. Most of the legislative features (who and how are decisions made) are controlled through the existing Tonomy DAO features. It is through Tonomy DAO that a democratic or proof of stake network are configured, or a representative or a direct voting system are employed.

The ecosystem governance DAO has several additional specific features outlined in this section of the White Paper.

Multi-DAO DAO

Due to the complexities of government and multi-stakeholder ecosystems, in some cases the governance of the ecosystem will be split across several governance DAOs. For example this could, for example be a main DAO for the parliment, and other DAOs for ministries. Within each DAO, different security groups can be created as well. With the ability to create different DAOs and groups within them, complex governance ecosystems can form to meet their needs using these two simple abstractions in Tonomy. This also allows simple ecosystems to grow and evolve to be more complex over time with ease.

Treasury

The ecosystem governance DAO Is responsible for managing the policies, income and expenses of the native currency. This is done through the treasury currency account available in Tonomy Pay.

There are two different types of fund management:

- **Automated:** Network policies Provide the fees and other expenses paid by network participants to access Network services. These fees go into a collective pool. The network policies also specify the incentives paid to the network operators. These Payment collection distributions Coded into the protocol level And are fully Automated and low-trust. The policies themselves are configured through the policy manager in the governance DAO.
- **Manual:** Ecosystems made used to create their own treasury pools which they manually manage. This gives them greater flexibility to use funds without needing to make policy changes for every payment system. For example this could be used to create a ecosystem fund generated from investors to pay development of apps, or for a fund to pay for a user support system (not one of the default network services).

Discussion and Communication

An integral part of decision-making requires discussion and deliberation in complex ecosystems. Tonomy provides an intuitive discussion forum as well as a more casual communication platform through which this is facilitated. Built into the discussion forum is the ability for non-binding votes and sentiment collection. This is done using the same anonymous voting technologies from Tonomy DAO, such as preference voting or binary voting. In this way, group perspectives can be collected and integrated into proposals to create the best proposals possible before they go for final decision-making voting.

EIP Comparison:
The Ethereum Improvement Proposal (EIP) is an important part of the Ethereum governance process and has been widely adopted across many open-source projects. The Policy Management platform in Tonomy encapsulates a similar level of features but is more general and can apply to alignment on policies and standards not specifically related to digital infrastructure. For example, it can govern healthcare policy in a state-nation ecosystem or the payment process and KYC requirements in an enterprise ecosystem.

Artificial Intelligence Enhanced Discussions

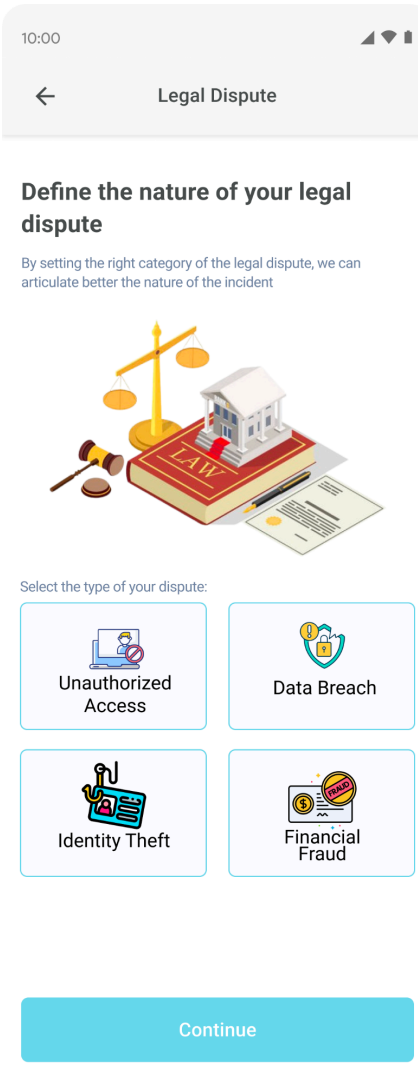


Figure 10: Legal Dispute

Integrated into the discussion and communication platforms is a artificial intelligence bot that helps navigate and guide new and experienced users through complex policy and technical discussions. It provides up-to-date summaries of the discussions, pros and cons and active analysis of the current sentiments based on votes, reactions and the discussions. In further assists in suggesting proposals and counterproposals when relevant to facilitate direct and practical progression of discussions. The bot is also able to quickly identify when proposals may violate the existing policies and provide quick links for verification from participants.

This provides a higher level of accessibility discussions amongst its participants and helps facilitate moderation and progression of the discussion in a practical way. To manage ethical use of AI, these features are optional, and users always need to opt-in to accept AI suggestions.

Network Infrastructure Administration and Monitoring

The organized registration of network Infrastructure service providers and the monitoring of their infrastructure performance and availability is an important part of the governance oversight. Here, the status and monitoring of different infrastructure providers can be easily viewed and checked. Alerts system are built in place to alert relevant groups when system infrastructure has issues.

Because this is a highly technical art of the system, it is likely that complex ecosystems will delegate authority to a separate governance DAO (a commission) to facilitate this oversight. The complexity of this could also be handled successfully using more hybrid governance models like liquid democracy. Each ecosystem will decide how to handle this technical oversight.

This portal facilitates an understanding of technical capacity and growth and enables the configuration of network settings, incentive structures, and service fees, further detailed in the Tokenomics model section.

Ecosystem and Governance Configuration

Each core application within the network features an administration panel, allowing for the customisation of network settings. For instance, Tonomy ID permits setting minimum security policies for single sign-on logins, while Tonomy DAO allows configuration of incorporation

data requirements. Governance DAO settings, including voting policies and communication platforms, are also configurable through this system.

Arbitration Platform

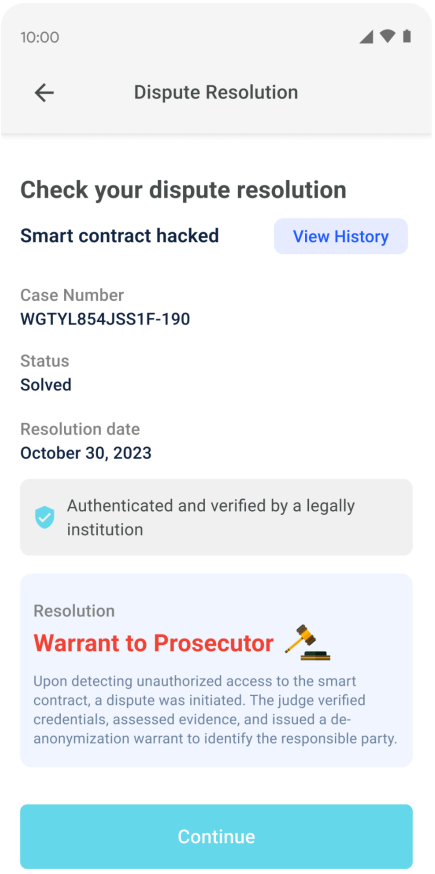


Figure 11: Dispute Resolution

Tonomy will incorporate an arbitration platform to facilitate dispute resolution among ecosystem participants, leveraging the policy system. This platform will evolve from a basic structure to a more complex system, accommodating various arbitration methods such as judges, juries, and public and private adjudication.

Arbitration Proof Verification

The arbitration process will heavily utilise verifiable data using W3C Verifiable Credentials from Tonomy ID digital signatures to streamline dispute resolution, reducing legal friction. Privacy-preserving functionalities, like selective disclosure, will enable public court cases without compromising private information.

Ecosystem Warrants

The system will encompass several vital functions to uphold self-regulation specific to the Tonomy:

- **Warrant Issuance:** Upon providing concrete proof of a security or protocol breach, a prosecutor may obtain a warrant for de-anonymizing identities, applicable in cases involving malicious actors or non-compliant entities.
- **Account Freezing/Unfreezing:** Proof of identity policy volioation (e.g. each person may only have one identity) can lead to the freezing of accounts, this exists to reinforce the identity verification protocol.
- **Imposition of Fines:** Evidence of policy violations not automatically enforced by software can lead to fines for individuals, DAOs, or the governance administration.

In all scenarios, digital evidence must be presented within a network-based arbitration system, where decisions are made following the network's policy interpretations.

Artificial Inteligence Assisted Policy Interpretation

During arbitration cases, artificial intelligence algorithms help provide a summary and links to the relevant ecosystem policies that may apply to the situation. This can then be used by the prosecutor, defendants, judges, juries and more to facilitate a more efficient and accessible conversation that will result in a well rounded and faster resolution. This significantly reduces costs and facilitates greater understanding and participation in the legal system.

Tonomy Developer Console

 *Pangea Build is powered by Tonomy Developer Console*

The Tonomy Developer Console is a sophisticated platform designed to facilitate developers in the streamlined setup and management of network infrastructure and applications. This no-code interface offers structured guidance, enabling app developers and infrastructure providers to seamlessly register, administer, and regulate their applications and services within the ecosystem.

Google Developer Console and Web3 comparison:
The Tonomy Developer Console platform offers a nuanced and user-friendly approach, greatly mitigating operational risks for developers and entrepreneurs engaged in ecosystem activities. Its conceptual framework is akin to the Google Play Console, which provides developers with the tools to manage Google resources or implement Single Sign-On (SSO) with their applications. In Web3, the prevalence of such intuitive, no-code development platforms is limited, often necessitating developers to navigate through extensive documentation and employ command-line inputs or Software Development Kits (SDKs) for system implementation and management.

The Tonomy Developer Console is enhanced with built-in analytics and advanced security features, positioning it as a more innovative and less risky option than other platforms. In the spirit of transparency, most information about applications and network infrastructure managed through the console is publicly accessible, barring data sensitive to privacy and security. While the general public holds read-only privileges, developers and infrastructure providers retain comprehensive control over the configuration and management of their respective products and services.

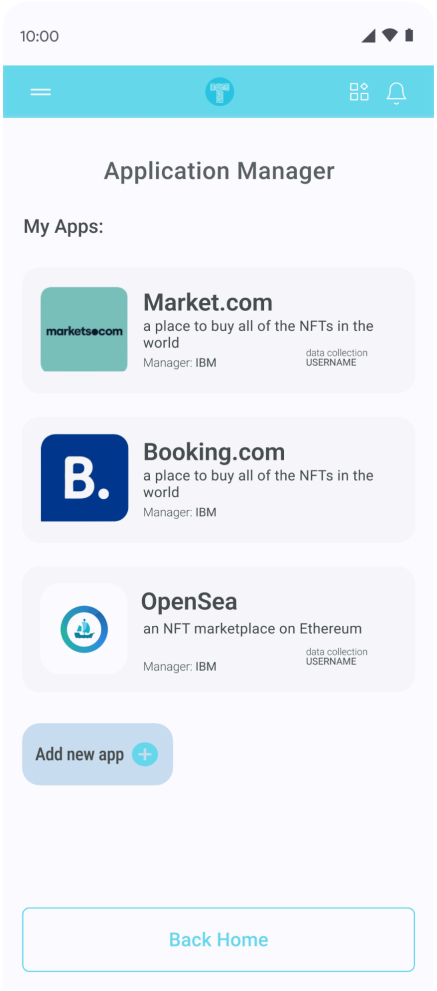


Figure 12: App Manager

Billing within the Tonomy Developer Console is bifurcated into two distinct categories:

- Applications and services offered by DAOs to the other network participants, where fees are levied based on infrastructure utilisation.
- Services provided by DAOs to run the core infrastucture of Tonomy networks, which are free of charge, with compensation managed through the network's policy, governance, and administration systems.

Application Manager

Application developers can register, administer, and remove applications from the private app market. This section allows for configuring requisite security policies for logins, such as the option of social login, varying multifactor authentication procedures, or different levels of identity verification. Developers can also specify the user data required from the sovereign storage vault upon login, such as names or data from other applications. Additionally, settings regarding login privacy, including permissions for blockchain transaction signing, are configurable here.

Customer Identity Management

Application owners are empowered to manage and oversee users accessing their applications. This feature facilitates control in alignment with the application's terms and conditions or privacy policy.

Application Services Manager

This section allows for the addition of auxiliary services to different applications. These services encompass:

- Registration of public keys for authorising digital signatures from the application system.
- Deployment and updating of smart contracts.
- DNS verification processes.

Artificial Inteligence Guidance and Education

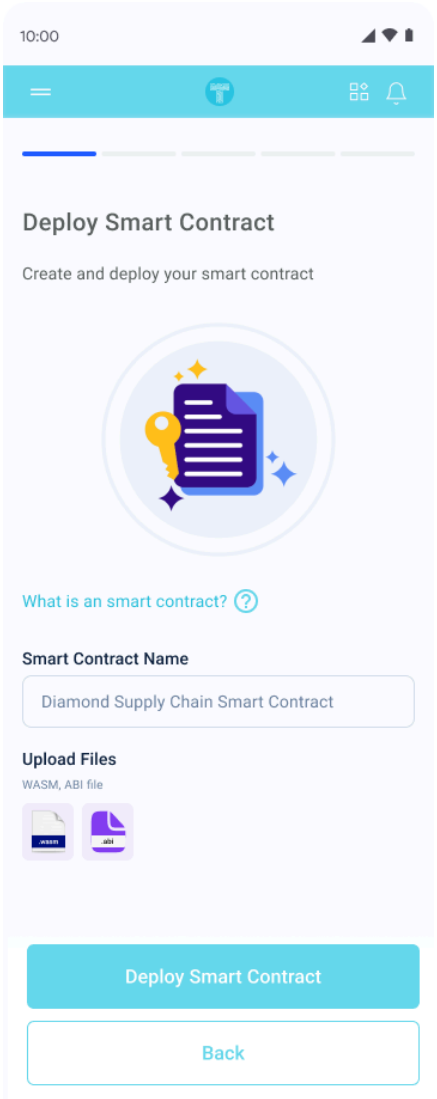


Figure 13: Smart Contract Deployer

To navigate the various configurations and functions available for technical participants of the ecosystem, artificial intelligence chat bots are available. These allow developers to ask questions and get answers on how to do things. The chat bots are connected to a helpdesk wiki, as well as the ecosystems policy system. This allows convenient and easy access in a cost-efficient way. By connecting to the ecosystem policy system, developers can also easily be aware of any policies that may affect the way they are configuring applications and infrastructure services.

Network Services

DAOs aspiring to offer services to the network, such as validated nodes, DIDComm nodes, or other services referenced in the Execution and Data Layer section of this document, can register, manage, and deregister their services here. This feature simplifies service management and ensures accountability and oversight over network services. Services are categorised and configurable based on type (e.g., validator nodes can adjust stakes, and identity verification bridges can manage signing keys).

Analytics/Insights

A comprehensive array of analytics and insights is available to service providers and application services, offering deep visibility into service performance and user engagement.

Developers Administration Portal

The Developers Administration Portal facilitates the configuration of overarching ecosystem infrastructure settings. Capabilities include:

- Enabling or disabling smart contract deployments or upgrades.
- Activating or deactivating various registerable services.
- Establishing minimum requirements for registration and configuring security policies, such as multifactor authentication or identity verification.
- Configuring fees and fee models for services, including application or public key registration.

Identity Layer

Tonomy's identity layer provides a sophisticated mechanism for account identification, utilising either anonymised, randomly generated account names or privately selected usernames. This framework is integral to the functioning of identities, DAOs, and applications within the ecosystem. It capitalises on blockchain technology as a singular,

verifiable source of truth, storing cryptographic data that underpins client-side controlled identities engaging in peer-to-peer interactions.

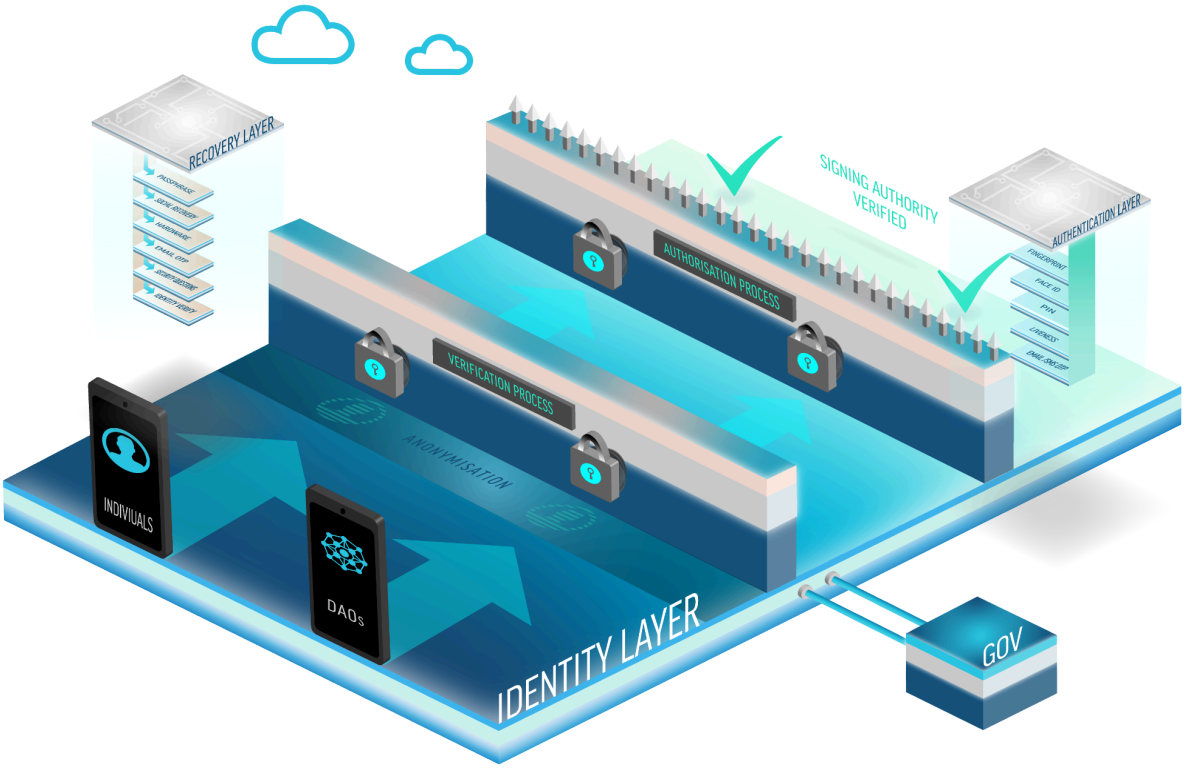


Figure 14: Identity Layer

General Account and Key Structure

Tonomy features a meticulously constructed account and key management system anchored in the robust account functionalities of the Tonomy Blockchain. Embracing a modular design philosophy, this system ensures comprehensive, consistent, and accurate operational processes.

Cryptocurrency/Ethereum comparison:
Distinct from conventional currencies, Tonomy accounts utilise an abstraction framework permitting the management of multiple, nested, and named keys in a versatile manner. This structure is extensively employed to foster a user-friendly experience in the application layer. In contrast, traditional cryptographic approaches often adhere to a one-account, one-key model, which imposes constraints on identity management and user experience, occasionally leading users to adopt less secure workarounds.

Role-Based Permission Management

Tonomy incorporates an advanced role-based permission management system, facilitating granular control over operations and linking authority to specific entities or collectives. This system transcends basic signature-verification models, enabling more refined and adaptable operation authorisation. For example, an organisation can allocate varying access levels to different team members, ensuring that operations are confined to their respective authority levels.

This separation from the business logic of applications standardises authentication and permission management, catalysing the development of universal tools for permissions management, performance optimisation, and security enhancement.

Hierarchical Authority Structure

In a Tonomy network, each account is controlled by a hierarchically arranged combination of other accounts and private keys. This structure, mirroring real-world permission systems, supports multi-user control and augments security. For instance, a corporate account might be regulated by combining the CEO's key and a collective of executive keys, maintaining balanced and secure operational control.

Named Permission Levels

Accounts within Tonomy can establish various named permission levels, each inheriting from higher-tier permissions. These levels encompass threshold multi-signature checks and combine keys and named delegations to other accounts. A user, for example, could establish a "Friend" permission level, permitting friends to execute specific operations on their account.

Permission Mapping

The network facilitates the mapping between contract operations and designated permission levels. This feature allows account holders to dictate which operations are executable by particular permission groups. A user might, for instance, link their social media activities to a "Friend" permission group, authorising friends to post on their behalf while maintaining traceability and accountability.

Evaluating Permissions

When initiating an operation, Tonomy employs a multi-tiered process to evaluate permissions. It scrutinises specific permission mappings related to the operation, verifying signing authority through a threshold multi-signature process. The system escalates through parent permissions if direct permission is not met, ensuring an exhaustive and secure validation procedure.

Flexible Account Types

Exploiting its hierarchical permission and key structure, a Tonomy network supports the creation of varied account types. This versatility is conducive to tailoring accounts for individuals, DAOs, applications, and potential new entities like AI bots or IoT devices. The system's adaptability positions it to evolve alongside emerging technologies and user requirements.

Individuals

The permission structure for individual accounts in a Tonomy network is hierarchically organised as follows:

- ➔ Recovery Layer: This topmost layer consists of keys linked to the user's configured recovery mechanisms. These could be account delegations to trusted contacts for social recovery, keys derived from secret questions or hardware devices.
  - ◆ Passphrase: The primary account access key, generated using the secure Argon2 key derivation algorithm from a set of six randomly chosen, easily memorable words.
  - ◆ Biometrics: A securely generated key uniquely associated with the user's biometric challenge.
  - ◆ PIN: A securely generated key uniquely associated with the user's PIN challenge.
  - ◆ Liveness: An account delegation to the identity verification bridge enabling liveness checks.
  - ◆ Email and SMS OTP: An account delegation to the accounts service, facilitating email and SMS one-time password (OTP) verification.
  - ◆ Local: A securely generated key without an associated challenge, utilised for peer-to-peer messaging and challenge-less signatures.

On iOS and Android devices, all these private keys are stored within a secure hardware enclave.

As detailed in the respective section, a private key is randomly generated in the browser's storage during the single sign-on process. Upon user consent for login, the corresponding public key is added to the blockchain as a separate permission, defining the security scope of the key and its application-specific associations.

Decentralised Autonomous Organizations (DAOs)

The permission structure for DAOs encompasses:

- ➔ Owners: This top layer includes delegations to individuals and other DAOs owning the entity. In democratic entities, each delegation is equally weighted. In share-based entities, delegations are weighted according to share ownership.

Below the owner level, three default groups (see Identity Access Management) are created:

- ◆ Contributors/Members: Representing all DAO contributors, not limited to owners.
- ◆ Developers: Entrusted with managing developer infrastructure via the Tonomy Developer Console
- ◆ Finance: Responsible for managing payments through Tonomy Pay.

DAOs possess the flexibility to establish new groups, representing various internal departments or units, each with distinct permissions and responsibilities.[9]

Decentralised Identifiers (DIDs)

In Tonomy, all entities, including individuals, DAOs, applications, and smart contracts, are assigned decentralised Identifiers (DIDs). These entities can use DID infrastructure, such as W3C Verifiable Credentials and DIDComm. These mechanisms operate transparently across the network, underpinning verifiable private data and communications.

Verification Process

Identity verification occurs during application login and is funded by the application. This process ensures that each individual maintains only one account within the network. In cases where multiple accounts are detected, the additional accounts may be frozen, but one account will always remain active for the user. Verification operates as a modular plug-in that applications can select during deployment. At launch, a set of standard verification mechanisms will be implemented.

Governance Layer

The white paper delineates the requisite governance layers using the trias politica model while acknowledging the applicability of other models to this governance system. The model comprises three components:

- **Legislative Layer:** Tasked with formulating and upholding the policies/rules/regulations governing the ecosystem. These rules oversee the infrastructure, such as validator nodes and identity systems for people, DAOs, application rules, financial aspects like inflation rates, etc. The process and authority for policy-making form part of these modules.
- **Executive Layer:** Responsible for implementing and maintaining the policies. This encompasses the operation and upkeep of software and infrastructure, including remuneration for developers, administrators, lawyers, and payments to infrastructure node operators. Policies under ecosystem governance are executed within these features, adhering to Elinor Ostrom's principles of effective policy implementation.
- **Judicial Layer:** Charged with interpreting policies in dispute scenarios. This involves an arbitration system capable of enacting positive reinforcements or sanctions to uphold policies in compliance with arbitration standards.

The flexible and modular approach using DAOs and groups allows the governance system to separate these three powers into separate groups of actors.

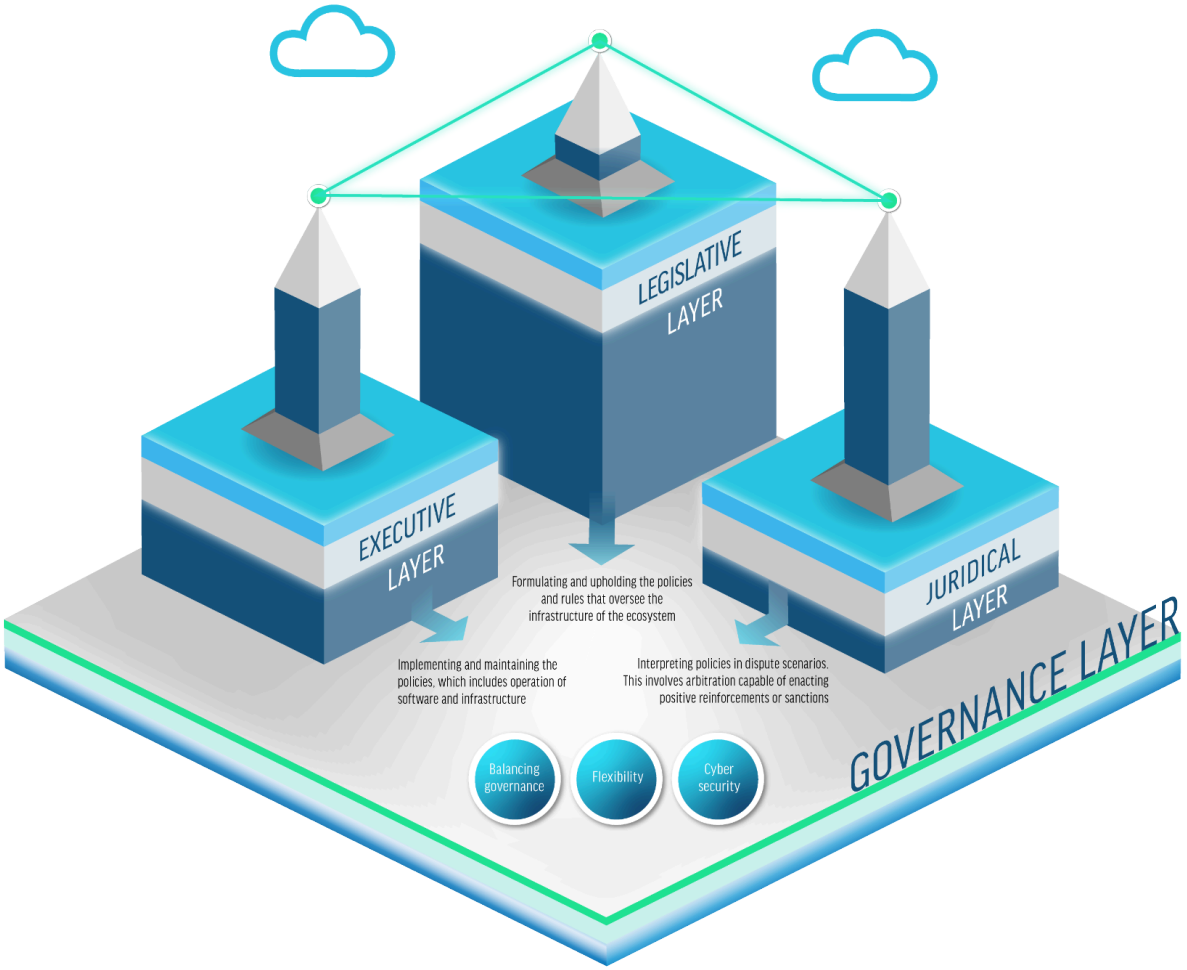


Figure 15: Governance Layer

State-Nation Governance comparison:
Traditional governance models heavily favour state-nation power. In contrast, Tonomy's technologies offer flexibility for governments to balance governance power between state-nation and lower governmental levels, promoting adaptability and versatility.

Cryptocurrency/Cardano Comparison:
Unlike most cryptocurrencies that rely on singular, financially incentivised governance models (proof of stake or similar), Tonomy supports both financial incentive models and truly democratic approaches (one person, one vote). It also advocates for a modular and upgradable governance framework, accommodating ecosystem evolution and growth.

In addition, all or most of the governance and administration decisions and configuration must be done by developers still using developer tools. In Tonomy Gov, the no-code platform allows non-developers to easily participate in decisions and execution of core ecosystem and DAO management.

Legislative Layer

The Tonomy DAO platform is endowed with sophisticated governance mechanisms at its zenith, providing comprehensive control over ecosystem governance. These intrinsic capabilities enable a variety of democratic and equity-based voting systems, encompassing direct, representative, or liquid democratic frameworks. This structure forms the cornerstone for collective policy development and regulation within the ecosystem, thereby metamorphosing it into an expansive, integrated Decentralized Autonomous Organization (DAO).

The Modular Programmable Consensus Algorithm, intrinsic to the blockchain architecture, empowers Tonomy with the ability to support programmable and modifiable governance structures (e.g. democratic). This flexibility allows for the implementation of various legislative models, such as democratic systems, at the protocol level.

Executive Layer

The execution of governance functions within the system is partially automated.

The network's fee and incentive scheme operates on full automation, ensuring protocol-level enforcement. This approach minimizes trust requirements and reduces financial impediments in the network's high-priority economic framework.

Additional executive functions are facilitated through discussion forums and communication platforms, or via Tonomy's core applications. For instance, manual disbursements from the Treasury to contributors are conducted using the Tonomy PAY application.

Estonia comparison:
Estonia has conclusively fortified themselves as a leading digital ecosystem provider.[10] Their digital infrastructure leads policy-making and has shown to significantly reduce friction.

Tonomy provides the core services of identity, chamber of commerce, government and finance, however it does this in a way where no infrastructure provider is in total control of any of these core systems. Equally importantly, no ecosystem members personal data is stored in a government database as seen in Estonia. Both these features significantly enhance the cyber security edges of the ecosystem as a whole as well as bolster privacy and trust for Tonomy ecosystem members.

Judicial Layer

The arbitration platform is pivotal in interpreting and applying approved ecosystem policies, utilizing evidence to deliver verdicts and enforce said policies. Judicial authority is granted privileged capabilities, including the issuance of de-anonymized warrants or fines, to safeguard the ecosystem's users. These exclusive judicial powers are detailed in the Warrants section.

Ecosystem participants can utilize this framework to enforce various ecosystem policies, including contractual agreements, subject to the specific policy configurations of the respective ecosystem.

Execution and Data Layer

The execution layer comprises an array of data consistency, consensus, and storage services, meticulously architected to satisfy the exigencies of identity, governance, and application strata. These services are tailored for high throughput and high availability within distributed architectures, emphasising minimal to no reliance on the trustworthiness of technical service operators. This objective is attained through an amalgamation of advanced cryptographic techniques and distributed systems computing methodologies.

Central to the execution layer is the **blockchain network**. It is a pivotal distributed execution framework, endowing the network with robust identity, DAO, and governance functionalities. Additionally, it provides a versatile distributed programming interface conducive to developing decentralised applications in private market sectors. The blockchain's role extends to being the unequivocal source of truth, guaranteeing uniformity and consistency across the service ecosystem. Predominantly, it facilitates authentication via decentralised Identifiers and orchestrates ordering services to maintain data coherence.

The data storage dimension is bifurcated into two distinct services:

- **Private Data Storage:** This service is dedicated to housing data that remains confidential and unseen within the ecosystem. It adheres strictly to data regulation norms and is specifically engineered to securely store private, personal, and organisational data. Primarily, it supports backup and recovery processes for data housed in the sovereign storage of Tonomy ID and Tonomy DAO.
- **Public Data Storage:** This service is earmarked for storing data that is openly accessible across the ecosystem. Employed exclusively when personal information is not implicated, it ensures adherence to data privacy regulations. Its primary use includes creating public profile information for DAOs and configuring application settings, such as security policies.

Furthermore, the network incorporates a **communication service** facilitating peer-to-peer private data transfer among various identities. The **identity verification bridge** is an instrumental service enabling third-party identity verification providers to integrate their verification proofs into the network. Additionally, a **key recovery service** is in place to offer a low-trust mechanism for backing up and restoring encryption keys utilised in the sovereign storage vault, thereby supporting comprehensive data backup during account recovery processes.

All services in the Tonomy Execution and Data Layer use the standardised decentralised Identifiers as the primary means for authentication and cryptography. Using the W3C standards supports compatibility and compliance with government and enterprise solutions while adhering to the required strict privacy and security requirements.

The execution and data layer services are partially underpinned by existing, proven technologies that meet the specified technical requirements. Concurrently, developing

proprietary new software is undertaken to bridge any gaps. The Tonomy Foundation's commitment to these technologies is not inflexible; adaptations may be made in response to emergent superior technologies or evolving requirements emanating from the application, identity, and governance layers.

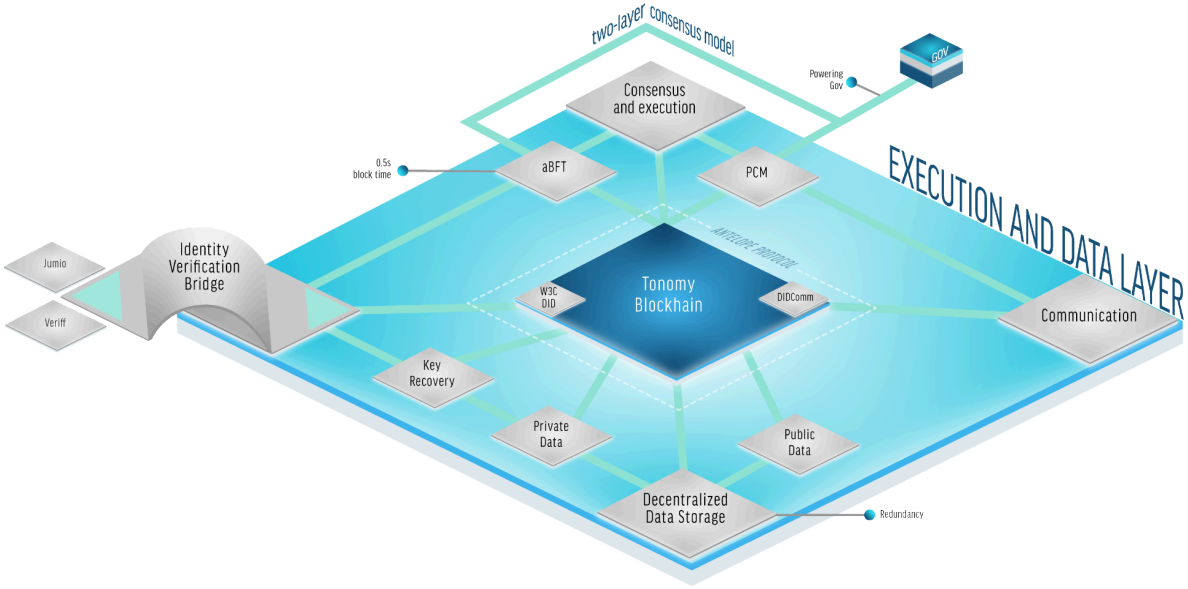


Figure 16: Execution and Data Layer

Blockchain

The Tonomy Blockchain, with its advanced features and adaptations of the Antelope protocol, aligns seamlessly with the multifaceted requirements of businesses, enterprises, and governmental entities. At its core, Tonomy offers a robust, scalable, and secure infrastructure that is crucial for these sectors, ensuring the ability to handle high volumes of transactions with efficiency and reliability. This is particularly vital for enterprises and government entities that deal with large-scale data and transaction processing.[11]

The Tonomy Blockchain exemplifies a paradigm of adaptation and enhancement in the blockchain domain. The core protocol of Antelope is being customised through on-chain programmable governance features, enabling the tailoring of network attributes to meet specific requirements of diverse ecosystems. This is achieved by leveraging modular components and configurable on-chain settings, thus providing a foundation for a wide range of applications, including governance and participation systems, employee identity for enterprise, decentralised finance (DeFi), supply chain management, non-fungible tokens (NFTs), and gaming platforms.

Tonomy Blockchain will adapt and extend the core Antelope protocol by using the on-chain programmable governance features to tailor networks to the individual needs of the ecosystem. This will be done using modular components and configurable on-chain settings.

Antelope, supported by some of the most usable networks such as WAX, Telos, UX Network and EOS is renowned for its role in underpinning some of the most agile, secure, and user-friendly Web3 products and services, managing millions of transactions daily. The WAX

network alone has hosted over 13B transactions, more than 10 times that on the Binance chain.[12] The protocol's emphasis on vertical scalability is evident in its capability to process up to 10,000 transactions per second before implementing sharding techniques.

Antelope Protocol

The decision to base the Tonomy Blockchain on the Antelope protocol is grounded in a comprehensive evaluation of Antelope's distinctive features, each of which aligns with the strategic objectives of Tonomy in building a robust, scalable, and user-centric blockchain ecosystem.

Modular Account Abstraction

Antelope's modular account structure is a key differentiator. This feature allows for the customisation of account types and permissions, catering to diverse user needs. This modular approach provides the flexibility necessary for Tonomy to implement nuanced access controls and identity management systems, a crucial aspect for DAOs and individual users.

Scalable Transaction Throughput

The protocol's capability to handle 10,000 transactions per second (tps) before sharding is a testament to its scalability. This high throughput is vital for Tonomy Blockchain, as it ensures that the network can accommodate a large volume of transactions without sacrificing speed or efficiency, a critical requirement for applications ranging from micro-transactions in DeFi to high-frequency trading systems.

Capability to Scale to 1 Billion Accounts

The ability to scale to 1 billion accounts is a significant feature that underscores Antelope's capacity to support many users. This scalability is essential for Tonomy's vision to create a blockchain network that is not only powerful but also inclusive, catering to a global user base.

Low Latency with Rapid Finality

Antelope's low latency, characterised by 0.5-second blocks with 4-second finality, ensures quick transaction confirmation times. This is crucial for Tonomy Blockchain's aim to provide a seamless and efficient user experience, particularly for applications requiring real-time interactions, such as gaming or live auctions.

Modular Programmable Consensus Algorithm

The Antelope consensus algorithm exhibits remarkable flexibility, crucial for the implementation of diverse governance models within the Tonomy Blockchain. This flexibility is instrumental in facilitating the development of custom governance structures for distinct Decentralized Autonomous Organizations (DAOs) and community-driven initiatives. It significantly contributes to the promotion of a more democratic and decentralized decision-making framework.

This enhanced adaptability is achieved through a dual consensus layer model, comprising:

- **Native Consensus Layer:** This primary layer is integral to the block confirmation process, ensuring each block's finality (irreversibility) through an asynchronous

Byzantine Fault Tolerant (aBFT) methodology. The native consensus layer is responsible for determining the finality of blocks, which are received and synchronized among elected producers. It operates on a schedule proposed by the political consensus layer, utilizing this schedule to authenticate blocks signed by the designated producer. For Byzantine fault tolerance, it employs a dual-phase block confirmation mechanism, wherein a two-thirds supermajority of producers from the current scheduled set are required to confirm each block twice. The initial confirmation phase designates a Last Irreversible Block (LIB). The subsequent phase ratifies the proposed LIB as final, rendering the block irreversible. This layer also plays a pivotal role in signaling potential changes in the producer schedule at the onset of each scheduling round.

- **Political Consensus Layer:** This secondary layer is pivotal in determining the producer schedule for participation in the native consensus. The configuration of this layer is executed programmatically via on-chain smart contracts. Consequently, the political consensus model can be diversified in numerous ways, including democratic, proof of stake, proof of share models, or any other programmable structure on the blockchain.

This two-tiered consensus model underscores the Tonomy Blockchain's commitment to a versatile and adaptable governance system, catering to the specific needs of various DAOs and fostering a more inclusive and decentralized decision-making ecosystem.

Flexible Programmable Transaction Fee Model

Antelope's transaction fee model, which can be programmed and adjusted, allows Tonomy to optimise costs for users and developers. This flexibility is essential for maintaining a competitive edge in the blockchain space, where transaction fees can be a significant barrier to adoption.

Upgradable Webassembly Smart Contracts

The support for upgradable WASM smart contracts, particularly in a widely-used language like C++, GoLang, Python and Rust, enhances the robustness and longevity of applications built on the Tonomy Blockchain. This feature allows for continuous improvement and adaptation of smart contracts, aligning with Tonomy's commitment to innovation and future-proofing its ecosystem.

EVM Support

The support for Ethereum Virtual Machine (EVM) makes Antelope highly compatible with a vast array of existing Ethereum-based applications and developer tools. This compatibility is crucial for Tonomy in facilitating easy migration and interoperability with the broader blockchain ecosystem.

Sustainable Footprint

Antelope's design considerations for environmental sustainability resonate with Tonomy's commitment to eco-friendly technology solutions. This aspect is increasingly important for both users and developers who are environmentally conscious.

Extended Features

The Tonomy Blockchain, utilising the Antelope protocol as its foundational framework, is poised to introduce several pivotal extensions to the protocol's existing features. These enhancements are meticulously designed to elevate the blockchain network's efficiency, security, and adaptability. The areas of extension include:

Modular Governance and Consensus Systems

The Antelope protocol employs a two-layer consensus model: a) Layer 1 - Native Consensus Model (aBFT) and b) Layer 2 Programable Consensus Model (PCM). Tonomy Blockchain aims to further develop this model by creating more sophisticated modular consensus systems on top of the programmable consensus layer. This advancement will enable a more dynamic and responsive governance structure tailored to the specific needs of various applications and use cases within the Tonomy ecosystem.

Manageable Transaction Fee and Resource Management

Antelope's platform allows for programmatic resource management and a flexible business model, enabling applications to adopt various models like a freemium model for executing transactions. In addition to these features, Tonomy Blockchain intends to refine the transaction fee and resource management system, making it more manageable and user-friendly. This will likely involve optimising the allocation and utilisation of key resources such as RAM, CPU, and Network (NET) bandwidth, all of which are integral components of the Antelope-based blockchain system.

Standardised Identity Account Structures

While the document does not provide specific details on standardised identity account structures, the Tonomy Blockchain is expected to build upon Antelope's comprehensive permission system. This system allows for creating custom permission schemata, enabling the development of permissioned applications atop a flexible infrastructure. Standardised identity account structures would further streamline and unify the approach to identity management across the Tonomy Blockchain, enhancing security and ease of use.

Account Delegations and Multi-Signature Permissions for DAOs

The Antelope platform's comprehensive permission system supports splitting the authority required to modify a smart contract across multiple accounts, each with varying levels of authority. Leveraging this capability, Tonomy Blockchain plans to strongly utilise account delegations and multi-signature permissions to create DAOs that are highly secure and user-friendly. This approach will likely involve devising intricate permission and delegation mechanisms that ensure robust security while maintaining operational efficiency and flexibility.

Tonomy Blockchain

The integration of the Antelope protocol within the Tonomy Blockchain represents a strategic alignment of advanced blockchain capabilities with the specific functional needs of a diverse and evolving digital ecosystem. Here, we delve into the depth of how Tonomy Blockchain will utilise the Antelope protocol:

Single Source of Truth for Infrastructure Services

The Antelope protocol will act as a foundational ledger, providing a reliable and immutable record of transactions and interactions across the Tonomy ecosystem. This will ensure consistency and reliability in data across all infrastructure services.

By serving as the central reference point, the protocol will streamline integration with various services like smart contract execution, data storage, and network communication, ensuring that all components operate with a synchronised and accurate dataset.

Single Source of Truth for Authentication

The blockchain will store public keys and hashes, enabling the secure verification of authentication and off-chain data. This feature is crucial for maintaining data integrity and transactions that originate outside the blockchain but require validation and incorporation within the ecosystem.

Identity Management, decentralised Identifiers, IAM, and CIAM

decentralised Identity (DIDs): Tonomy will leverage Antelope's capabilities to facilitate creating and managing decentralised identities (DIDs). This approach enhances user privacy and control over personal data.

Integrated Access Management (IAM): The protocol will enable a robust framework for managing access to network resources, ensuring that only authorised users can perform specific actions based on their identity and role.

Customer Identity and Access Management (CIAM): CIAM capabilities will allow Tonomy Blockchain to manage customer identities, preferences, and consent, delivering a seamless and secure user experience.

Token Management

Antelope's token management capabilities will be utilised to create and manage various tokens within the Tonomy ecosystem. This includes utility tokens, governance tokens, and others, with features like transferability, divisibility, and programmability

The system will support privacy-centric tokens, facilitating anonymous transactions with the ability to comply with regulatory requirements through controlled de-anonymization mechanisms.

Governance

DAO Governance: The protocol will underpin the governance mechanisms for DAOs within Tonomy, allowing for democratic decision-making and stake-based governance models.

Flexible and Programmable Governance: With Antelope's modular programmable consensus algorithm, Tonomy Blockchain can implement various governance and system management models. This flexibility ensures that governance structures can evolve with the needs of the community and ecosystem.

Communication

In Tonomy's advanced communication infrastructure, the adoption and enhancement of DIDComm features play a pivotal role. This sophisticated communication service integrates a WebSocket DIDComm transport, ensuring secure, private, and interoperable messaging capabilities across the Internet. This system is particularly notable for its high latency, privacy, security and reliability.

The Tonomy Communication Infrastructure, with its integration and extension of DIDComm features, is exceptionally well-aligned with the stringent and multifaceted requirements of businesses, enterprises, and government entities. Firstly, the infrastructure's emphasis on secure and private messaging resonates strongly with the critical need for data confidentiality and integrity in these sectors. The use of WebSocket DIDComm transport ensures that communications are secure and adhere to globally recognised standards, a key consideration for organisations operating in regulated environments.[13]

The infrastructure's commitment to privacy and security is paramount for businesses and enterprises, particularly those dealing with sensitive customer data or proprietary information. The fully managed keys feature simplifies the complexity of cryptographic security, allowing enterprises to benefit from high-level security protocols without needing in-depth technical expertise. This aspect is crucial for businesses that prioritise data protection but may not have the resources to manage complex security systems.

In the context of government entities, the infrastructure's interoperability across different identity systems is a vital feature. It allows seamless communication and data exchange across various departments and agencies, many of which may use different systems and protocols. This interoperability is essential for efficient governance and service delivery.

DIDComm

The decision to employ DIDComm as the foundational technology for the Tonomy Communication Infrastructure is underpinned by many considerations, all of which align with the overarching objectives of security, privacy, interoperability, and user sovereignty.

- **Global Standardization:** DIDComm's recognition and support by the World Wide Web Consortium (W3C) positions it as a contemporary global standard, offering a reliable and universally accepted framework for digital communication.[14]
- **Self-Sovereign Identity Support:** DIDComm's architecture inherently supports self-sovereign and autonomous identity management,[15] a cornerstone in our commitment to empowering users with control over their digital identities.
- **Interoperability Across Identity Systems:** DIDComm demonstrates remarkable interoperability, functioning seamlessly with various identity systems, including web applications, Bitcoin accounts, and emerging identity frameworks. This flexibility is crucial for a network aspiring to widespread application and integration.
- **Transport Agnosticism:** As highlighted in the document, DIDComm is transport-agnostic, capable of operating over a range of protocols including HTTPS, WebSockets, Bluetooth, URLs, QR Codes and more. This adaptability ensures that communication remains uninterrupted and efficient, regardless of the underlying transport mechanism.

- **Advanced Privacy and Security Features:** DIDComm strongly emphasises preserving the integrity of messages and the authenticity of senders, employing state-of-the-art cryptographic techniques. It also offers features like onion routing, enhancing privacy by preventing unauthorised parties from discerning communication details.

Tonomy Communicate, by incorporating DIDComm, takes a significant leap in optimising the potential of decentralised communication, particularly through implementing fully managed and sovereign keys. This enhancement represents a critical innovation in the realm of secure and autonomous digital communications, aligning with the overarching goals of the Tonomy to prioritise user sovereignty and security.

Communication in Tonomy Networks

Communication will be employed in various facets of Tonomy networks:

- **Device-to-Device Communication:** Facilitating secure messaging between a user's multiple devices, such as a phone and desktop.
- **User-to-User Interaction:** Enabling encrypted messaging between users, akin to a secure messaging app.
- **User-to-Application Communication:** Allowing users to transmit verification information and other data to applications securely.
- **User and DAO Interactions:** Providing a secure channel for users to communicate with DAOs for activities like sending invoices.

Private Data

The private data layer within the Tonomy ecosystem represents a groundbreaking approach to managing sensitive information in digital environments. This layer is meticulously designed to cater to the specific needs of businesses, enterprises, and governmental entities, ensuring the confidentiality and integrity of their data. The layer offers a secure, decentralised framework for data management and operations by leveraging advanced encryption technologies and self-sovereign identity principles.

In a business and governmental context, the private data layer provides a robust platform for handling confidential data, including personal information, trade secrets, and sensitive governmental records. It ensures compliance with various data protection regulations, such as GDPR, while offering a flexible and secure data storage and access solution.

The Tonomy ecosystem extends the concept of private data by using fully managed self-sovereign keys. This innovative approach enables entities to maintain complete control over their data, ensuring that the data owner's policies govern access and encryption and not by third-party service providers.

Client-Side Encryption

Client-side encryption in the Tonomy ecosystem ensures that data is encrypted at the user's device before it is transmitted or stored on any server. This method employs advanced cryptographic algorithms to secure data. Even during transit or at rest, the data remains

encrypted, thus safeguarding it from potential vulnerabilities in the transmission channels or storage systems.

DID Authentication

Decentralised Identifiers (DIDs) are a cutting-edge solution for authentication in the Tonomy ecosystem. DIDs allow users to prove their identity without relying on centralised authorities. This decentralised approach not only enhances security but also provides users with greater control over their personal information. It mitigates risks associated with centralised identity repositories.

Advanced Encryption with Indexing and Search

This feature is a breakthrough in handling encrypted data. The Tonomy ecosystem uses specialised algorithms that allow for the indexing and searching of encrypted data without ever decrypting it. This capability means users can perform efficient searches and access operations on their encrypted data without compromising its security, a vital feature for businesses that require both security and efficiency.

Recovery of the Sovereign Storage Vault

The recovery mechanism for the sovereign storage vault addresses scenarios where a user might lose access to their device or forget their passphrase. The Tonomy ecosystem implements a secure recovery process that involves multiple layers of authentication and can include biometric verification, multi-factor authentication, and trusted recovery contacts. This process ensures that users can regain access to their data without exposing it to external vulnerabilities.

Warrants

Data access warrants can be claimed by proving that there has been some form of identity fraud or security or policy breach. In this case, prosecutors who go through the process of presenting proof and being approved can receive a data access warrant. This will allow the prosecutor to request data from another user's account, as well as retrieve a set of encryption keys they will be able to use to decrypt the data and inspect it for their security purpose.

Public Data

The Public Data Layer of Tonomy is a sophisticated digital architecture designed to generate and manage public data within the Tonomy ecosystem. This layer serves as a pivotal component for many users, including businesses, enterprises, and governments, by facilitating the creation of public profiles for DAOs and providing essential configuration data for applications. These functionalities are crucial during user login and interactions, ensuring a seamless and efficient user experience.

This layer is adept at handling public data, encompassing information that must be accessible across the Tonomy ecosystem. This includes but is not limited to, public profiles of DAOs and configuration details of various applications essential for user interaction. The Public Data Layer thus stands as a cornerstone in Tonomy, empowering a range of

stakeholders by providing them with the necessary tools and information for effective decision-making and operations.

A key innovation of the Public Data Layer lies in its approach to extending the concept of data ownership. Utilising fully managed self-sovereign keys, this layer introduces a paradigm shift in how data ownership is created and verified. By implementing self-sovereign key management, the layer enhances data ownership and security, allowing users complete control over their information.

DID Authentication and Encryption

The Public Data Layer employs decentralised Identifier (DID) technology for robust authentication and encryption. This feature ensures that each user's identity is securely verified and their data is encrypted, providing a high level of security and privacy. The use of DIDs in the Public Data Layer signifies a commitment to maintaining a secure and trustworthy environment within Tonomy.

Flexible Modular Data Structures and Searching

Flexibility are at the core of the Public Data Layer's design. It supports modular data structures, enabling users to tailor the data architecture to meet their specific needs. This modularity extends to the layer's search capabilities, offering a versatile and user-friendly search experience that can handle complex queries efficiently.

Supports Data Streaming and Storage Model

The layer is equipped with a sophisticated data streaming and storage model. It can handle both event- and state-based storage, allowing users to choose the model that best fits their requirements. This feature is particularly beneficial for applications requiring real-time data streaming or maintaining a historical record of data changes.

Indexing and Fast Querying

Efficient data retrieval is a critical aspect of the Public Data Layer. It supports advanced indexing mechanisms, enabling fast and efficient querying of the stored data. This feature is essential for applications that require quick access to large volumes of data and for users who need to make timely decisions based on the retrieved information.

High decentralisation and Availability

The Public Data Layer is highly decentralised, ensuring that the data is stored across multiple nodes in the network. This decentralisation enhances the layer's resilience and reliability. Moreover, the layer is designed to be highly available, ensuring that users can access the data they need whenever needed, without significant downtime or interruptions.

Key Recovery

The Tonomy Key Recovery service is a proprietary technology created to allow accounts to solve only recover their encrypted software and data balls in case they lose/forget their primary recovery phrase.

Key recovery is just one part of the account recovery step. Before the encryption key is recovered, the user must first recover their authentication keys. This is covered in the Tonomy ID app in multiple ways.after the authentication key is recovered, this can be used to request that the encryption key be recovered.

Encryption key recovery with Shamir's Secret Sharing

The encryption key is a private key c created using random entropy on the user's device when they create an account or log in. This key cannot be used to authenticate the user to any service and cannot be used to move funds of tokens or modify any on-chain or off-chain assets or data. The encryption key is only used to encrypt and decrypt data on the client side from the sovereign storage vault backup service. In this way, the security of the user is protected even if the key recovery service network acts maliciously in consensus (very unlikely as many entities need to conspire and lie in synchronised secret).

The recovery protocol uses Shamir's secret sharing to split the encryption key into multiple shards on the user's device and send each show to a different service provider. Service providers use the user's DID and authentication (a different key) to verify the request comes from the correct account and then save the data. If the user loses their encryption key, they must go through account recovery to recover their authentication and then can request that the encryption key be recent to them.

De-anonymization with Warrants

The Tonomy governance system allows for warrants to be issued that allow prosecutors to get access to a user's personal information. This is only used in the cases where the prosecutor can provide sufficient evidence to show a safety concern by checking the user's personal information.

Key Recovery service providers, by default, will only accept requests for key shards from the user to whom they belong. The exception is when a warrant is used and provided, granting the request access to the key. This can then go on to be used with the same warrants to access, retrieve, and decrypt the user's personal information.

There are long-term plans to research and develop a system where these key shards are not stored on services (servers) but instead shared amongst many of the user's contacts. Tonomy Foundation is researching the use of trusted execution environments for additional security.

Identity Verification Bridge

The identity verification bridge service is used to bridge existing third-party service providers like Jumio or Veriff onto the network and provide reusability of verified identities.

These service providers bridge an identity verification request from the network to the third-party service. Once verification is complete, they wrap the proof provided by the third-party service in a W3C verifiable credential, which is then returned to the user. The user, due to the nature of verifiable credentials, is then able to freely use this as proof of their identity and reuse this over and over.

The identity verification bridge does not store identity data. The third-party service provider may retain data for their maximum retention period after which the data will only exist on the user's device.

Tokenomics and Security Framework

The tokenomics architecture within the Tonomy is strategically designed to ensure optimal **allocation and utilisation of system resources**. It simultaneously aims to incentivise resource availability and **prevent the overuse of resources** that could lead to denial-of-service attacks. The inner details of the resource allocation model are designed to stay hidden from users under normal operating circumstances, such that they should only manifest to a user that is trying to attack the system to prevent it, or when a user needs to add priority to their transaction to ensure execution.

This segment delves into the incentives associated with network infrastructure and the payment mechanisms that support these incentives. The network may necessitate additional fiscal considerations for compensating governing council members and other key contributors in governance services, such as judges and prosecutors within the arbitration system, which are handled through the governance Treasury feature based on ecosystem preferences. As these are not infrastructure critical features, ecosystem fund allocations such as governance and arbitration incentives are not part of the security framework.

The tokenomics system also serves as a streamlined and user-friendly payment mechanism, facilitating transactions between users, DAOs, and within the governance infrastructure. Its modular and configurable nature allows tailored monitoring and adaptation to meet specific ecosystem requirements.

The Pangea - LEOS Tokenomics document outlines the specific tokenomics model to be implemented in the forthcoming Pangea civilization launch through the LEOS currency. Alternative network configurations may adopt different models.

Tokenomics Roles

The Tonomy network encompasses a diverse range of roles, each integral to its ecosystem's functionality and security:

- **People:** These are individuals actively participating in the network, engaging in transactions, governance, commercial and community interactions.
- **DAOs:** Collaborative legal entities formed by network participants, taking various legal forms like businesses and communities, and playing a vital role in decision-making and resource allocation.
- **Apps:** Software applications used for governance, commercial, and non-profit activities, facilitating operations and interactions within the Tonomy ecosystem.
- **Services:** Servers operating essential system services like blockchain nodes and identity verification, crucial for the network's stability and reliability.
- **Gov:** Specialized DAOs or groups of DAOs responsible for ecosystem governance, maintaining the system's balance and fairness.

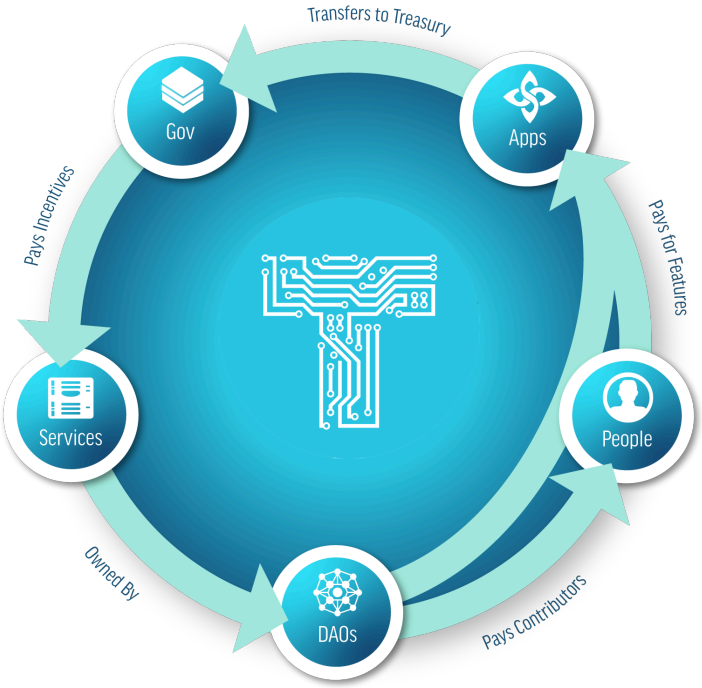


Figure 17: Tonomy Network Roles

Each role is pivotal to Tonomy's robustness and adaptability, contributing to its sustained growth and security.

Tokenomics Model

Figure 17 illustrates the flow of payments of the Tonomy native currency between the various roles in the network. These are:

- **Services** provide the digital infrastructure, including servers and other necessary elements for network operation.
- **Services** are automatically paid through the **Gov** treasury on the basis of the incentive structure of the network
- This treasury is funded from the payment of features through **Apps** by **People** and **DAOs**.
- Features offer both free and paid access, with **People** generally having some level of free-tier resource access based on identity verification, while **DAOs** pay for all feature usage.
- Services are owned by **DAOs** which are run by **People**. Gov is also a DAO.

In this way, a circular economy is generated. The accounting system underlying this facilitates the guaranteed availability of the network and insurers bad actors and not undermine the system.

This model is used to analyse the tokenomics of the system which are sound when both the following two conditions are met:

- **Economics:** when the payments into the Gov treasury are equal to the incentives out of the treasury.
- **Security:** when all underlying resources provided by each infrastructure service are guaranteed to always be available.

The model does not take into account additional optional features the ecosystems may decide to use the Tonomy native currency for such as incentives for contributors to the governance system or for use as legal barter for goods and services between DAOs and People, as these do not effect the security model.

Security of Core Network Resources

In the Tonomy system, each **Service** provides a set of digital infrastructure and exposes a **Core Network Resources** (CNR) accounting system used to account for the use of this resource. This is crucial to maintaining security and ensuring constant availability.

CNRs are completely hidden from most users. People will indirectly access these resources by purchasing them through monthly subscriptions or accessing network features through Apps. Only developers of apps need to worry about understanding CNRs. Developers will be able to purchase additional RAM for Apps, or expand their DAOs sovereign data vault through the Tonomy Developer Console.

Table 1 shows an overview of each Service and it's CNR that it offers.

Service	Core Network Resource (Units)	Description	Used by
Blockchain	RAM (bytes)	Data stored in smart contracts used by governance and core apps as well as DAO-owned apps. Such as account information, public keys, balances or more.	Apps, Services
	NET/CPU (priority unit)	Ability to send transactions within the network. Limited by the processing capacity of the blockchain network.	Identities, DAOs
Private Data	Private Data (Gb)	Data stored in the sovereign storage vault	Identities, DAOs
Public Data	Private Data (Gb)	Public data stored for public profiles	DAOs, Apps, Services
Comms	Messages (msg/s)	Messages sent between entities in the network	All
Key Recovery	Keys (bytes)	Shards of keys stored on the recovery notes	Identities
Identity Verification Bridge	Verifications (verifications)	Identity verification requests done through third-party identity verification services	Apps

Table 1: Core Network Resources

Each service handles the management of their resources differently. Each service also handles the data redundancy differently. By implementing an accounting system for each resource for each account in the network, Services can then easily create limits to ensure that network resources are guaranteed to always be available.

Paid Network Features

Fes are levied for accessing various features. The fee structure is diverse, covering a range of features. Table 1 Shows the network-based services and an example of the fee structure for those features.

For individuals

App	Service	Cost per month	Price unit
Tonomy ID	Pro account	Ø IdPro	per person

For DAOs

App	Service	Cost per month	Price unit
Tonomy ID	ID verification	Ø IdVerif	per verification
	Private data storage	Ø IdSovStorage	per Gb
	P2P Messages	Ø IdMessage	per 1M messages
Tonomy DAO	Pro account	Ø DaoPro	per company
	Incorporation	Ø DaoIncorp	per company
	Seat per person	Ø 1DaoSeat	per person
	Public data storage	Ø DaoSovStorage	per Gb
Tonomy Pay	Escrow payments	Ø PayEscr	per transaction
	Payment authorizations	Ø PayAuth	per transaction
	Pro with advanced analytics	Ø PayPro	per company
Tonomy Dev	App deploy	Ø DevApp	per app
	Smart contract deploy	Ø DevContract	per contract
	On-chain keys	Ø DevKey	per key
	Pro with advanced analytics	Ø DevPro	per company

Table 2: Example fees for network services

The fee model is flexible and can be adjusted based on the payment rates, units, or the period over which services are consumed (daily, monthly, etc.).

Service Incentives for Network Operators

All of the execution and data layer services are incentived within the ecosystem depending on it’s role and expenses.

Each Service has different pay rates based on their services using the following formular:

*Pay = PayBase + StakingRewardsFlag * (Staked Native Tokens / Total Staked Native Tokens) * StakePool + Expenses*

PayBase = base incentive
StakingRewardsFlag = Flag to turn off or on staking-based rewards
StakePool = Daily pool to be split based on stakes
*Expenses = Other operational expenses***

** Expenses are based on CNRs that are not already considered in the PayBase such as data stored for Public Data, or verifications for the Identity Verification Bridges.

Tokenomics Governance

The financial equilibrium of a Tonomy network is maintained using protocol enforced accounting using rules maintained by the governance system. The equilibrium is achieved when the combined fees from features equals the incentives paid to network operators.

The Tonomy Developer Portal facilitates the configuration of these incentives. Pay rates for various server infrastructure services are based on factors like staked native tokens, operational expenses, and a daily funding pool from the Treasury.

The network incentives configuration panel also allows for the specification of the maximum number of nodes eligible for service registration, balancing the need for minimal service provision with equitable fee distribution among operators.

It is through the governance system that underlying prices and fee structures are monitored and updated through proposals. This core responsibility of the governance DAO ensures the network can grow and adapt to the network's needs which keeping the networks infrastructure layer secure and accessible.

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